2.2 Forest Productivity

Overview

Productivity of our forests is one of the lowest in the world standing approximately at 1.0 m³ /ha/year compared to the global average of 3.0 m³ /ha/year. Even, the forest plantations in India, constitute 17 per cent of global population but have the productivity as low as 1.0 m³ /ha/year. At the same time output of the plantations under farm forestry and agroforestry is not high so as to match the productivity figures in other countries–major reason for it being the non-availability of quality planting material.

The proper scientific management of land and forest resources especially in the hills is quite important for achieving the long-term conservation and production needs of the forests. Government of India has declared a moratorium on the green felling and this issue of ban is always taking the back seat while the question of scientific management of the forest resources is discussed across, mainly because of the lack of scientific data behind. In addition to the number of parameters multiplying the problem, enormous congestion due to addition of new recruits and proper scientific management due to lack of data on the assessment of floral components always remains the concern. On the top of it, all these factors have got some bearing on the productivity of forest. Forests may reproduce more successfully when special efforts are made to encourage regeneration. Either artificial regeneration that involves planting seeds or seedlings, or natural regeneration that relies on existing seedlings or seed may be used.

Seeds although take up only a minor proportion of the overall cost of plantation and their management, yet their insufficient supply is often seen as a major bottleneck for carrying out various improvements in the production of planting stock. Even the survival in various plantation programmes is quite poor owing to the number of factors including the quality of planting stock. The plantations in our country are generally driven by targets. Compromises made during selection of nursery stock for achieving plantation targets have significant effect on survival and growth of man made plantations. Though some morphological parameters have been fixed in case of important tree species for selecting nursery stock for planting, yet they are not adhered to while carrying out the plantations. Often nurserymen/managers get influenced by the targets and make compromises in nursery stock selection to accommodate all available planting material irrespective of its quality. Therefore, fixing up of minimum standards of seedling quality, culling of sub-standard stock in the nursery etc., will definitely result in higher survival and establishment and enhanced productivity.

The effective planning and implementation of afforestation programmes depends on the availability, at all times of sufficient quantities of seeds with right physiological stage and improved genetic quality. The seed must be collected from a genetically proven superior source. Secondly, there must be a continuous checking by testing the physical and physiological characteristics of the seeds. Finally, it is important that seed should be stored until required without losing its germinative capacity and viability. Gujarat state Forest Department has selected seed stands, established several seed production areas, seedling seed orchards and CSOs under planting stock improvement programme. The seeds, thus, obtained have not been tested so far and therefore, a study was undertaken in consultation with SFD, Gujarat to evaluate their established seed sources of important species.

Azadirachta indica, *Prosopis cineraria* and *Tecomella undulata* are very important species in arid

and semi arid regions of western India and play an important role in greening the vast areas of the region. However, seedling parameters viz seed germination, collar diameter, seedling length etc which not only determine the quality of seedlings, but also affect overall production is yet to be done. Similarly, standardization of biofertilizer requirements for several important forest tree species of arid and semi arid areas is lacking. The study therefore, has been undertaken to develop a complete protocol from seed collection to production of quality seedlings for the arid zone of India.

Total 365 seedlots of four species viz; *Acacia nilotica, A. catechu, Dalbergia sissoo* and *Tectona grandis* were collected for the seed trait studies. Variation in hundred seed weight and germination variation was observed in *Acacia nilotica, Acacia catechu* and *Dalbergia sissoo,* collected from the various sources from Gujarat. Seeds of SSO and CSO had higher (2-5%) seed weight and percentage of germination as compared to seed stand. Infrastructure facilities for raising quality seedling in nursery were developed.

Thirty numbers of Candidate Plus Trees (CPTs) have been selected in West Bengal, Bihar and Jharkhand. The photosynthetic efficiency using portable photosynthesis meter and estimation of chlorophyll content on role of seasonal variation and growth regulators has been assessed for clonal propagation. A clonal procedure for *Anthocephalus chinensis* through air layering of mature ortets employing auxin treatment has been evolved. VMG of *Anthocephalus chinensis* and *Bombax ceiba* has been established and its hedging regimes are being standardized.

Planting stock of *Bambusa nutans, Dendrocalamus asper* and *Dendrocalamus strictus* are being raised through Tissue Culture and clonal culm propagation at Ranchi, Lalgutwa and Mandar in Jharkhand and 0.50 ha plantation has been raised. About 67 villages and 45 markets were surveyed for assessment of bamboo shoot producing species, production period and consumption in Jharkhand.

Interactive meetings were held with senior functionaries of HP State Forest Department on various issues pertaining to quality parameters of Nursery Stock of Deodar and Ban Oak in Shimla and Rampur Forest Circles of H.P. Physiological assessment of Deodar and Ban Oak nursery stock, particularly with Root Growth Potential (RGP), was taken up for standardization of parameters for identification of their quality planting stock. The plantation success through wildlings of *Cedrus deodara* has been found to be a critical issue and results are not encouraging till date even after detailed investigations.

The experimental sites established for assessing the various morphological parameters of the nursery stock of deodar and ban oak, in Shimla and Solan districts of Himachal Pradesh (HP) could not perform well because of the less snow fall/rains, resulting in large scale mortality in their experimental plantations –indicating moisture as the triggering factor for mortality.

Increase in the population and over-exploitation, especially of the forest resources for meeting the requirements of the growing populace, the demand for fuel-wood, fodder etc., can no longer be met with from the existing resources. Accordingly, practice of agro-forestry in its true sense is further required to be popularized. No doubt, such practices in India have been known and recognized since time immemorial and are being followed traditionally in different manners all across the country but need to be documented and understood with reference to its ecological, bio-physical and socio-economic aspects. However, agroforestry is gaining importance as land use practice in different parts of the country. In farmlands, the farmers intercrop tree species with many agricultural crops like cotton, soybean, maize, ground nut and many other food plants. The agro-forestry models with *Wrightia tinctoria* R.Br and *Gmelina arborea* Roxb. as tree species with Red gram and

Sorghum as agricultural crops, are being developed in Karnataka.

Ailanthus excelsa, Ziziphus mauritiana, Colophospermum mopane and *Prosopis cineraria* were planted in agroforestry trials at Bilara, Jodhpur. *A. excelsa* attained maximum height (318 cm) and collar diameter (10.86 cm), whereas *Z. mauritiana* exhibited minimum height (184 cm) and *P. cineraria* minimum collar diameter (6.54 cm). Total dry weight biomass was maximum in *P. cineraria* (14.0 kg/tree) and minimum in *Z. mauritiana* (2.0 kg/tree), whereas root biomass was highest in *C. mopane* (3.87 kg) and lowest in *Z. mauritiana* (0.97 kg/tree). The fodder production was highest in *C. mopane* (3.0 kg/tree) and minimum in *A. excelsa* (1.0 kg/tree).

The establishment of multitier cropping system by raising Aonla intercropped with Arhar and Adrak is in progress at OSR experimental area of Tropical Forest Research Institute Jabalpur and OFR in farmer's field at Neemkheda village, Jabalpur district.

In order to introduce selected genotypes of Karanj, Kusum and Bamboo as tree components in Agroforestry models in lateritic belt of eastern India, 2-year old seedlings of Karanj and Kusum were planted at Lalgutwa and Mandar and a seven-year old bamboo plantation was selected at Mandar in Jharkhand. Five agricultural crops viz., ginger, turmeric, colocasia, black gram and ragi were sown/ transplanted under trees from May to July. Soil samples were collection for analysis. The study is in progress.

In sandy hill pediment land at Bhuj in Gujarat, *Cordia gharaf* and *Cenchrus ciliaris* based silvipastoral system produced maximum biomass, followed by *Zizyphus mauritiana* with *C. ciliaris* after 38 months of planting. Dense grass sowing adversely influenced the tree growth, while scattered grass promoted growth.

Two species of bamboos viz. *Bambusa nutans* and *Dendrocalamus strictus* were selected to establish the bamboo based agroforestry system at experimental area of TFRI Jabalpur and to create the awareness among the farmers of different villages of M.P. and Chhattisgarh state for the adoption of bamboo in their field.

Assessment of land use practices in jhum areas and investigation of different production related parameters were carried out. Productivity enhancement in abandoned jhum land through agroforestry management and value addition was done. Quality and yield improvement in agroforestry based food product under integrated nutrient management were analysed. Rehabilitation of jhum land through potential bamboo species with reference to carbon sequestration and livelihood development was carried out.

While agroforestry models have been developed for several agricultural crops however, the research on development of agroforestry system with medicinal plants is not adequate. In the context of growing interests among the farmers for cultivating tree species in farmlands, particularly Casuarina and Eucalyptus and existing potential market for medicinal plants, the study has been initiated to develop suitable agroforestry systems with medicinal plants in Tamil Nadu. Studies on cultivation of the medicinal plants with *Casuarina* and *Eucalyptus* and their compatibility in agroforestry system will open up a new vista and encourage the farmers to practice the system and get more remuneration than intercropping with any other agricultural crop.

Industrially important medicinal plants such as *Asparagus racemosus*, *Cassia senna, Decalepis hamiltonii, Gloriosa superba*, *Hemidesmus indicus*, *Plectranthus barbatus, Withania obtusifolia* and *W. somnifera* were sown in four locations in Tamil Nadu. The seeds of medicinal plants were collected annually and analysed for their properties. The growth parameters of medicinal plants and tree species were recorded and the soil attributes were also estimated. All these medicinal plants have compatibility and suitability under the industrial tree species. The result showed that colchicine content in *Gloriosa superba*, was higher under Eucalyptus than other tree species, although colchicine content was high in *Gloriosa*

superba under other species also. Such a medicinal plants based agroforestry project may help to increase the soil fertility and recover the perennial medicinal plants like *Hemidesmus indicus*, *Decalepis hamiltonii.*

Studies on sustainable management of medicinal plants in JFM areas in two agroclimatic zone of Madhya Pradesh were conducted. Germination percentage was improved by pretreatments on *Schleichera trijuga, Terminalia arjuna, Sapindus laurifolia, Terminalia chebula, Abelmoschus moschatus, Rauvolfia serpentina, Emblica officinalis* and *Mimusops elengi,* out of 12 target species.

In the plantation trial on highly saline black silty clay soil of little Ran of kuchchh, *Salvadora persica* proved to be the best species with 83.7% survival after 50 months, followed by *Acacia ampliceps*. Application of FYM and wheat husk favoured better survival and growth.

Preliminary growth data indicated that *Gmelina arborea* performed well on all the study sites in Shimla and Solan districts and has attained an average height of about 250 cm within three years of its establishment. Though very early to predict, yet, it can be a potential species for carrying out future plantations in the lower hills.

Keeping all the above aspects in view, ICFRE is making all out efforts through some research projects so as to suggest specific strategy to the stake-holders.

Projects under the Theme			
Projects	**Completed Projects**	**Ongoing Projects**	**New Projects Initiated During the Year**
Plan	10	23	12
Externally Aided	04	06	04
Total	**14**	**29**	**16**

2.2.2 Silviculture

Enhancement of Seed Longevity of *Diploknema butyracea*

Fruits/seeds of *Diploknema butyracea were* collected from four locations viz. Gurna, Jadapani, Harkante and Matela in Pithoragarh FD (Uttarakhand), seed parameters, initial germination, viability, vigour, studies on desiccation sensitivity of seeds done. For storage studies, seeds were desiccated to two moisture levels i.e. 30% and 25%, and desiccated seeds were stored at two temperatures viz. ambient room temperature and 15^0C. Seed longevity enhanced to 30 days in undesiccated seeds stored at ambient room temperature. Seeds of *D. butyracea* were categorized as Tropical recalcitrant seeds with lowest safe moisture content of 30%. Seeds sown in nursery in different media and containers and observations on seedlings growth, taken periodically. Better growth (height, collar diameter, vigour index) was observed in seedlings in polybags. Potting media of soil: sand in 2:1 was found to be best for the growth of the seedlings.

Developing Seed Technology and Propagation Techniques for Germplasm Conservation of *Buxus wallichiana*

Fruits/seeds of *Buxus wallichiana* were collected from Matkangra block (Chakrata Forest Division) and also from Mandal forest in Kedarnath Wild Life Sanctuary. Seeds were subjected to stratification, Gibberellic acid, KNO_3 pretreatments for enhancing the germination. Highest germination was 50% in seeds from Chakrata treated with GA_3 (0.01%) for 48 hours. For Mandal seeds it was 77% in GA_3 (0.02%) for 48 hours, treatment. Seed stored at 15^0C for one year yielded 26% germination, ones stored at 5^0C resulted in 10% germination while seeds at RT did not germinate at all. Thus, seeds of *B. wallichiana* were short lived and orthodox. Propagation experiments for *B. wallichiana* conducted in Deoban nursery (Chakrata). Stem cuttings, treated with 12 combinations

of different concentrations of rooting hormones (IBA and NAA), were kept in mist chamber for rooting. 70% rooting observed in stem cuttings treated with 1000 ppm IBA.

Enhancement of Seed Germination in *Anogeissus latifolia* through Various Seed Technological Inputs.

Seed Maturity indices of *Anogeissus latifolia* have been quantified. Seed handling, germination and storage protocol have been developed. More than 90% emptiness was observed in the seeds of this species. Sucking of sap by insect from fruits during developing stage seems to be one of the causes of the emptiness. Systemic insecticides have been applied in the trees to control the disease during August 2011 with the help of Entomology Division of FRI and seeds were collected from these trees during March 2012. It seems that some insects were responsible for the emptiness of seeds in *A. latifolia,* as more half filled seeds were found in seed collection from treated trees. More intensive study is required to control the fruit sucking insect in the species and should be carried out in Entomology Division of FRI.

Biodiversity Conservation and ecological security: Establishing Germplasm Garden of Some Rare and Endangered Plants

Locations of five species viz. *Catamixis baccharoides, Ulmus wallichiana, Rauvolfia serpentina, Berberis aristata* and *Mahonia jaunsarensis* were identified and collection of propagation material (seeds/ cuttings/wildlings) was done from Chakrata, Hardiwar and Dehradun area for their multiplication and conservation. Wildings of *Catamixis baccharoides* have been successfully established in germplasm garden. Germplasm of *Mahonia jaunsarensis* and *Berberis aristata* have been propagated through cuttings. Accessions from CIMAP have been received and added to the garden. Germplasm of *Ulmus wallichiana* has been collected from Chakrata and Kashmir and plants have been produced successfully through cutting.

Variability Studies on Seed Quality Parameters and Seed Mycoflora of *Bauhinia purpurea, Bauhinia semla and Bauhinia variegata* for their *ex-situ* Conservation

In April/May 2011 pods/seeds of *B. purpurea* collected from Saharanpur, Muzaffarnagar and Kanpur in UP, Roorkee, Vikasnagar, Dehradun in Uttarakhand; that of *B. retusa* collected from Tehri and pods of *B. variegata* collected from different locations in Uttarkashi district. Seeds of *B. purpurea* and *B. variegata* from all sources in UP and few from Uttarakhand had high viability while *B. variegata* from Uttarkashi exhibited low germinability and high fungal infection. Variability in pod and seed morphological parameters, moisture content, germination and storability studied. Viability and vigour of seed collections of the year 2009 and the year 2010 also assessed quarterly. Seeds are gradually losing viability and rate is faster in *Bauhinia retusa* seeds. Seeds of *B. purpurea* have maintained 45 – 85% viability after 2 years in storage. Seeds of different species of *Bauhinia* (2010 and 2011 collection) were grown on blotter paper for identifying the fungal isolates. All the sources of *B. purpurea* had *Penicillium* (24) infection followed by *Aspergillus* (23) and *Rhizopus* (8). Most of the fungal isolates belonged to *Aspergillus* sp. and *Penicillium* sp. *Trichoderma* was only present in *B. variegata* from FRI source. Sub culturing of different isolates of fungi was done and maintained on PDA slants.

Influences in Regeneration of Silver Fir (*Abies pindrow*) and Spruce (*Picea smithiana*) Forests -Effect of Natural Leachates on Seedling Growth in Nursery.

Litter, humus and soil samples have been collected from fir and spruce forests in Deoban, Chakarata on monthly basis and soil samples have been analyzed for Total Nitrogen, Available N and Organic Carbon. Leachates of litter, humus, soil and of under-storey plants have been prepared. Seeds of fir and spruce has been collected from Chakrata and sown in nursery at Deoban forest nursery for further experimentation. Application of leachates on fir and spruce seedlings and data recording is continuing.

Allelopathic Potential in Regeneration of Sal (*Shorea robusta*) forests .

Litter, humus and soil samples collected from Sal forests, Dehradun on monthly basis and soil samples analyzed for Total Nitrogen, Available N and Organic Carbon. Leachates of litter, humus, soil and of under-storey plants prepared. Seeds of sal collected and sown in nursery at FRI, Dehradun for further experimentation.

Forest Genetics Resources

Genetic Improvement of *Jatropha curcas* for Adaptability and Oil Yield (Funded by CSIR, New Delhi)

Performance of different accessions of *Jatropha curcas* in unreclaimed sodic soils was found unsatisfactory. At five and half years of age, the plants exhibited poor survival and growth. None of the accessions could record growth rate comparable to plantation of this species on a good site. Seed yield has been negligible. In Dehradun valley, at four years of plantation age, maximum seed yield of 244.80 kg/ha was obtained with application of 2kg FYM+ N10 g+ P20 g +K10 g/Pit, F4/2kg FYM+ N10 g+ P20 g +K10 g/Pit. Pruning at 30, 45 or 60 cm height resulted in production of more number of branches and greater canopy diameter than control. Plants fertilized with 2kg FYM+ N10 g+ P20 g +K10 g/Pit/F4/2kg FYM+ N10 g+ P20 g +K10 g/pit possessed greatest height, number of branches and canopy diameter. Effect of fertilizer irrigation frequency interaction was not significant.

Field Evaluation of Superior Germplasm of *Jatropha curcas* in Uttarakhand as a Part of Multilocation Trial (Funded by DBT, New Delhi)

Trials are being maintained. Growth parameters of different accessions were recorded. Seed production has not yet started at the age of three years.

Establishment of Multilocation Clonal Trial and Study of Wood Anatomical Properties and Cellulose Content of Promising Clones of *Populus deltoides* .

Field trials of 30 clones have been established at four sites i.e. Saharanpur, Ambala, Ludhiana and Udham Singh Nagar districts. Nursery of selected clones has been established again for next year's field trials. Germplasm bank was maintained. Cellulose content of 30 clones have been estimated and wood anatomical studies on 20 clones completed.

Vegetative Propagation of Some Difficult-To-Root Commercially Important Tree Species.

Rooting has been achieved in branch cuttings of *Diploknema butyracea, Lagerstroemia parviflora* and *Adina cordifolia. Anogeissus latifolia* has not responded to air layering or propagation through cuttings.

Evaluation of *Bombax ceiba* for Seed Sources in Northern India.

Experiment on rooting of branch cutting has been established. Literature is being collected from published sources. Growth and form behaviour of the species has been examined and criteria for selection of trees and stands have been worked out. 10 CPTs have been selected and their cuttings planted.

Nursery Techniques of *Stereospermum suaveolens*

Screening of two provenances of Uttar Pradesh and Uttarakhand of *S. Suaveolens*, where naturally available trees were found, and genetic resources was carried out to elucidate the genetic variation and relationship of pod and seed traits on germination percentage, to select the best planting material for higher productivity. From all seed sources, eight traits viz. pod length, Pod width, 100-pod weight, Seed width, 100 seed weight, seeds per pods and maximum seed length with wings and without wings were studied. Pods and seeds traits correlation studies revealed that irrespective of the pod

characteristics, the seed characteristics, especially the length remained more or less the same. Thus, the seed length and width look to be fairly independent of the pod size for this species.

Also tested germination of seeds with different pre-treatments and vegetative propagation studies with different hormonal concentration.

Conservation and Cultivation of Economically Valuable Lesser Known/Less Utilized Fruits Tree Species and to Determine Possible Chemical Components Present in Fruits

Survey was done of *Spondias pinnata* and *Artocarpus lakoocha* trees/localities in Allahabad district and collection of its fruits done during different months and drying. Fruit and seed parameters studied. Seed germination under nursery conditions with different treatments studied. Vegetative experiments in *Artocarpus lakoocha* and *Spondias pinnata* with different hormonal treatments were carried out. Chemical analysis of *S. pinnata* fruits to determine possible chemical component present in it fruits was also done.

Development of Models for Conversion of Plantations into Secondary Forests in Andaman

Conducted the plantation surveys in North Andaman, Middle Andaman, Baratang and South Andaman and sample plots of 5 ha each in Teak plantations, Padauk plantations and mixed plantations, located adjacent to moist deciduous forests, semi evergreen forests and evergreen forests selected. A total of 12 sample plots of 5 ha each were selected. Each sample plot was further subdivided into 5 plots of 1 ha each for various treatments and control. The species diversity present in sample plots of Padauk, Teak and Mixed plantations has been assessed. Similarly the species diversity in the adjoining forests is being assessed to convert the plantations into secondary forests close to natural profile. The Department nurseries at Mannarghat in South Andaman, Nilambur in

Baratang, Bakultala in Middle Andaman, Tugapur in Mayabunder Division, Aerial Bay in Diglipur Division have been identified for raising the seedlings.

Developing Yield Tables for Short Rotation Tree Crops in Kerala (funded by the Kerala Forest Development Corporation)

The present project aims to develop regional prediction models for constructing yield tables for five fast growing tree crops *viz. Acacia auriculiformis, A. mangium, Albizia falcataria, Eucalyptus pellita,* and *E. grandis* in Kerala. Sample plots were laid out in plantations of *Acacia auriculiformis, A. mangium, Albizia falcataria,* and *E. grandis* and trees were measured for girth at breast height. The measured trees were grouped into different girth classes. Mean trees for each girth class were felled for actual volume estimation. The parameters like basal girth, gbh, total height, commercial height (height up to 5 cm diameter), and clean bole height were also recorded. The data set on growth parameters will be used for calculating actual volume for both over and under bark volume. The best-fit regression models will be developed for all the five species using easily measurable parameter – girth at breast height and then finally regional yield table will be prepared for future yield estimation of plantations.

Standardization of Pruning Practices and Optimum Doses of Organic and Inorganic Fertilizers to Increase Leaf Surface Area of Tendu

Surveyed and selected sites in Morga, Kotadol and Litipara in Chhattisgarh state, having good quality and high production of tendu, as suggested by M.D. Chhattisgarh State MFP Federation.

Experiments on foliar spray of chemical fertilizers were conducted in Morga to observe the effect of different doses of fertilizers, either individually or in combination, on increment in size of tendu leaves using RBD statistical design. Maximum increase

(16.19%) in surface area of tendu leaves was observed when a combination of 2% nitrogen and 1% phosphorus was applied through foliar spray, which was followed by 1% phosphorus treatment when compared with control.

Experiments on chemical and biofertilizers *viz.* urea, single super phosphate, vermicompost and neem based biofertilizer on enhancement of quality and sustainable production of tendu leaves were conducted at Morga using RBD factorial design.

Experiments on pruning practices of tendu with treatments including time interval of pruning, height of pruning and girth classes were conducted at Morga using RBD Factorial design.

Conducting Experiment on Foliar Spray of Chemicals at Morga

Collecting Tendu Leaves from Experimental Site

Reclamation of Fly Ash Dykes with Suitable Amendments at NTPC Korba, Chhattisgarh

Surveyed and selected fly ash dykes at NTPC Korba and conducted vegetation survey by Quadrat method in the surrounding forest area for the assessment of native species. The following species communities were found Trees - Eucalyptus, *Cassia siamea*, *Cassia fistula* Shrubs - *Lantana camara, Phoenix sylvestris, Xanthium strumarium* Herbs- *Hyptis suaveolens, Cassia tora, Triumfetta rhomboidea* Collected fly ash samples and analyzed them for their physio-chemical parameters.

Studies on the Effect of Different Level of Seed Collection on Natural Regeneration of Sal (*Shorea robusta*) in Chhattisgarh

Three sites, Bastar, Raipur and Bilaspur agro-climatic zone were selected and sample plots were laid out to study the effect of different level of seed collection, fire and grazing in pure, mixed and degraded sal forests of Bastar, Raipur and Bilaspur agro-climatic zone.Phyto-sociological studies including regeneration survey of newly recruited seedlings of seed and coppice origin and samplings of sal of all the experiments laid out in pure, mixed and degraded sal forests of Bastar, Raipur and Bilaspur agro-climatic zone had been completed. The experimental results showed that different level of seed collection had positive impact on overall regeneration and recruitments. After eleven months of observations, very low percentage of recruits were observed to survive (6.64%) on uncontrolled grazing site and fire affected sites.

Best recruits status (17.06%) was found to be at the sites with cleaning and loosening of soil practices followed.It was followed by 12.98% at loosened soil site and 11.24% at the sites where undesirable herbs were cleaned.

Studies on Seed Traits of Seeds Collected from Seed Stands / SPAs / SSOs / CSOs of Important Species of Gujarat State

Seeds of *Azadirachta indica* (15kg), *Prosopis cineraria* (10kg), *Acacia nilotica* (5kg), *Acacia*

nilotica var. *cupressiformis* (2kg), *A. tortilis* (2kg), *Ailanthus excelsa* (15kg), *Tecomella undulata* (1kg), *Pongamia pinnata* (2kg), *Salvadora oleoides* (2kg), *Cassia fistula* (5kg), *Capparis decidua* (0.2kg), *Acacia senegal* (5kg), *Lasirus sindicus* (100g), *Cenchrus cilliaris* (4kg) and *C. settigerus* (1kg) were collected for seed bank and supply to AFRI-Model Nursery for raising seedlings to be used in research projects and supply to end users. Seeds of *Tectona grandis (95)*, *Acacia nilotica* (2), *Acacia catechu* (10), *Dalbergia sissoo* (34) sources were collected during 2011-12 from Gujarat.

A total of 365 seedlots of four target species (*Acacia nilotica*, 14, *A. catechu*, 50, *Dalbergia sissoo*, 83 and *Tectona grandis* 200 seedlots) have been collected over five year period and significant differences observed in 100 seed weight/stone weight and percent germination studies. Seeds collected from seed production area, SSOs and CSOs have higher (2-5%) seed weight/per cent germination in comparison to seed stands. In *A. nilotica*, 100 seed weight varied from 12.60-16.70g and per cent germination from 80-96%. In *A. catechu* it varied from 3.79-5.66 g and 25-84%. In *D. sissoo*, it varied from 1.81-3.75 g and from nil to 63% germination. In teak 100 stone weight varied from 17-60g.

Refinement of Modern Nursery Practices for Raising Quality Seedlings of Selected Important Forest Tree Species of Arid and Semi Arid Areas

Surveyed and selected morphological superior seed trees of *Azadirachta indica* (Neem) and *Prosopis cineraria* (Khejri) in and around Jodhpur. Seeds were collected from the selected trees of *P. cineraria* and *A. indica* and depulped and dried for nursery studies. 100 seed weight of Neem and Khejri varied from 11.80g to 19.88 g and 4.47 to 4.66 g, respectively. Different potting mixtures were prepared. Seed sowing of *P. cineraria* was carried out in the mother beds. Infra-structures (Root trainers/shade house with sprinkler facilities) were also developed.

Determination of Morphological and Physiological Quality Parameters of Nursery Stock of Deodar (*Cedrus deodara)* and Ban oak (*Quercus leucotrichophora*)

Raised and maintained nursery stock of Deodar and Ban Oak at Model Nursery, Shimla and Shilly nursery, Solan respectively. Experimental plantations, as carried out as per the morphological parameters of these species during August 2008 & 2009 in Shimla and Solan districts of Himachal Pradesh, were maintained. To achieve first objective of the project, survey was done through interview and a structured questionnaire was developed for that purpose. It was found that only one physical parameter was adopted in the SFD's nurseries for measuring the quality of Deodar and Ban Oak nursery stock *i.e.* height (shoot length) of the nursery stock. Owing to very less snow fall/rains during 2008 and 2009 followed by continuous drought like conditions during summer resulted in large scale mortality in experimental plantations of these species. Initiated studies for judging quality of Deodar & Ban Oak nursery stock based on Root Growth Potential (RGP).

During the year, the quality planting stock of Deodar (5,000 no.) and Ban Oak (20,000 no.) was maintained at Model Nursery Shimla and Shilly nursery Solan respectively. Work on physiological assessment of Deodar and Ban Oak nursery stock continued, particularly with Root Growth Potential (RGP) trials and also fresh trials, laid out in the nursery pertaining to physiological parameters. Experimental plantations done during 2008 and 2009 in Shimla and Solan districts maintained and data pertaining to survival and growth recorded. The trails repeated in gunny bags also, maintained and data recorded regularly.

For achieving one of the major objective of the project successfully, organized 2 no. interactive meetings with senior functionaries of HP State Forest Department on various issues pertaining to quality parameters of Nursery Stock of Deodar and Ban Oak in Shimla and Rampur Forest Circles of the state.

Out Planting of Deodar in Gunny bags

Interactive Meeting on Quality Parameters of Nursery
Stock of Deodar and Ban Oak

Development of Techniques for Raising Deodar (*Cedrus deodara*) Plantations through Tall Plants

Pilot scale experimental plantations of Deodar planted on the basis of height and root collar diameter classes, as established during August 2008, February 2009 and repeated again during August 2009 and August 2010 were maintained in the field intensively. Experiments were also carried out as per Root Exposure Time and Root Dessication Protecting Substances, while extracting and planting wildling directly in the field as well as in the nursery in gunny bags. The data pertaining to field survival recorded regularly and the initial results recorded were not found encouraging except for the experiments with the wildling repeated

during August 2010. Tall plants were raised in the nursery in big containers such as gunny bags, plastic containers etc and subsequently maintained.

During the year 2011, finalized one additional site for pilot scale experiments near Shillaru in Shimla district. Field and nursery trial as established earlier were maintained properly, including carrying out the out planting of tall plants raised in gunny bags/ plastic containers, carried during August 2011. Nursery studies continued for raising tall plants of Deodar. Survival data recorded on regular basis for both nursery and field trials. The plantation success through wildling

Raising of Deodar Tall Plants in Nursery

Out Planting of Deodar Tall Plants in the Field

is still a critical issue and results are not encouraging till date. Nursery experiments for raising tall plants in gunny bags and plastic containers are still continuing at Model Nursery Shimla and Shillaru nursery.

Studies on Seed Germination and Longevity of *Abies spectabilis* (D.Don) Spach

This project was initiated from April, 2011 only and during this period, extensive surveys were conducted for identifying the natural population of *Abies spectabilis* in five Forest Divisions in the state of Himachal Pradesh. As a result of the survey, identified nine natural populations of *Abies spectabilis* in Churdhar area of Sarpet Beat in Nohradhar Range of Shimla Wild Life Division, Budhavan and Chowagor area of Tosh Beat in Kasol Range of Parvati Forest Division, Rahla area of Kothi Beat in Manali Range of Kullu Forest Division, Ula kanda area of Ula Beat in Kalpa Range and Chot Kanda area of Nichar Beat in Nichar Range of Kinnaur Forest Division, Uchpago area of Chhitkul Beat and Barda Kanda area of Rakchham Beat in Sangla Range of Sarahan Wild Life Division, Dangiabe area of Yangpa Beat in Katgaon Range of Sarahan Wild Life Division. The data pertaining to geographical coordinates of the identified sites i.e., altitude, latitude and longitude along with associated species of *Abies spectabilis* recorded. The soil samples were collected from the identified sites and analyzed in the laboratory for soil pH, organic carbon, moisture content, electrical conductivity, nitrogen and potassium content to know the site characteristics of the identified locations. The cones of *Abies spectabilis* were collected from the two identified locations i.e., Chhitkul and Churdhar forest and seeds were extracted from the cones. The morphological data of the cones and seeds i.e., cone length, cone width, cone weight, specific gravity of the cones and seed length, seed breadth, 100 seed weight and moisture content of seeds collected during the period, recorded. The nursery beds prepared and seed germination trials laid out in the laboratory and nursery.
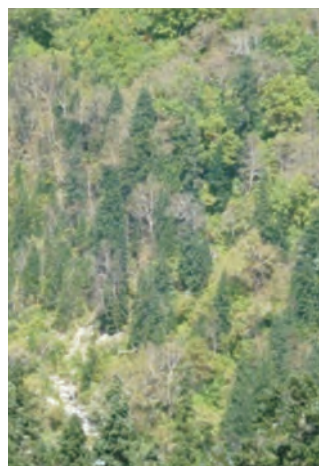
The seed storage trials also initiated by using different storage containers and storage environment and germination and viability data recorded.
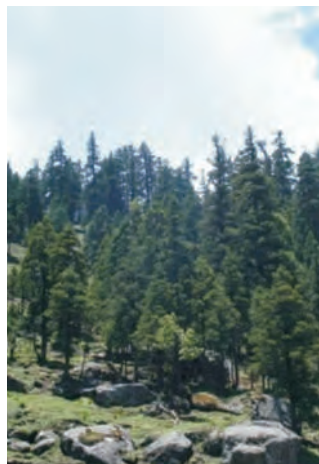
Churdhar,Shimla Wild Life Division

Rakchham, Sarahan Wild Life Division

Yula, Kinnaur Forest Division

Chhitkul, Sarahan Wild Life Division

Natural Populations of *Abies spectabilis* in Himachal Pradesh

Integrated Strategy for Evaluation of Indigenous Fast-growing Multipurpose Trees of Eastern India for Plantation Forestry

Selection and screening of kadamb and semul seed sources in Bihar, Jharkhand and West Bengal; and standardization of propagation packages for mass production of superior planting stock is significant for employment of these species in plantation forestry.

Air layering protocol for clonal multiplication of mature ortets has been standardized in *Anthocephalus chinensis* and *Bombax ceiba*.

Edible Shoot Production of Selected Bamboo Species and Extension of Shoot Production Period Through Cultural Practices

A total of 67 villages and 45 markets have been surveyed in Jharkhand and information on quantity of edible shoot consumed by villagers, species used, persons engaged in collection, self bamboo utilization, quantity marketed, persons involved in shoot trade, average quantity sold and earnings etc. have been collected. Conducted field trials on shoot production period and yield of the species by improving soil health through soil working, mulching, irrigation and organic and inorganic amendments and also through clump management. Effect of shoot removal at different intensities have also been studied on quality and quantity of edible shoot production and on the general health of the clumps of the said species so as to standardize shoot extraction method.

One day Workshop (30.08.11) on 'Cultivation of Bamboos for Edible Shoot Production and Processing' and a Five days' Training (25.07.11 to 29.07. 11) on 'Bamboo Propagation, Cultivation and Management for sustainable Livelihood' for farmers were organized at IFP Ranchi.

2.2.3 Social Forestry, Agro-forestry/ Farm Forestry

Development of Model of Some Important Medicinal Plants with *Melia composita* and *Emblica officinalis* in Degraded Land of Punjab and Uttarakhand

Review of literature work has been done from the library on Agri-Silvi-medico agroforestry systems. Surveyed and selected the sites at Handesra, district Mohali of Punjab and Naukra grant (Buggawala), district Haridwar of Uttrakhand and discussed with the farmers for site preparation and Agri-Silvi-Medico agroforestry research activities in their farm land in Punjab and Uttarakhand. Developed both the sites at Handesra (Punjab) and Naukra grant (Buggawala), Uttrakhand. Raising and maintenance was done of *Melia composita* seedlings in central nursery and medicinal plants procured. Soil samples were collected from both the sites and their analysis is in progress. Data were also recorded on village profile from Handesra (Mohali) and Naukra grant, Buggawala (Haridwar). The work is in progress.

To Study the Timber Markets of Important Agro forestry Species in Eastern Uttar Pradesh

The survey has been done in identified villages of the districts of Bahraich and Barabanki and market places as saw mills, industries, contractors and middlemen for providing information to traders and growers on selected agroforestry species. The preparation of database is in progress. The data compilation has already been done for two districts-Raebareilly and Allahabad for traders and growers information having marketable timber under agro forestry for selected species.

Development of Site Specific Medicinal Plant Based Agro-forestry Models for Existing Plantations in Eastern Uttar Pradesh and Establishment of Demonstration Model

Site has been selected at experimental trials of medicinal plants with the tree crops of mango, Aonla, Mahua, Bamboo and Eucalyptus in Allahabad district. Procurement of propagules of Sarpgandha, Pachauli and Satawar and Kalmegh was got done from CIMAP, Lucknow. A nursery for propagation of medicinal plants has been established and agroforestry experiment has been laid out.

Evaluation of Potentials and Constraints of Agroforestry Development of Uttarakhand, based on Econometric Analysis

Collection of literature is in progress. Development of data collection tools/questionnaire has been

completed and their testing in the field is in progress. Locations of agro forestry trials were identified with the help of secondary data/information. Data were collected from Haridwar district.

Introduction and Evaluation of Fast Growing Tree Species under Agroforestry Systems in Different Agroclimatic Zones of Tamil Nadu

Agroforestry systems with fast growing tree species were established, over 15 ha farm land in three agroclimatic zones (Northeastern, Cauvery delta and Southern zones) of Tamil Nadu with tree species viz., *Melia dubia, Gmelina arborea, Neolamarckia cadamba* and *Sweitenia macrophylla* over 5 ha each in three zones.

Intercropping activities carried out and the biomass and yield of annuals of various species (as intercrops) has been assessed. From the intercropping activities carried out in the first year, *M. dubia* with Turmeric registered highest net annual returns of ₹ 1,25,700 followed by *G. arborea* with Banana (₹ 41,550), *M. dubia* with Tapioca (₹ 32,468) on per ha basis. Allelopathic study has been conducted with the exudates prepared from the fast growing tree species leaf, stem and root and study completed in Maize, Sorghum and Black-gram. One training has been conducted on 'Capacity building on agroforestry

Establishment of Agroforestry System with *Melia dubia* and Sorghum under Farmers' Field in Northeastern Zone of Tamil Nadu

Establishment of Agroforestry System with *Melia dubia* with Castor under Farmers' Field in Northeastern Zone of Tamil Nadu.

Establishment of Agroforestry System with *Melia Dubia* with Groundnut under Farmers' Field in Northeastern Zone of Tamil Nadu.

plantation establishment and management' to farmers' of Pudukottai district.

Improving Productivity of Bamboo Cultivation in Farmlands of Tamil Nadu (funded by National Bamboo Mission (NBM), Government of India)

Nine bamboo field trials have been established over three ha, each spread over 3 agroclimatic zones of Tamil Nadu, to standardize the silvicultural practice. During 2011–12, maintenance of these trials were carried out. In addition, 10 ha. of bamboo germplasm bank with 33 species and 85 accessions and bamboo multiplication garden with 23 species and 57 accessions were established under the project at IFGTB Field Station, Kurichi, Coimbatore.

Development of Elite Planting Material and model Plantation (funded by NOVOD board)

The project aims at raising 50 ha of Neem and Pungam model plantations. Around 12,500 Neem and 12,600 Pungam seedlings were raised during 2010-11 under the project. During 2010-11, 10 ha of model plantations were established at Salem (4ha) and Coimbatore (6 ha) During 2011-12, 15 ha of Pungam plantations have been established in 40 ha land offered by Tamil Nadu Magnesite Limited (TANMAG), Salem – a Government of Tamil Nadu undertaking. In principle,

approval for a sum of Rs. 3.55 lakhs has been granted by M/S Tamil Nadu Magnesite Limited (TANMAG), Salem towards the maintenance of model plantations of Neem and Pungam.

A Value Chain on Industrial Agroforestry In Tamil Nadu (funded by ICAR)

In order to demonstrate the potential of the genetically improved planting materials, demonstration plots of Eucalyptus over 20 ha and Casuarina over 15 ha have been raised. 16 high yielding clones of Eucalyptus developed by IFGTB have been used. In Casuarina, superior seedlots from seed orchards and clones of *Casuarina junghuhniana* and Casuarina hybrids have been used. In order to develop new generation planting material and to increase the use of genetically diverse material in the planting programmes, 9 clonal trials have been laid with 70 clones of *Casuarina junghuhniana* and 4 hybrid clonal trials have been laid with 26 *Casuarina equisetifolia* x *C. junghuhniana* hybrids. One hybrid of *Eucalyptus tereticornis* x *E. grandis* has also been identified for mass propagation and planting.

Development of Agroforestry Models in *Wrightia tinctoria* R.Br and *Gmelina arborea* Roxb. as Tree Species in Semiarid Tropics of Andhra Pradesh.

Most of the physical targets set out for the project were met during the period under report. Cultivated the Redgram and Sorghum crops and recorded the yield data. *Wrightia tinctoria* and *Gmelina arborea* tree crops are maintained. Meanwhile pot culture and bioassay experiment is being conducted in the FRC nursery to see allelopathic interactions.

Development of Multitier Cropping (Silvi-Agri-Spice) system

Identified and selected two study sites as an OSR experimental area of TFRI and as an OFR in farmer's field, Neemkheda village, Jabalpur district to establish the multitier cropping system by raising Aonla intercropped with Arhar and Adrak. Preliminary cultural operations like clearing, weeding, ploughing, levelling of field, basal dressing with Farm Yard Manure were done. Procured and transplanted two varieties of *Phyllanthus emblica* (Aonla) viz. NA7 & NA 10 at the spacing of 10mx8m and 10m x 6m intercropped with *Cajanus cajan* (Arhar) in Factorial RBD. The data on nutrients study revealed that Organic matter , available macro nutrients (N, P, K) were in medium range except available phosphorus which was very low in both the field i.e. Farmer's field as well as in research station. The growth parameter of NA-7 Aonla plants (one year old) shows a regular increase in mean height (minimum 86 cm to maximum 114.30 cm at 10m x 8m, whereas, NA10 is performed minimum 93.60cm and maximum 172.10 cm along with agriculture crop in the study sites.

Development of Lac Based Agroforestry (Silvi-Agri-Lac) System

Surveyed the local area for the selection of farmer's field to establish the OFR under the project. Saplings of two species of Lac host viz. *Flemingia semialata* and *Flemingia macrophylla* were procured from the Natural Resin and Gum Research Institute (Jharkhand) Namkum, Ranchi and transplanted in the OSR and OFR, selected as two study sites under the project. For the estimation of physical properties and nutrient status of land, soil samples were collected and analysed. Observation on growth and survival of both the species were recorded. Data on growth parameter were recorded and *F. macrophylla* shows better maximum (250cm and minimum 90 cm), whereas, *F. semialata* shows maximum height 150cm and minimum 60 cm after one year of its plantation. The soil samples were collected and analysed for the estimation of Macro nutrients and physical properties (pH; 6.9 - 7.4, EC; 0.049 – 0.062 and OM; 0.28 - 0.39) of the sites. Data showed that the macro nutrient like Nitrogen 94.08 to 188.16kg/ha, Phosphorus 7.74 - 10.32 kg/ha and Potassium 79.21 – 130.40kg/ha , Ca^{++}- 10.02-26.8 and Mg^{++}- ranged 8.8 - 20.0 after one year of plantation.

Assessment of Land Use Practices in Jhum Areas and Investigation of Different Production Related Parameters

Geo- coordinate of the land Use System were collected and mapping was done for Tipi watershed (Arunachal Pradesh) with use of different GIS tools. Data sheets were prepared for information regarding prevalent Land use systems in Tipi watershed. The different types of existing LUs were identified i.e. home garden, fisheries, settled cultivation areas. Yield parameters for the prevalent seasonal crops

Socio-economic Survey

Estimation of Crop Production

were studied through quadrate methods. The soil samples of the Watershed area were also collected and analyzed.

Productivity Enhancement in Abandoned Jhum Land through Agroforestry Management and Value Addition

The trials were maintained for second year experimentation in the two sites in Kawnpui (Mizoram) and Baljek Aduma (Garo hills, Meghalaya). Market Survey was conducted and data collected from farmers as well as from local markets for exploring pattern of demand and supply for important farm products. Designing and layout of site specific agroforestry models under existing land use types were laid out in three types i.e. traditional, participatory and scientific patterns. The farmers have shown their preferences and motivation towards the scientific method of practices which is also positively correlated with the direct and indirect benefits out of it. In support of scientific interventions, a low cost vermicompost unit and water harvesting pond were also set up at the two sites. First rotation of *Jhum* produce was collected (Snake guard, *Solanum* spp (local breed), Pumpkin, Cowpea etc. and under progress paddy) and their yields estimated accordingly. The site-specific on-farm trials – appropriation of suitable plantation geometry and tree – crop association studies are under progress.

Application of Organic fertilizer: Scientific Approach

Rain Water Harvesting for Irrigation Purpose at Trial Site

Bamboo Check Gate for Soil Conservation

Jhum Produce Participatory Approach

Quality and Yield Improvement in Agroforestry Based Food Product under Integrated Nutrient Management

Several soil samples have been collected from different agro-climatic zone of Assam (Total 9 places) with plant samples like Lady's finger, Bitter gourd, Cucumber, Spine gourd etc. for iodine estimation. Field trail for iodine bio-fortification in bamboo based agro-forestry crops (Lady's finger & Radish) has been established in Satra, Jorhat while two Arecanut based agro-forestry trial site in Dharapur (Kamrup district) and Khanikor gaon, Sarupathar (Golaghat district) also established. The Chemical treatment of KIO_3 & KI (1,2,3,4,5 mg/kg) has been done on the vegetables as foliar and soil. Simultaneously, a pot experiment has also been established in RFRI on spinach plant. The analysis of pot experiment is under progress. The Iodine content of some collected vegetables and soil samples have been analyzed. The physico-chemical properties of soil samples like moisture content, Organic carbon, pH have also been analyzed. Comparing the control, the Iodine value of Lady's finger has increased after treatment of 3,4,5 ppm but it was not significant in case of 1 and 2 ppm. When the vegetable was treated with KIO_3, the value of Iodine increased as compared to the value of KI. Both the soil and foliar application, the Iodine value varied.

Trial Field at Dharapur, (Kamrup District)

Trial of Rabi Crops (Raddish) at Satra, Jorhat

Development of Economically Viable and Integrated Agroforestry Models for Arid Region

Agroforestry model was maintained at farmer's field at village Harsh, Bilara, District - Jodhpur. *Sesbania aculeata* (Dhaincha) was grown during the year in the field for green manuring. Survival, growth and biomass production data were recorded, compiled and analysed. Performance of *Cordia mixa* was found the best out of horticultural species and *Prosopis cineraria* of silvicultural species.

Ailanthus excelsa plants attained maximum height (318 cm), followed by *Colophospermum mopane* (293 cm), *P. cineraria* (256 cm) and *Cordia mixa* (251 cm), whereas, *Z. mauritiana* attained minimum height (184 cm). Similarly, collar diameter was found maximum in *A. excelsa* (10.86 cm), followed by *C. mixa* (8.39 cm), *C. mopane* (7.22 cm) and *P. cineraria* (6.54 cm). The plant height and collar diameter of *C. mopane* and *P. cineraria* and height of *Ailanthus excelsa* and *Cordia mixa* were significantly ($P < 0.05$) higher in agroforestry plots as compared to the control (without crop). Wheat crop could not be grown by farmers due to lack of irrigation water at site.

One tree of the each species in agroforestry and control plots were felled and uprooted for biomass and root study at the age of six years. *P. cineraria* tree exhibited highest total dry biomass (14.018 kg per tree),

followed by *C. mopane* (13.277 kg per tree), *A. excelsa* (11.378 kg per tree) and *C. mixa* (7.114 kg per tree in the agroforestry plot. The lowest biomass production was obtained in *Z. mauritiana* (2.067 kg per tree), in the agroforestry plot. The total biomass was reduced by 51%, 78%, 91%, 52% and 64% in *P. cineraria, C. mopane, A. excelsa, Z. mauritiana* and *C. mixa*, respectively in control plots as compared to agroforestry plots. Fodder production (leaf dry biomass) was highest in *C. mopane* (3.046 kg per tree), followed by *P. cineraria* (1.077 kg per tree) and *A. excelsa* (1.038 kg per tree) in agroforestry plots, whereas, fodder production of these species in control plots was reduced.

Root dry biomass was highest in *C. mopane* (3.875 kg per tree) and lowest in *Z. mauritiana* (0.957 kg per tree) in agroforestry plot. Root biomass was less in control plot of each species as compared to agroforestry plots. The primary and secondary roots of *P. cineraria,* penetrated vertically deep in soil. In *P. cineraria* an interesting and prominent feature was that secondary roots were initiated below 50 cm depth as compared with just below the soil surface in other species. The primary and secondary root of *A. excelsa and Z. mauritiana* extended in umbrella shape, whereas, roots of *C. mixa* and *C. mopane* expanded on the long distance around each direction below the soil surface of 25 cm in agroforestry plots as well as control plots. Large variation in rooting depth was observed in various species.

Identification of Extent of Forest Lands in Forest Fringe Villages (Funded by NRAA)

This NRAA funded project started in the month of October, 2011 with the objective of Socio-economic survey and ecological studies in forest fringe villages situated within 1 km range of forest. Complete survey work was to be carried out in 24 districts of Rajasthan and Gujarat (12 + 12) and in each district, 61villages and within each village, 12 households were to be surveyed. To carry out this survey work, a question-naire was made and printed. Tours for survey work

Forest Near Khachan Village in KotraTehsil, Udaipur

Dob Village in Jhadol Tehsil Central Udaipur

Bitta Village in Jhadol Tehsil

Khachan Village in Kotra Tehsil

Boslathi Village in KherwaraTehsil

Socio-economic Survey and Vegetation Studies in Udaipur District of Rajasthan

started in January, 2012 and 61villages of Udaipur district and 14 villages of Pali district were surveyed. For the selection of household in a village, three different categories were made; affluent, medium affluent and non-affluent on the basis of income of family, number of livestock, agriculture land holding, type of house etc. and from each category household were surveyed in a fixed ratio and for vegetation study, three different sizes of square plots (31.62×31.62m, 3×3m, 1×1m) were laid out in forest. Its GPS location were noted and observation on trees, shrubs, and sapling and herbs and seeding were recorded. Following observations were coming from the survey work: majority of farmers have approx 0.25 ha land holding, grow wheat, maize and chick pea as major crop, source of irrigation is rainfall or well, having approx 4-5 livestock, majority of villages have primary school. Regarding ecological study mainly; *Butea monosperma, T. grandis, P. juliflora, P. sylvestris* were found whereas, among understorey plants*, Cassia tora, Euphorbia caducifolia and Zizyphus numularia* were observed commonly.

Introduction and Performance Trials of *Gmelina arborea* for Agroforestry in Lower Hills of Himachal Pradesh and Jammu & Kashmir

Procurement of seeds from five different locations was accomplished through Institute of Forest Productivity, Ranchi. Field Research Stations of the Institute at Johron (Paonta Sahib) and Bir Palasi (Nalagarh) representing the Low Hill Zone had been used for planting stock production. After field survey, four sites in lower hill zone at Puruwala and Kot in HP and Nudh and Basanterbella in J&K measuring, 0.5 ha each had been identified and experimental trials, following RBD design with three replications were established. Preliminary growth data indicated that the *G. arborea* was performing well on all the study sites.

Though quite early to predict, yet *G. arborea* may be a future planting species for the lower hills keeping in view its short rotation period.

Keeping this important factor in view, two trainings cum demonstration programme on, "Nursery and Plantation techniques of *Gmelina arborea*" for the ultimate benefit of front line staff of the State Forest Department, farmers, Mahila Mandals, members of VFDCs etc were organized at Sambha in district Kathua (J&K) and at Kayarda in district Sirmour of Himachal Pradesh.

Enhancement of Soil Carbon and Nitrogen Sequestration Potential of Mined/Overburden Soils in Jharkhand through Management Practices

Two coal mine overburden sites, viz., Khilaris Coal mines (CCL, Ranchi) and Sikini Coal Mines (owned by private licensee) were selected for the study. Nursery established for seedlings production for planting at overburdens.

Soil samples were collected from the overburden soils and physio-chemical properties were analysed. Pot trial experiment is in progress with four tree species in the Khilari overburden soil, which is reclaimed by vermicompost and green manuring. As bulk density of the overburden soil is high, 50% of sand was added to the overburden soils. Performance of species with respect to germination and growth are being recorded.

Introduction of Selected Genotypes of Karanj, Kusum and Bamboo as Tree Components in Agroforestry Models in Lateritic Belt of Eastern India

Two-years old seedlings of Karanj and Kusum were used for tree plantation. Seedlings of Kusum & Karanj were planted at Lalgutwa and Mandar, respectively in the month of May. Seven-year old plantation of bamboo was selected for agroforestry at Mandar. Five agricultural crops viz., ginger, turmeric, colocasia, black gram & ragi were sown/ transplanted under three tree components from May to July. Analysis of soil samples is in progress.

2.2.4 Forest Soils & Land Reclamation

Bioremediation of Bauxite Residue through BGA/ bio-inoculants

Bioremediation is a low cost and environmental friendly technique which uses plants and microbes to clean up moderately contaminated areas and problematic soil. Bauxite residue (Red mud) is an industrial waste by-product of Aluminium industry. Under this project, HINDALCO was visited for surveying the Red Mud Production. Red Mud is being produced as by - product during the Alumina extraction through Bayer Process. HINDALCO dumps red mud after drying process called dry stacking of Red Mud in nearby area close to the forest. Red Mud Samples were collected from HINDALCO and analyzed. Effect of bioinnoculant in the bioremediation of red mud has been studied. Promising cyanobacterial species were identified for bioremediation of Red Mud. The effect of these promising cyanobacterial species in combination with other bioinoculant amendments was also studied. The effect of these combinations on the growth performance of selected plant species has been studied in pot experiment and suitable species were identified as per their growth performance on Red Mud medium, amended with promising cyanobacterial species and other bioinoculants. A field trial of seedlings of selected species inoculated with promising cyanobacteria and bioinoculants was established at artificial Red Mud pond at Research Nursery, Padilla, Allahabad and performance was recorded. Methodology for bioremediation of Red Mud pond was developed. The developed methodology may be used to solve the ever increasing environmental problems related to Red Mud storage and disposal and facilitate the revegetation of red mud ponds as well.

Phytoremediation of Water Logged Waste Land through Biodrainage and Soil Amendments

Irrigation potential has been increased in recent years for the increased and sustained yield of agricultural products. The introduction of canal

irrigation has caused a rise in ground water table leading to water logging and secondary salinisation. Presently, about one-third of the world's irrigated area is facing the threat of water-logging. About 4981.43 sq Km area in Uttar Pradesh is suffering from water-logging resulting in reduced productivity. The present study is aimed to phytoremediate the waterlogged/ high water table area through plantation of Biodrainage Species. Water logged site of eastern U.P. has been surveyed and nursery of selected species viz. *Acacia nilotica, Terminalia arjuna, Syzygium cuminii, Eucalyptus sp.* and *Trewia nudiflora* has been raised. Maintenance and management of the nursery carried out. Survey and selection of suitable waterlogged site near Sharda Sahayak Khand canal side for experimental trial and SWOT analysis was done at the selected site. Suitable observation wells near selected waterlogged sites were selected and marked for monitoring of water table. Regular monitoring of water table in observation well was done. Collection of soil samples of selected site was also done for analysis. Soil analysis is in progress along with preparation for establishment of experimental trial at selected site.

Relative Effect of Geology, Vegetation and Climate on soil Formation of Uttarakhand

Uttarakhand forest of North Western Himalaya is a confluence of all the rock formations resulting in different soil and vegetation types on different climatic zones. The importance of geology in forestry research is of great significance in evaluating the soil fertility status and in managing the soil for greater production.

Surveyed the area and collected the soil and rocks samples from Dehradun, Tehri Garhwal, Pauri Garhwal, Uttarkashi, Chamoli, Rudraprayag and Nainatal districts of Uttarakhand under different natural forests. The soils are generally acidic to neutral in nature with pH increasing with depth. It has been observed that *Spruce/Fir* flourishes very well on schist, gneiss, phyllite and slate under mountain soils and brown hill soils. *Cedrus deodara* grows very well on

limestone, dolomite, quartzite, slate, schist and phyllite under forest brown hill soil group. *Quercus leucotrichophora* grows very well on limestone, slate, shale, quartzite and phyllite.

The major soil groups found in these locations are sub montane and brown hill soil occurring on different parent material. It has been observed that *Pinus roxburghii* flourishes very well on limestone, dolomite, quartzite, shale and slate. The major soil groups found in these locations are forest brown hill soil. It has been observed that *Shorea robusta* flourishes well on limestone, dolomite, sandstone conglomerates and shale and the major soil group found in these locations are brown hill soil. Miscellaneous forest grows well on limestone, shale, slate, quartzite parent material and soil group found in these locations under these species are brown hill soil and skeletal soil.

Present study indicated that relief and age acting on geology govern the existing soil, whereas, effect of altitude and climate on geology gives rise to natural vegetation. Climate and aspect on a particular site has given rise to existing floristic composition and also different pedogenic processes active at any site. Project completion report is under preparation.

Soil Organic Carbon Store under Different Land Uses in Haryana

Intergovernmental Panel on Climate Change has recognized soil organic carbon pool as one of the five major carbon pools for LULUCF sector. It is mandatory to all nations to provide soil organic carbon stock and changes in the stock of their forests in LULUCF sector under Nation Communications to the UNFCCC.

No systematic study has been undertaken to estimate the soil organic carbon in Haryana by following uniform methodology for field and laboratory work as per IPCC. This project will generate the authentic and scientific information on the assessment of soil organic carbon stock under different land uses in Haryana and which will serve as benchmark information for the future investigations to

ascertain the changes over a period of time on this very important aspect of climate change.

During this year, field work in Jind, Fatehabad, Sirsa, Kaithal, Kurukshetra, Karnal, Panipat and Yamunanagar district of Haryana was carried out. Sites were selected in different forest ranges in forest divisions of above said districts and in different blocks and collected soil samples. Selected the sites at different locations in all the above districts and soil samples were also collected from other various land uses *i.e.* block plantations, horticulture and agroforestry. Overall, 1246 soil samples were collected which include 378 samples from forests, 336 samples from block plantations, 280 samples from horticulture land use and 252 samples from different models of agroforestry.

All the collected soil samples were processed in laboratory for carbon, bulk density and coarse fragment and analysed for soil organic carbon during this period. Estimation of bulk density and coarse fragment were completed in all collected samples. In this project, up to field work in Bhiwani, Fatehabad, Jhajjar, Jind, Kaithal, Kurukshetra, Mahendragarh, Rohtak, Sirsa, Karnal and Yamunanagar districts of Haryana, has been completed.

Assessment of Soil Quality Indicators for Different Forest Stands in Uttarkashi District

Soil quality assessment is invaluable in determining the sustainability of soil management practices. It identifies problem areas and assesses differences between management systems and is valuable to measure the sustainability of land and soil management systems at present and in the future. Maintenance and improvement of soil quality is also a prime concern.

The study will provide information on the distribution of nutrient status, organic carbon content, soil physical and chemical properties. Poor sites will be identified which will help the local people as well as scientific researchers in identifying the new sites for plantation development. Soil quality index may be

inferred from various soil indices derived from physical, chemical or biological attributes that reflect its condition and response.

Literature has been collected on the relevant subject for the project. Reconnaissance survey of the study site has been made. Visit to Naugaon, Barkot, Radi, Silkyara, Hanuman Chatti, Janki Chatti, Uttarkashi and Yamunotri (Upper Yamuna and Uttarkashi Forest Division), Uttarkashi district made and soil samples collected from Chir, Oak, Deodar & Spruce and Fir forest stands from three sampling points at pre determined depth i.e. 0-15, 15-30, 30-60, 60-90 and 90-120 cm with the help of auger. Soil samples collected from the field were prepared being analyzed for different physical and chemical attributes.

Assessment of Soil Microbial Community and Soil Quality under Poplar and Eucalyptus Plantations in Haryana

Government of Haryana has framed its own forest policy in 2006.The policy has fixed the goal of achieving 10% forest and tree cover by 2010 and eventually 20% in the State. The indiscriminate use of water, fertilizer and pesticides over the years led to soil and environmental degradation and affected yield sustainability. Microorganisms play an important role in nutritional chains that are an important part of the biological balance in the life on our planet. Soil bacteria remain in constant dynamic state in soil and their community structure is greatly influenced by the change in climate, physico-chemical and biological factors.

Over-use of chemical fertilizers and pesticides have adverse effects on soil organisms that are similar to over-using antibiotics, with continued use, resistant organisms developed, and other organisms that compete with the disease-causing organisms are lost. The present study will help to assess the change in activity of soil microbial health (bacteria and fungi) with the application of fertilizer and biofertilizer (if any) in

poplar and eucalyptus plantations. Soil quality under fertilizer treated plots and biofertilizer treated plots will be assessed. This study will lead to characterize and identify various types of bacterial and fungal species which have growth promotory or inhibitory effect on poplar and eucalyptus plantations.

Survey of the area in Haryana where poplar and eucalyptus plantation were present adjacently, was done. Samples were collected from various villages like Kheda Powerhouse, Manakpur farms, Sug, Jaroda, Harnoli, Panjanto, Issupur, Narangabad of Yamunanagar and Kurukshetra district of Haryana. Soil samples so far collected are being analysed in the laboratory.

Ecology and Species Recovery Studies in Tsunami Impacted Mangroves of Andaman Islands

Conducted survey in mangrove areas affected due to Tsunami in South Andaman, Baratang, Middle and North Andamans. The affected areas were classified as heavily, moderately and least damaged based on Stratified random sampling. A total of 12 sample plots of 2 ha each have been selected in North Andaman, Middle Andaman, Baratang and South Andaman. The vegetation survey in adjoining mangrove areas have been undertaken. Species composition, abundance and size of mangrove stands, have been documented. Life history traits such as patterns of reproduction, propagule distribution and successful seedling establishment are being documented. Mangrove nurseries have been established in two locations. The following mangroves have been recorded during the survey. *Acanthus ebracteatus, Acanthus ilicifolius, Aegialitis rotundifolia, Acrostichum aureum, Acrostichum speciosum, Aegiceras corniculatum, Avicennia marina, Avicennia officinalis, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera parviflora, Ceriops tagal, Cynometra iripa, Excoecaria agallocha, Heritiera littoralis, Lumnitzera racemosa, Lumnitzera littorea, Nypa fruticans, Pemphis acidula, Phoenix paludosa, Rhizophora mucronata, Rhizophora stylosa, Rhizophora apiculata,* *Rhizophora hybrid, Sonneraria apetala, Sonneratia caseolaris, Sonneratia griffithii, Scyphiphora hydrophyllacea, Sonneratia alba, Sonneratia ovata, Xylocarpus granatum* and *Xylocarpus mekongensis.* *Sonneratia ovata* is a threatened mangrove species as per IUCN.

Identification of Suitable Tree Species and other vegetation for bio-drainage in Bargi command area

The study was conducted with the objective to drain out excess water of the soil in water logged/canal seepage areas through vegetative means and to enhance the site productivity along the left bank canal of Bargi command area, Jabalpur. The study has been concluded and final draft report has been submitted to the funding agency. Following conclusions can be drawn from the study :

In the experiments simulated in lysimeters, most of the selected species performed better under water logged conditions as compared to control, which could be due to their high water requirement. *Eucalyptus* hybrid, *Pongamia pinnata, Albizia procera* and *Terminalia arjuna* exhibited their maximum growth values under 0-0.25m water regime.

Maximum water use on per day basis was found in *Eucalyptus* hybrid, followed by *Pongamia pinnata* under different depths of water logging in lysimeters. Water use by the species decreased with increase in depth of water logging, which could be due to more surface area of roots in contact with soil water. Significant monthly variation in water use was observed in the species under test, which was directly related to the climatic conditions.

The transpiration rate was found maximum in *E. hybrid*, followed by *P. pinnata* and *T. arjuna*. The results showed that with the increase in water logging, transpiration rate increased in all seven species. Peak transpiration was observed at 12 hour during the period for most of the species, but for some species the peak period shifted to 11 hour or 13 hour.

Eucalyptus hybrid, followed by *P. pinnata* and *T. arjuna* was found to have significant effect on lowering down the water table in the canal command area. Monthly variation in water table due to tree plantations was found directly related to temperature, humidity and rainfall. Depth of water table, in plantations of all the tree species gradually increased from January to mid June, with the increase in maximum and minimum temperature. After this period, water table suddenly increased due to decrease in temperature and onset of rainfall in the second half of June. In July, August and September the water table continued increasing in all the plantations due to high

Plantations of different tree species raised along left bank canal of Bargi command area

rainfall. Maximum decline in water table in *E.* hybrid plantation was observed at 14:00 – 16:00 hours in summer.

Integrated Nutrient Management for Improved growth of Trees on Overburden Dumps

Survey was conducted in Kanhan region of Western Coal Fields Limited, Junnardeo and Pench area of Western Coal Fields Limited, Shivpuri area, for selection of coal mine overburden site for laying out experiment. Shivpuri open cast coalmine at Haranbhata has been selected for taking up the experiment. Overburden samples were collected from the selected site and the samples were analyzed for its physico-chemical properties *viz*, texture, bulk density, pH, EC, organic carbon, available N. P. K. Cation Exchange Capacity, exchangeable Ca, Mg, available micronutrients viz. iron, manganese, zinc and copper. Plantation has been done with ten species. Initial reading recorded and overburden dump samples analyzed. Further work is in progress.

Rehabilitation of Jhum Land through Potential Bamboo Species with Reference to Carbon Sequestration and Livelihood Development

Bambusa balcooa (Bhaluka), *Bambusa nutans* (Mokal) and *Oxytenanthera parviflora* (Hill Jati) raised from both rhizome and seedling following standard statistical design in the experimental plots at Johnar Sinar Village (Silonjan) and Jilangso village (Kohora) Karbi Anglong, Assam were properly maintained. Survival data were recorded and gap filling was done by replanting the seedlings as per layout. Progressive growth rate of 22 months old bamboos showed maximum length and GBH in *B. balcooa* followed by *O. parviflora* and *B. nutans* in both sites. Above ground and below ground biomass of three species were recorded and observed same trend as in growth. Composite soil samples were collected randomly from the experimental sites and estimated for Organic Carbon, bulk density and pH. Percentage of both plant carbon

and OC in soil showed comparatively high value in *B. balcooa* followed by *B nutans* and *O. parviflora*.

Plantation of Rhizome in 7x7 plot

Jilangso (Kohra) Experimental Plot

Recording Growth Data in Bamboo Trial

Enhancing Productivity of Saline Wastelands in Kachchh- through Improved Tree Planting Techniques and Silvipastoral Study (Gujarat SFD sponsored project)

Sub Project-A: improved tree planting techniques

The Little Rann (5,300 sq km/2,045 sq mile) of Kachchh is a flat, saline waste land having extensive saline mudflats and lies in the hinterland of the Kathiawar Peninsula, between the gulfs of kachchh and Khambat in Gujarat. Much of the Little Rann is a wild ass sanctuary (WAS). *Prosopis juliflora* has invaded areas of WAS. Research trials were laid in July, 2007 to find out suitable exotic and indigenous fodder plant species with appropriate planting practice.

Research trials were laid with *Acacia ampliceps, Acacia bivenosa* (exotic) and S*alvadora persica* (indigenous) on black highly saline silty clay (medium), soil depth: 40-75 cm at Kordha, Sami Range in Patan, Gujarat. Trials of *Acacia ampliceps* and *A. bivenosa* were laid with control, Wheat Husk (1/2 kg) , FYM (5kg) , WH + FYM, Bajara Husk (250g) and FYM + BH treatments. *A. ampliceps*, called the salt wattle, is a very fast growing shrub/small tree from North-Western Australia that has considerable importance as fodder on alkaline/saline soils, especially where its roots have access to a shallow brackish water table. *A. bivenosa* (two nerved wattle) makes a complex with *A. ampliceps* (salt wattle). Trial of *S. persica* was laid with control, Wheat Husk (1/2 kg) , FYM (5kg) , WH + FYM and FYM + Urea (20g). Randomised block design with three replication was followed for all the trials. Spacing was 4 m X 4 m for *A. bivenosa (12 plants/ treatment)* and *S. persica* (16 plants/treatment) and   3m x 3m for *A.ampliceps* (16 plants/ treatment).

S. persica proved to be the best plant with 83.7% mean survival after 50 months in the exremely harsh conditions of high salinity, heat stress after two consecutive summers (2009 & 2010) and one drought year (2009)   and erratic monsoon afterwards.

Treatments improved the growth; height, crown and collar diameter after 50 months. Treatment consisted of FYM + Urea was the best for maximum height 158.5 cm, crown dia 140.3 cm and collar dia 7.0 cm as compared to control 136, 118.5 and 5.6 cm for height ,crown and collar dia, respectively.

Above ground biomass study was done on the basis of the mean height, crown and collar diameter. As selection criteria, one tree was selected from each treatment for destructive sampling in all the three replications at the age of 50 months. Thus, a total of 15 trees were felled for biomass study. Above ground green biomass as 2.5 kg/tree in control to 7.1 kg/tree in T5 (FYM + urea) treatment. Although, all the treatments enhanced the biomass growth, but increment was maximum (2.5 fold) for T5, followed by 2.4 fold in T3 treatment indicating the positive influence of FYM application.
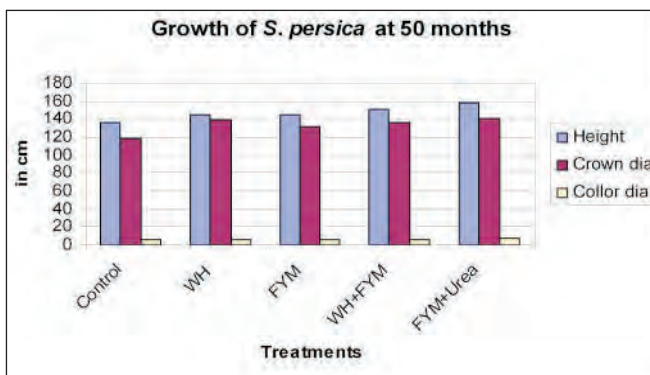
Growth Parameters (cm) of *S. persica* with Different Fertilizer Treatments at Age of 50 Months
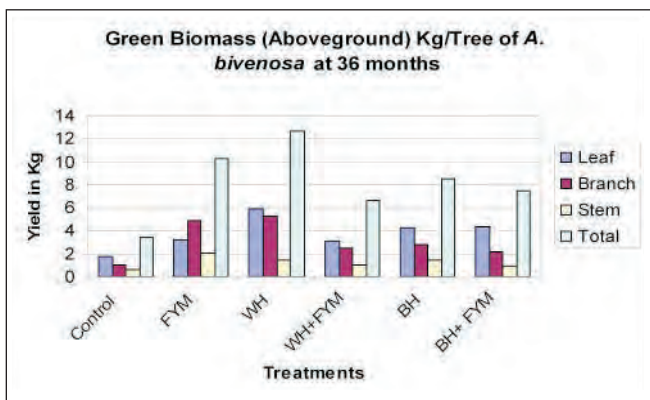
Above Ground Green Biomass Yield (gm/tree) of *A.bivenosa* at 36 Months of Age

A. bivenosa was at second place, survived in one summer and one drought year with 10.2 % decrease in mean survival, 77.3% at 30 months compared to 12 months (86.1%). However, second consecutive summer effected the species and the survival was significantly reduced (40.0%) in summer 2010 and recorded as 46.3 % at 36 months. It attained significantly high growth and biomass estimation.

Treatment influenced the biomass yield and all the treatments recorded higher biomass as compared to control (3.43 Kg). Maximum 12.68 kg biomass yield was obtained for T_3 (wheat straw) treatment, followed by 10.22 kg for T_2 (FYM) treatment. A combination of FYM and wheat straw did not yield much.

Acacia ampliceps suffered the maximum damage in summer of 2009 and after the second successive hot summer, mean survival was further reduced to only 12.7% ranging from 6.0% in control to 18.7% in T3 (wheat husk) in different treatment and, thus, survival of *A. ampliceps* was poor. However, some of the surviving trees attained good growth. Based on average growth (height and crown diameter) one tree per treatment was cut and aboveground green biomass was estimated in field, it was ranging from 5.5 kg to 13.01 kg per tree in different treatments.

Results indicate that all the three plant species have the potential to revegetate the bare salt affected soils. They maintain good survival, attained significantly higher growth than sandy soils. Management practices enhanced the growth of all the three species under arid conditions on black soils. *A. ampliceps* and *A. bivenosa* flowered and produced viable seeds within a year, while on sandy soil, they took three to five years. *S. persica* also flowered and produced fruits in second year. Plantation activities have improved the soil conditions and reduction in pH and EC and improvement in percent SOC inside the plantation area. Weed biomass estimated every year indicated that

rainfall influenced the number of species and in high rainfall year, even glycophytes appeared in significant number.

Thus, it can be concluded that *S. persica* is the best plant with maximum survival, but due to halophytic nature, its fodder acceptability is less. However, *A.ampliceps* and *A. bivenosa* can be introduced in Wild Ass sanctuary and with management practices which will enhance fodder yield.

Sub Project B : Silvipastoral Study

Trials with four tree species, namely, *Cordia gharaf, Prosopis cineraria, Zizyphus mauritiana* and *Colophospermum mopane* and three grass species, namely; *Cenchrus ciliaris* and *C. cetigerus* were laid in RBD in three replication at Mochirai, Bhuj in July, 2006. The area was undulating, and soils were loamy sand textured. Soil pH and EC was 7.3 to 7.5 and 0.49 to 0.89 dSm^{-1} for 0-25, 25-50 50-75 cm soil layers, respectively. Organic carbon in 0-25 cm, 25-50 and 50-75 cm soil layer was 0.34, 39 and 0.36 %, respectively. Area is hilly pediment. Soil depth is less and an underlying rocky impermeable calcium carbonate layer was found at 25-75 cm depth at different places. Area was deep ploughed in summer to facilitate moisture conservation. In summer, temperature goes up to 47° C and in winter around 4°C. The rainfall during the experimental period was 596 mm in 2006, 663 mm in 2007, 247 mm in 2008, 419 mm in 2009, 896 mm in 2010 and 742 mm in 2011.

Cenchrus setigerus based Silvipastoral trial

In this experiment, *C. setigerus seed* was sown manually at high seed rate 8-10 kg /ha (very dense) where soil depth was medium 40 -75 cm. After 64 months, the mean survival was 96.3%, for control and 90.6% with grass treatment. Although, control trees recorded higher mean percent survival than control throughout the study period, however, the difference was not significant. Species wise, all the species recorded more than 90% survival, *Cordia gharaf* recorded maximum 96.3% survival, followed by

Z. mauritiana (93.5%) and *P. cineraria* (91.6%). Survival of *C. mopane* was less than 50%.

In this experiment, initially *C. gharaf* was the best performing species, but after 52 months, *Z. mauritiana* took over in height and crown diameter. *P. cineraria* was at third place and *C. mopane* did not perform and discontinued from experiment. Dense grass sowing adversely influenced the growth and biomass of tree species, treatment wise, the mean height was 202.8 cm, crown diameter176.5cm and collar diameter 7.1 cm for control as compared to 162.3 cm height, 153.7cm crown diameter and 5.5 cm collar diameter with grass treatment. Species wise, the mean height and crown diameter for *Z. mauritiana* was 237.5 cm & 210.9, followed by *C. gharaf* 208.4 & 197.9 cm and *P. cineraria* 102.0 cm & 86.5 cm respectively at 64 months of age.

Effect of grass growth was more adverse on collar girth and control trees (without grass) attained 30.7% more collar girth (7.15cm) as compared to grass treatment (5.47cm). Species difference continued to be highly significant (p-0.00) and now with 9.67cm mean collar diameter, C. *gharaf* attained 1.89 and 2.42 times more collar dia as compared to Z. *mauritiana* (5.3cm) and *P. cineraria* (4.0cm), respectively.

Biomass

Based on mean height and crown diameter, component wise above ground biomass estimation was done for *Z. mauritiana* and *C. gharaf* in control and with grass treatments at 38 months. Control trees recorded significantly higher biomass for both the species. It was 1.6 fold more for *C. gharaf* (7.5 kg) in control to 4.8 kg with grass treatments for green biomass. For *Z. Mauritiana,* the yield was 2.5 fold high (4.0kg to 1.9kg). Same trend continued in dry mass, where *C. gharaf* recorded 1.7 and *Z. mauritiana* 2.3 times more in control trees. Green biomass of *P. cineraria* was estimated at 64 months and it was 4.28 kg /plant in control treatment as compared to 2.27 kg/plant in with grass treatment.

Cenchrus ciliaris based Silvipastoral trial

In this experiment, grass sowing was done at low seed rate (1.0 m strip at a distance of 3 m), where soil depth was shallow 25-40 cm only. Survival at 64 months for control treatment was 87.6% , while with grass it recorded 97.5%. There was no change between 52-64 months growth period. Contrary to *C. setigerus,* mean percent survival with grass was higher in case of *C.ciliaris* as compared to control trees throughout the study period however, the difference was not significant.

At 64 months, both control and with grass treatment, same mean height recorded (173.8 cm), which is less than mean height at 52 months. Between 52 to 64 months, many *Z. mauritiana* trees fell down due to poor root development, failing to support the tree in shallow soil depth, resulting in 7.1% decrease of mean height (from 225.2 to 209.2 cm) indicating that in shallow soil depth, pruning should be done to maintain the plants in shrubby form. Height difference among species was significantly different, but it was due to very less height for *P. cineraria* (58.1 cm). the difference between *C. gharaf (257.2 cm)* and *Z. mauritiana*(209.1 cm) was also significant at this stage. Same is the trend for crown diameter.

Biomass was estimated at 38 months. Green biomass yield was 4.5 to 5.3kg/tree for *Z. mauritiana* and 8.0 to 8.6 kg/tree and1.76 to 1.89 kg/tree for *C. gharaf* with grass and control treatments respecitively, suggesting that at low seed rate*,* grass sowing promote tree growth. Here, *P. cineraria* did not attain enough growth to estimate biomass.

Thus, it can be concluded that in shallow soil*,* grass sowing in scattered manner promotes tree growth due to better moisture availability but dense grass sowing adversely affect the tree growth. *C. gharaf : C. ciliaris* was the best silvipastoral system, followed by *Z. mauritiana: C. ciliaris*. Growth of *P. cineraria* was slow in medium soil and poor in shallow soil. *C. mopane* did not survive due to site conditions.

Among grass species, *C. cilaris* was the best, closely followed by *C. setigerus*. *D. annulatum* took time for establishment, but spreads fast after establishment. Rainfall influenced the grass yield and in a well distributed monsoon year, *C.ciliaris* recorded 1.94 kg/m^2 yield, followed by *C. setigerus* 1.51 kg/m^2.

Identification of Soil-vegetation Relations and Indicator Species for Assessment and Rehabilitation in Lower Aravalli of Rajasthan

A study was carried out at five different locations with varying rainfall of 988 mm, 961 mm, 950 mm, 568mm and 424 mm in Banaskantaha (Trisulia), Motimori (Sabarkantha), Banaswara (Bara Nandra kho), Rajasmand (Sabalia) and Pali (Borvad forest block), respectively (i) to study on physical properties and nutrient status of soil derived from different parent material, and (ii) to study on vegetation structure and indicator species on dominant soil types. Based on IVI values, these sites were dominated by *Wrightia tinctoria*, *Tectona grandis*, *Lanea coromadelica* and *Anogeissus pendula* tree species, respectively. Among the shrubs, *Nyctanthes arbor-tristis* at first two sites of Gujarat, whereas, *Lantana camara* was dominated at Banswara, *Rhus mysorensis* at Rajasamand and *Euphorbia caudicifloia* at Pali sites. Among herbs and grasses, *H. suaveolense*, *A. lanceolatus*, *Aristida mutabilis* and *Apluda mutica* dominated the respective site. Total numbers of species (tree, shrubs, herbs and grasses) were 85, 100, 109, 95 and 87 numbers at the sites in Banaskantha, Sabarkantha, Banswara, Rajasamand and Pali, respectively in 2011. Height of the herbaceous vegetation was in the order of Rajsamand > Sendra > Banswara > Sabarkantha > Banaskantha, where number of herbaceous species were 8.6, 8.4, 9.9, 18.2 and 10.1 number, respectively. Production of herbaceous biomass was highest at Sabalia site of Rajasamand and the lowest at Pali site. The order of sites in terms of herbaceous biomass production was Rajsamand > Banswara > Sabarkantha > Pali > Banaskantha. Soil water content (SWC) was lowest at Pali site throughout the year. SWC

Observation Recording on Vegetation in Sabalia Forest Block
in Rajasamand

Vegetation Growth in Baranandra Kho Forest Block
in Banswara

Vegetation Growth in Motimori Forest Block in Sabarkantha

Vegetation Growth in Borwav Forest Block in Pali

was highest at Banswara in June, 2011 and February, 2012 and at Sabarkantha site in October, 2011. In October, 2011, soil pH was lowest at Sabarkantha and was associated with the lowest electrical conductivity, NO_3-N and highest SWC, number of species and their populations. Concentration of NH_4-N was highest at Trisulia forest in Banaskantha, whereas, it was lowest in Motimori Forest in Sabarkantha Division. The highest NO_3-N concentration at

Rajsamand was related to lowest number of species and highest quantity of herbaceous biomass.

Characterization and Classification of Forest Soils of Rajasthan

The project was initiated in September, 2007 with the objective to characterize and classify forest soils of Rajasthan following the USDA classification system. During the reporting period, soil and vegetation survey was conducted in Bundi, Jhalawar, Kota, Karauli, Swai

Very Deep Soil at Taranagar Range, Churu
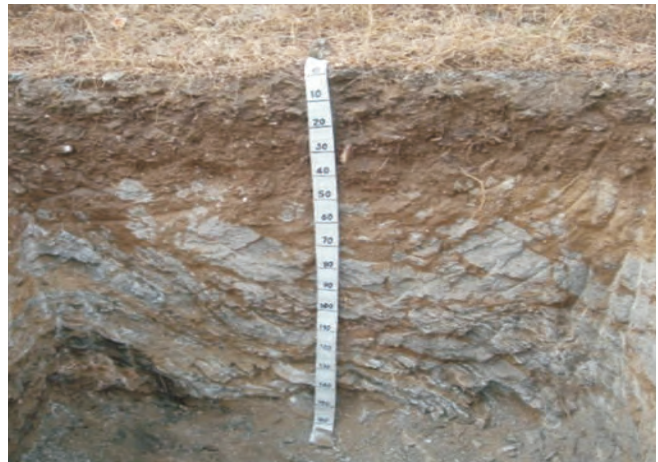
Shallow Gravelly Soil at Kurabad, Udaipur

Prosopis juliflora in Bandra Forest Block, Barmer Having High CaCO$_3$ Content in Deeper Soil Layer (380mg kg)

GIS Lab

Madhopur, Udaipur, Churu and Jodhpur districts. 146 soil profiles in 146 forest blocks were studied and field observations recorded on vegetation status, regeneration, litter, aspect, drainage, soil structure, consistency and colour. Physico-chemical characterization of the soils has been done in the field as well as in laboratory. Soil samples were collected and analysed for soil texture, structure, consistency, colour, pH, electrical conductivity, organic carbon, NO$_3$ and NH$_4$ – nitrogen and phosphorus.

Soils were moderately deep to very deep at most of the sites in Jodhpur, however, 30% sites have shallow soil with calcareous hard pan. Soils in Churu district are deep to very deep in nature with sandy texture. In Udaipur, soil depth varied from 60 to 180 cm in different blocks. Colour of soils showed a wide range of variation too. Whereas, most of the soils were dark brown to brown in colour, at some places soils were pink and yellowish red in Udaipur. Soils were mostly gravelly. Only 10% soil samples had < 20% gravels. Among the soils tested, soils of Barmer district have high CaCO$_3$ (380 mg kg^{-1} at Bandra forest block).

Carbon Stock and Soil Classification Mapping for Rajasthan Forests

The project was initiated in November, 2011 with the aim to develop digitized maps of forest carbon stock, forest soil types and soil nutrient status for Rajasthan and to determine relationships (if any) between *in-situ* biomass density, soil parameters and remote sensing characteristics. GIS laboratory has also been fabricated using one-time grant.