

Forest and Climate Change



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Climate change has multi-faceted implication and therefore, addressing the related issues requires sound scientific understanding of the subject. Research on climate change is inter-disciplinary as well as multi- disciplinary in view of the larger impacts of the climate change on all the aspects of forest ecosystems. Thus, there is a need for an integrated approach to study the problem cutting across disciplines of physical, biological and social sciences. ICFRE and its institutes have initiated various field studies under the theme 'Forest and Climate Change' covering various aspects of forests and climate change including mitigation and adaptation in the forestry sector.

The details of research projects are mentioned below:



AICP on Elevated CO₂ (FRI)

Open Top chamber facility at FRI (controlled and automated) was established in year 2013-2014. The primary focus of the study was to investigate the impacts of changing climatic conditions on growth and productivity of important agro-forestry species and their adaptive behaviour to elevated CO₂ concentration and temperature. The parameters related to growth and morphology of clones such as stem height, stem diameter, number of leaves and branches were measured. The productivity in terms of biomass production was found to be enhanced under elevated CO₂ and temperature conditions. Water use efficiency also enhanced under elevated CO₂ condition as a results of reduced stomatal conductance leading to decline in loss of water through the process of transpiration.

The maximum biomass under elevated CO₂ (800 ppm) was recorded for *Eucalyptus citriodora* [(Safeda) Seedling - F2 progeny] whereas minimum for *Populus deltoides* [(Poplar) Clone – G48] followed by *Eucalyptus* hybrid FRI-PH4 [(Safeda) Clone - FRI-PH4], *Eucalyptus tereticornis* (Seedling - F2 progeny), *Dalbergia sissoo* [(Shisham) Clone 18], *Melia dubia* [(Burma Drak) Seedling (progeny) – 64] and *Melia dubia* [Seedling (progeny) – 75]. Overall, seedlings of *Eucalyptus citriodora* was found to have higher biomass compared to efficient *Melia dubia*. Based on the above observations, the carbon dioxide sequestration clones were selected and categorized accordingly.

Benefits of the research: A “Open Top Chamber Facility” with controlled and automated environment has been established which could be used to screen and categorise the forestry species with capacity of more carbon sequestration rate and capable to grow well under changing climatic conditions. The recommendation based on carbon sequestration ability would help farmers, forest departments, national highway authority, Indian rail department and industry etc.

Assessment of soil organic carbon under different land uses in Tamil Nadu (IFGTB)

In the ongoing NFRP project on 'Assessment of soil organic carbon under different land uses in Tamil Nadu', extensive survey was undertaken in Virudhunagar, Madurai, Tirunelveli and Tuticorin districts covering the Southern Agro-climatic zone of Tamil Nadu. Soil samples (180

nos.) belonging to Padarnthapuli, Nanguneri, Vayalogam and Mayamankurichi soil series were collected from different land uses viz., Agriculture (sugarcane, maize, groundnut, cotton), Agro-forestry (Teak +maize, *Ailanthus* + maize, Neem+sorghum, Neem+Fodder sorghum and Teak + banana) and Plantation (Teak, *Casuarina*, Neem, Bamboo, *Eucalyptus*, *Melia*) for estimation of carbon stock. Soil organic carbon storage was found to be highest under agro-forestry land use and the clay + silt sized fraction (<53 µm) retained the highest amount of organic carbon at 0-30 cm soil depth in the Southern Agro-climatic zone.

Benefits of the research: This research activity will help in developing strategies on organic matter management for mitigation of gaseous-C emission and also, the best management practices for enhancing carbon status of soil.

Screening of tree species for intra-specific variation in carbon sequestration potential under elevated CO₂ (IFGTB)

On the basis of rooting ability, 33 clones of teak have been short-listed and being multiplied for studying intra-specific variation in teak for carbon sequestration potential under elevated CO₂ levels. Data on intra-specific variation in response to elevated CO₂ in *Casuarina equisetifolia* (Vilayti saru), was completed. Earlier studies conducted at IFGTB showed that there exists greater inter-specific variation in tropical tree species in response to elevated CO₂. To understand inter and intra-specific variations for carbon sequestration potential under ambient and elevated CO₂ levels, the clones of *Eucalyptus camaldulensis* (Neelgiri), *Casuarina equisetifolia* and teak selected for high productivity will be further screened for changing atmospheric CO₂ concentrations. This selection of clones adapted to elevated CO₂ levels can be used for future breeding programmes aimed at developing 'climate ready genotypes'.

Benefits of the research: The outcomes of the project will identify clones/phenotypes having positive response and higher carbon sequestration in *Casuarina*, *Eucalyptus* and Teak. ICFRE can earn revenue from production and sale of superior planting stocks for the elevated CO₂ levels.

Assessment of decay of wood in the forests and impact on methane release contributing



towards climate change (IWST)

For assessing the release of CH₄ from dead/decay trees from the tropical forests of Karnataka, the study sites were selected in different agro-climatic zones of the state involving species like, *Carallia brachiata* (Andipunar), *Dalbergia latifolia*. (Rosewood), *Terminalia* sp. (Matthi), *Tectona grandis* (Teakwood), *Dalbergia sissoo* (shisham) and *Anogeissus latifolia* (Dindiga) having age 90 years and above. Based on standardized protocol, maximum and minimum emission of CH₄ concentration was recorded and accordingly the mean CH₄ emission with respect to different species were : rosewood (Poonampet)- 1949.89 ppm, matthi (Poonampet)- 4630.36 ppm, teakwood (Dharwad)- 1561.92 ppm, shisham (Dharwad)- 3059.45 ppm, dindiga (Dharwad)- 1470 ppm, Matthi (Dharwad) - 2672.64 ppm and unidentified tree (IWST Campus)- 10717 ppm. The CH₄ concentration was estimated as 11976.73 ppm during summer and 152.84 ppm during winter in *Carallia brachiata* indicating the influence of seasonal factors. The anaerobic culturing of core wood samples and gas samples revealed that *Methanogenium* species was responsible for Methanogenesis.

Benefits of the research: Development of strategies to mitigate the gases contributing to the global warming.

Impact of forest covers change on stream flows of the Narmada River Basin using Macro-scale Hydrological Model (TFRI)

Study has been initiated to identify as well as quantify the forest patches regulating most of the sustainable flow of Narmada River using macroscale hydrological model named SWAT (Soil and Water Assessment Tool). The climatic,

soil and land-use data were procured from India Meteorological Department (IMD), Pune, NBSS&LUP, Nagpur and NRSC, Hyderabad respectively. The SWAT model was set up and basin boundary, watersheds and channels were derived using cartosat DEM v1.3. With the help of CWC and India WRIS reports all gauging sites were enlisted and discharge data for all gauging stations (till year 2011) was collected from India WRIS. Groundwater observation well data was acquired from Regional Groundwater Board, Bhopal. Soil and Water Assessment tool (SWAT) model is under implementation.

Benefits of the research: This study will quantify the hydrologic services of forests with specific focus on lean seasonal flow in Narmada river. Assessment of forest patch-wise flow will assist in objective decisions on forest diversion/environment impact assessments.

Adaptation and Mitigation Measures in Relation to Shortening of Jhum Cycle *vis-à-vis* Soil Nutrient Status and Productivity in different Traditional Systems of Nagaland (RFRI)

Observations were made on different traditional practices that are currently in use for short-term fallow jhum land restoration by tribal communities. Alder (*Alnus nepalensis*, local name: Rupo in Angami) and leguminous pulse (cover crops) based fallow management practices were found to be dominant.

Benefits of the research: Benefits of the research will pave the way for identification and adoption of the most sustainable indigenous fallow management model in other parts of Northeast India as an adaptive and mitigative measure in order to ensure food security with



Legume cover crop in fallow jhum land



Pollarded Alder trees and potato cultivation



improvement in soil fertility and minimum pressure on natural forests.



Legume cover crop in fallow jhum land



Cajanus cajan plants in the fallow Jhum land

Studies on changes in Soil Quality and Carbon Build-up under different land- use systems in Nagaland (RFRI)

More than 50 villages were surveyed and over 100 surface and sub-surface soil samples were collected from forests, jhum lands, fallow jhum, plantations and tea gardens. The soil samples were analyzed for soil organic carbon, pH, electrical conductivity (Ec), texture, bulk density, available nitrogen, available phosphorus, available potassium, cation exchangeable capacity (CEC), exchangeable calcium, magnesium, sodium and potassium. There was not much significant difference in the value of pH and EC under the studied land

uses, while the value of available N and K were significantly better under the plantation areas. The value of Soil Organic Carbon (SOC) density ($t\ ha^{-1}$) at 15 cm depth was maximum in plantation areas (63.30) followed by abandoned jhum land (54.66) and fallow jhum areas (52.75).

Benefits of the research: Application of a soil fertility index and soil evaluation factor to a forest soil monitoring programme would provide a mechanism for evaluating changes in soil properties due to various land uses, across the landscape. The information would be useful in taking policy decisions regarding land use in the region.



Soil Sample collection from different land use systems of Mon and Zunheboto districts of Nagaland



Assessment of diversity and carbon sequestration potential of above ground woody biomass of Semi-evergreen Forests in Assam (RFRI)

Estimation of biomass and carbon sequestration potential was conducted in tropical semi- evergreen forests distributed across Jorhat, Golaghat, Karbi Anglong and Sonitpur districts of Assam from randomly laid 126 quadrats of 0.1 ha area each. Aboveground (AGB) carbon in the semi-

evergreen forests was estimated at 77.36 t/ha. The total AGB carbon stock of all the tree species was estimated at 38.7 t/ ha.

Benefits of the research: The data generated will be used as benchmark to monitor further changes in AGB carbon stock due to various management practices in these forests. It will also be useful as a baseline for any afforestation/ reforestation projects that may be developed by the forest department under Clean Development Mechanism.



Field data collection for assessment of diversity & carbon sequestration potential

Assessment of Carbon Stock in Forest Types of Shimla Forest Circle, Himachal Pradesh (HFRI)

The major forest types identified in Shimla circle were viz; *Pinus roxburghii* (Chirpine), *Pinus wallichiana* (Kail), *Quercus leucotrichophora* (Ban oak), *Quercus semicarpifolia* (Mohru oak), *Cedrus deodara* (Deodar), *Abies pindrow*

(Silver fir, tosh), *Picea smithiana* (Spruce, Rai), *Alnus nitidea* (Alder), *Cupressus* sp. (Cypress) forest, Northern dry mixed deciduous forests and alpine pasture. The field study was conducted in the selected sites for the identified forest types as per standard methodology. The details of carbon stocks from the studies in Fir-Spruce forest, Cypress, Alder and Northern dry mixed deciduous forests are as below:

Parameters \ Forests	Fir- Spruce forest	Cypress forest	Alder forest	Northern dry mixed deciduous forests
Biomass production of under-storey (t/ha)	8.231	2.845	3.508	5.158
Carbon stock of under- storey (t C/ha)	3.645	1.223	1.532	2.20
Litter production (t/ha)	1.95	1.04	1.72	1.60
Carbon stock in litter (t C/ha)	0.835	0.437	0.711	0.634
Soil carbon pool (upto 45 cm depth) [t C/ha]	68.39	53.03	39.20	31.75



Kharsu Oak Forest (Rohru Division)



Silver Fir-Spruce Forest (Rohru Division)

In Deodar, Kail, Mohru and Kharsu oak forests litter production was 1.56 t/ha, 1.96 t/ha, 3.05 t/ha and 4.34 t/ha having carbon stock in litter 0.663 t C/ha, 0.842 t C/ha, 1.298 t C/ha and 1.848 t C/ha, respectively, whereas, soil carbon pool up to 45 cm depth in these forests was 88.03 t C/ha, 58.86 t C/ha, 59.20 t C/ha and 51.01 t C/ha, respectively.

Benefits of the research: In view of the prevailing Climate Change scenario, the studies will provide useful baseline database for comparison of carbon stock over a period of time across the forest types.

High Altitude Transition Zone (HATZ) in Himachal Pradesh: Long-term Study to Assess the Effect of Global Warming and Trails to Rehabilitate Degraded Site in this Zone (HFRI)

The germplasm of threatened medicinal plants collected from the HATZ for *ex-situ* conservation is being maintained in the nursery beds at the Western Himalayan Temperate Arboretum (WHTA) established at Potters Hill near Shimla. *Betula utilis* (Bhojpatra) saplings too have been out planted in the arboretum. Sowing of *Quercus baloot* (Oak), which was

done in polybags in Kinnaur, has also been planted in the arboretum.

Benefits of the research: The outcomes of the study will provide baseline data for future studies with reference to the climate change and upward movement of species growing in the transition zones.

Measurement of Vegetation and biomass parameters under Vegetation Carbon Pool Assessment (VCP) (IFB)

Identification, Inventory and recording of plant species in the plots, and documentation of voucher specimens, estimation of biomass of each plot, and creation of data base of all plots, collection of plant specimens and soil samples for analyzing carbon were performed. Data collection for 49 plots situated in all the six districts has been completed. A database has been created for all the surveyed plots.

Benefits of the research: The data generated will indicate carbon sink estimates and throw light on climate change and also soil health.