CLIMATE CHANGE & FORESTRY RESEARCH NEEDS IN HIMALAYAS

Workshop Report

Prepared by:

Climate Change & Forest Influence Division

Forest Research Institute, Dehradun

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Appendices

Acknowledgements

We express our appreciation to the two lead speakers and discussants who willingly and competently synthesized their understanding of climate change modeling and their experimental work into brief presentations for the benefit of the audience.

1. Climate Change & Forests: Status of Science & Research Gaps	*Prof. N.H. Ravindranath, Indian Institute of Science, Bangalore, India*
2. Data Needs for Climate Impact Modelling	*Ms. Indu K. Murthy Indian Institute of Science, Bangalore, India*

We thank Dr. V.K. Bahuguna, Director General, Indian Council of Forestry Research & Education, Dehradun who, in his introductory remarks, set the tone for the workshop by underlining the research priorities of the role of forest hydrology in climate change models and the need for revision of forest types to overcome the changes in forest ecosystems which have taken place in the last half a decade.

We are also thankful to Dr. S.S. Negi, Director, Forest Research Institute, Dehradun who, in his welcome address, delved on the need for logical and justifiable climate change predictions based on relevant intricate climatic factors and environmental parameters and the influence they exert not only upon each other but amongst themselves, as well.

We are also thankful to all the participants who contributed their thoughts and ideas during the workshop and were most vocal to drive their point home. The list of participants is enclosed at Appendix A.

1. Introduction

Forest sector is critical in addressing climate change and is a very contentious subject during global negotiations. To live in an inhospitable environment for an endless period, is a situation which no right thinking person is likely to cherish. The changing land use pattern, rise in concentration of Green House Gases (GHGs) in the atmosphere, manifold increase of pollution levels from the pre-industrial limits, rapid industrialization leading to enhanced obnoxious fumes and of course unprecedented forest fragmentation and degradation have all led to fast environmental deterioration which is a major cause of concern. The gaping hole in the ozone layer over Antarctica is worrisome. This together with anthropogenic factors and our developmental needs have had a deleterious effect on our environment.

The forest managers at this stage can hardly afford to remain silent spectators to this catastrophe. The changing climate scenario needs immediate attention to combat the menace and come up with appropriate mitigation strategies. But the cry of the forest managers and planners for the need for a sustainable environment is often muted by the din of our development needs. Thus they have to rely on a variety of forecasting tools to drive their point home and convince the planners and decision makers of the imminent impending cataclysm.

There exists a number of process based ecological models to predict the three key elements of climate change viz. moisture, temperature and CO_2. Different models portray different pictures of future landscapes or the effect on the key climate change indicators on a business as usual scenario.

This report documents the discussion and recommendations of a two days workshop on “Climate change & forestry research needs in Himalayas” held at National Forest Library & Information Centre of Forest Research Institute, Dehradun on 24-25 Oct, 2011. The workshop was convened by Climate Change & Forest Influences Division of FRI, Dehradun to provide a forum to explore the advancements made in climate change simulation models. The goals of the workshop were:

1. To evaluate and understand different types of climate change models relevant to the Indian context.
2. To discuss the requirements of data to be collected for long term usage.
3. To identify the parameters of Plant Functional Types (PFTs) to run the climate change simulation models successfully.
4. To discuss the interdisciplinary project proposal on impacts of climate change on forests threadbare and identify the weaknesses for rectification.
5. To identify the content necessary for development of the project to study the effect of climate change on vegetation and shift in species.

As result of this workshop, we expect the forest scientists to develop a better understanding of the complex concept of climate change modeling and a comprehensive insight of the requirement of parameters relevant to the Indian context. The weaknesses of the interdisciplinary project proposed on climate change by Climate Change & Forest Influence division of FRI were discussed threadbare in which the scientists from different fields interacted and gave their views. The said project formulated to study the impacts of climate change on forest ecosystems and identify indicators of climate change included the following components each of which were discussed with their implementing team.

1. Floral distribution and Species range shifts.
2. Impact on Biogeochemical interactions
3. Phenological Studies
4. Genetic diversity and species richness
5. Insect Diversity/ abundance/ migration
6. Fungal diversity & change
7. Bio-chemical Indicators
8. Hydrological indicators & process based modeling

The remainder of this report is structured as follows:

- An overview of the workshop format.
- A summary of presentation made on climate change research gaps and models available for climate change predictions.
- A summary of presentation made on the data required to be collected for successful running of climate change prediction models.
- A summary of discussion on project proposal to study the impacts of climate change on forest ecosystems and identify indicators of climate change.
- Recommendations for incorporation of specific suggestions and corrections in the interdisciplinary project proposed on climate change.

The appendices to the report contain the list of participants with their email addresses, and the workshop technical programme.

2. Workshop Overview

Before the workshop, an all encompassing interdisciplinary project proposal to study the impacts of climate change on forest ecosystems and identify indicators of climate change was formulated by Climate Change & Forest Influence division of FRI, Dehradun. Eight components were included in the said project and sent to respective teams identified for implementing the said component.

The respective implementing teams researched on the available literature and gave their inputs as far as period wise specific objectives of the research is concerned together with work plan and tentative financial requirement. Thus these different components were improved upon after incorporating the suggestions/ discussions with their implementing teams.

Thereafter, it was felt by the project proposal developer viz. "Climate Change & Forest Influences Division" of FRI to conduct a workshop to gain direct access to the knowledge pool from Prof. N.H. Ravindranath of Indian Institute of Science, Bangalore, who not only has vast knowledge on the subject but is also an internationally acclaimed expert on climate change modeling, to find out any further weaknesses in the said interdisciplinary project proposal and improve upon it.

The workshop was structured around presentations from the two lead speakers and interactive discussion with the participants. It was followed by a detailed presentation from the project proposal developer to study the impacts of climate change on forest ecosystems and identify indicators and component wise discussion with each implementing team.

Topic of Presentation	Presenter
Climate Change & Forests: Status of Science & Research Gaps Including climate change modeling	*Prof.N.H. Ravindranath, Indian Institute of Science Bangalore, India*
Data Needs for Climate Impact Modelling	*Ms. Indu K. Murthy Indian Institute of Science, Bangalore, India*
To study the impacts of climate change on forest ecosystems and identify indicators of climate change.	Sh. M.P.Singh, Head Climate Change & Forest Influences Division, Forest Research Institute. Dehradun, India.

3. Synthesis of Discussions as per Presentations made in the workshop

3.1. Summary of presentation made on climate change research gaps and models available for climate change predictions - Prof. N.H. Ravindranath

The first presentation was made by Prof. N.H. Ravindranath, Indian Institute of Science, Bangalore on "Climate Change & Forests: Status of Science & Research Gaps". The contribution of deforestation and land use to CO_2 emissions and their ability to provide large potential to mitigate climate change was highlighted. The issues for discussion included the following, each of which were dealt separately.

1. GHG Inventory from Forestry or LULUCF sector – IPCC methods; data and models
2. Mitigation potential assessments at different levels –for land based projects
3. Impact of climate change on forest ecosystems, biodiversity and livelihoods
4. Adaptation and resilience enhancement
5. CDM and REDD+; policy and methodological issues
6. International negotiations
7. Greening India Mission
8. Research issues and priorities

The following research areas on Climate Change and Forests being dealt at IISc, Bangalore were also elaborated upon:

1. Assessment of impact of climate change and vulnerability of forest ecosystems
2. Assessment of adaptation strategies
3. GHG inventory for land-use sectors
4. Carbon stock changes and mitigation potential assessment of forest sector under climate change
5. Forest policies; A&R, CDM, Carbon stocks
6. CDM (afforestation & reforestation), REDD projects
7. Macro-economic implications of climate change impacts, vulnerability, adaptation and mitigation

The main focus of the presentation was on climate change modeling options available in India and the research opportunities on mitigation assessment potential and mitigation options and the assessment of vulnerability indicators. The need for development Plant Functional Types (PFT) in Indian context was highlighted. The salient features of the presentation by Prof. N.H. Ravindranath are given below. The details have not been included due to paucity of time and space.

Topic	Details in brief
Mitigation assessment	- CDM projects - Greening mission - CAMPA - JFM / CFM / Social Forestry / NEAB - REDD plus - IPCC assessments
Mitigation Options	• Forest Conservation – Halting or reducing Deforestation – Reducing forest degradation • Afforestation / Reforestation • Agro-forestry • Bio-energy plantations
Models for mitigation assessment	• PROCOMAP • GCOMAP • CATIE • TARAM
Global Vegetation Model:	1. BIOME 4: Equilibrium model 2. IBIS (Integrated Biosphere Simulator): dynamic global Vegetation Model 3. Working currently on LPJ & CLM models
Climate Model: GCM and RCM data from	• Hadley HadRM3 data (50x50 km^2) • In future other GCMs will be used
Criteria & Indicators for Mitigation projects	• Disturbance index: An indication of the human disturbance for a particular forest patch. More the disturbance index, higher the forest vulnerability. • Fragmentation status: An indication of how fragmented the forest patch is. More the fragmentation status, higher the forest vulnerability. • Biological richness: Indicates the species diversity of the forest patch, a measure of the number of species of flora and fauna, per unit area. Higher the biological richness, lower the forest vulnerability • Impact of climate change on carbon sinks of forests: For estimating climate change impacts, IBIS, which is a dynamic global vegetation model, was used.

<table>
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<tr><td>INPUT DATA REQUIREMENTS OF IBIS AND ITS OUTPUTS</td><td>
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<tr><td>Vulnerability Assessment – Indicators</td><td>1. Climate change impact Indicators
2. Bio-physical Indicators
3. Socio-economic Indicators</td></tr>
<tr><td>RESEARCH OPPORTUNITIES</td><td>• Assess the impact of climate change on forest ecosystems of different regions
– Shifts in boundary of forest types
– Changes in species mix and species vulnerability
– Identification/ranking of vulnerable forest regions and hot spots
– biomass production and Net Primary Productivity
• Assessment of vulnerability of forest vegetation & local communities
• Estimation of GHG / Carbon inventory – periodic
– Forest inventory and modeling
• Assess mitigation potential at different scales
• Forest area, deforestation rates, carbon costs / changes
• Policy Analysis Research/ Development & Support for Climate Negotiations</td></tr>
</table>

Topic	Details in brief
Research	• Initiate long term monitoring plots to study vegetation response to CC • Enhancing modeling capacity • Generate database for forestry CC related analysis and projects • Developing pilot adaptation project • Addressing DATA GAPS is most critical for research in the forest sector
Long-term monitoring of vegetation response to climate change parameters	Identify indicators to assess climate response – Biome types / forest / grassland/ wetland – Forest types – Species composition / dominance – Physiological and phenological indicators – Net Primary Productivity – Forest fires – Pests and diseases – Invasive species – Recruitment and mortality rates and regeneration patterns
Establish long-term monitoring plots	– Develop monitoring protocols – Periodic monitoring, data compilation, archiving, analysis and publications
Dynamic vegetation modeling for assessment of climate change impacts on vegetation	– Selection of GCM – Selection of period of assessment (2030, 2050, 2100) – Selection of DGVM – Generation of input data, including downscaled climate data – Historical and current climate parameters – Generation of climate projections – Soil and water related parameter generation
Definition of Plant Functional Types (PFTs)	– Global model generated PFTs – Indian forest-specific PFTs – Identification of physiological and phenological parameters for DGVMs – Conducting field and laboratory studies to generate parameters – Validation of DGVMs and PFTs – Computer programmes for running models

3.2. A summary of presentation made on the data required to be collected for successful running of climate change prediction models - Ms. Indu. K. Murthy

The second presentation was made by Ms. Indu K. Murthy, Indian Institute of Science, Bangalore on "Data Needs for Climate Impact Modeling". Initially it was explained why modeling was required and how the Climate Models works.

When the model is "running", each corner of every square in this grid is like a tiny weather station where the model calculates atmospheric processes. The model runs through simulated days, weeks, months, and years. Usually this is done to make climate predictions for 100 or more years into the future.

Approach to climate change impact assessment

- Decide grids
- Get past climate data
- Select specific climate model
- Select specific vegetation models
- Identify data needs required to run model

Selection of grid size - GCM /RCM

- ➢ Models work by calculating what the climate is doing (in terms of wind, temperature, humidity, etc.) at a number of discrete points on the Earth's surface and in the atmosphere/ ocean.
- ➢ These points are laid out as a grid covering the surface of the Earth, dividing it up into a lot of little boxes
- ➢ Models come in coarse and fine resolutions, like coarse and fine screens, depending on how much detail is needed.
- ➢ The finer the grid, the more detailed the resulting simulation, but also the more computing time the model requires.
- ➢ A typical global atmospheric model might have ten vertical layers and 65,000 grid points, making a total of more than half a million points.
- ➢ Regional Climate Models use a finer resolution for a limited area of the globe.

GCMs depict the climate using a three dimensional grid over the globe, typically having a horizontal resolution of between 250 and 600 km, 10 to 20 vertical layers in the atmosphere and sometimes as many as 30 layers in the oceans. Their resolution is thus quite coarse.

The major part of the presentation was devoted to data requirements for different models and the salient points are given below.

Type	Categories of Models				
	Equilibrium Vegetation Models e.g., BIOME		Dynamic Vegetation Models. e.g., IBIS, LPJ		
Features	o Assumes equilibrium conditions in both climate and terrestrial vegetation. o Predicts the distribution of potential vegetation by relating the geographic distribution of climatic parameters to the vegetation. o The equilibrium approach is implicitly large scale in nature as it ignores dynamic processes. o It generally requires far less information and provides estimates of potential magnitude of the vegetation response at regional to global scales.		o Captures the transient response of vegetation or biomes to a changing environment. o Uses explicit representation of key ecological processes such as establishment, tree growth, competition, death, nutrient cycling etc. o Dynamic models require much more information on the characteristics of species than is easily available or even known for some areas of the globe.		
	BIOME		**IBIS – Integrated BIosphere Simulator**		
	Climate data needs	**Non-climate data**	**Climate data**	**Non-climate data**	
Data Needs	• Monthly mean temperature (degree C) • Monthly mean precipitation (mm) • Monthly sunshine hours (% of maximum)	• Water holding capacity of top 30 cm of soil • WHC of next 120 cm of soil • Conductivity indices of water through these two columns	• Monthly mean cloudiness • Min temp ever recorded at that location minus av temp of coldest month. • Monthly mean rate of precipitation (mm/day) • Monthly mean relative humidity (%) • Percentage of sand • Percentage of clay • Monthly mean temp (°C) • Topography (m) • Monthly mean temperature range(°C) • Initial vegetation types • Mean "wet" days per month days • Monthly mean wind speed • Land mask	**Vegetation parameters** 1. Foliar biomass turnover time (yrs) – R-leaf 2. Root biomass turnover time (yrs) – R-root 3. Wood biomass turnover time (yrs) – R-stem 4. Foliar allocation coefficient – A-leaf 5. Root allocation coefficient – A-root 6. Wood allocation coefficient- A-stem 7. SLA (Specific leaf area) 8. LAI 9. Pathway (C3/C4) 10. Leaf Form 11. Rubisco activity V_{max}	**Soil parameters** 1. Sand fraction 2. Silt fraction 3. Clay 4. Porosity 5. Field capacity 6. Wilting point 7. Air entry potential 8. Saturated hydraulic conductivity 9. Texture class

Parameters		**Equation**
SLA (Specific Leaf Area)	Measure of leaf thickness, plays an important role in leaf and plant functioning. It is calculated by dividing the area of a portion of a leaf by the dry weight of that same portion of leaf.	SLA = Leaf area per plant / Leaf weight per plant
Allocation fraction of total photosynthate (Carbon)	Denotes amount or fraction of carbon deposited in various parts of species, especially in root, leaf and in the stem.	Carbon % = 100 – (Ash weight + molecular weight of O_2 (53.3) in $C_6H_{12}O_6$).
GDD (Growing Degree Days		GDD=T (max)+T (min)/2 –T (base
LAI (Leaf Area Index)	Ratio of total upper leaf surface of vegetation divided by the surface area of the land on which the vegetation grows. LAI is a dimensionless value.	LAI = mean leaf area per plant /mean available land surface per plant
Residence time of carbon	Determines the capacity of an ecosystem to function as a source or sink of carbon. The overall residence time of carbon in primary forests is determined by (1) what fraction of photosynthetic products get respired quickly and (2) the residence time of C allocated to living plant tissues, and (3) the time each of these components takes to decay, including what fraction is oxidized to CO_2 versus what becomes stabilized in soil organic matter.	R = Biomass stock (Stem/ root/leaf) / MAI (Mean Annual Increment)

Climate data required (BIOME 4, IBIS & LPJ)

Data Points	Frequency	Time horizon
Monthly mean cloudiness	Monthly	Present, 2020, 2050
Minimum temp ever recorded at that location	Monthly	Present, 2020, 2050
Monthly mean precipitation rate (mm/day)	Monthly	Present, 2020, 2050
Monthly mean relative humidity (%)	Monthly	Present, 2020, 2050
Monthly mean temperature (C)	Monthly	Present, 2020, 2050
Monthly mean temperature range (C)	Monthly	Present, 2020, 2050
Mean "wet" days per month (days)	Monthly	Present, 2020, 2050 & 2080
Monthly mean wind speed at sig=0.995 (m/s)	Monthly	Present, 2020, 2050
Monthly sunshine hours (% of maximum)	Monthly	Present, 2020, 2050 & 2080

Vegetation and Soil Data Needs for Modeling

Impact and vulnerability analysis	**Mitigation Potential analysis**	**Inventory analysis for soil carbon change**	
		CENTURY	***ROTHC***
Parameters defining PFT	% Carbon in Biomass (D, S)	Lignin content of plant material	Monthly temperature (degree C)
Max Rubisco activity at 15 C, at top of canopy (mol[CO_2] $m^{-2}s^{-1}$) (D, S)	Mean Annual Incr. – MAI (D,S,A)	Plant N (D, S,A)	Monthly rainfall (mm)
Specific leaf area (m^2kg^{-1}) (D, S)	Wood density (D,S)	Soil texture (D,A)	Monthly Evaporation (mm)
Foliar biomass turnover time constant (years) (D, S)	Standing vegetation (t/ha) – (D,S,A)	Soil N inputs (D, A)	Plant residues (tC/ha) – Monthly
Root biomass turnover time constant (years) (D, S)	% of MAI as Timber (D, S)	Initial soil C, N, P and S levels (D, S,A)	Farm yard manure (tC/ha) – Monthly
Wood biomass turnover time constant (years) (D, S)	% of Timber Export (D, S)		Soil cover (covered/fallow)
Foliar allocation coefficient (fraction) (D, S)	Mean Annual Incr. – MAI (D,S,A)		Plant residues (tC/ha) – Monthly
Root allocation coefficient (fraction) (D, S)	Biomass Expansion Factor – (D,S,A)		

Veg type parameters	**Product Conversion factor % of non-stem AG biomass for fuelwood (S)**
Initial total LAI of evergreen tree (upper canopy) PFTs (D,S)	Initial Soil carbon stock tC/ha) (D, S, A)
Initial total LAI of deciduous tree (upper canopy) PFTs (D,S)	Soil C accumulation (tC/ha/yr) (D,S,A)
Initial total LAI of shrub (lower canopy) PFTs (D,S)	Litter - Decomposing Period (D,S,A) - Annual Amount (% of MAI) (D,S,A)
Initial total LAI of grass (lower canopy) PFTs (D,S)	Biomass Expansion Factor – (D,S,A)
Initial total LAI of evergreen tree (upper canopy) PFTs (D,S)	Product Conversion factor % of non-stem AG biomass for fuelwood (D, S)
Initial total LAI of deciduous tree (upper canopy) PFTs (D,S)	Initial Soil carbon stock tC/ha) (D, S, A)
Initial total LAI of shrub (lower canopy) PFTs (D,S)	Wood density(D,S)

Introduction to LPJ

- The Lund-Potsdam-Jena Model (LPJ) has been developed as a DGVM with a broad range of potential applications to global problems. Three major considerations have guided its development:
    - Process-based yet computationally efficient representation of land-atmosphere coupling.
    - Explicit inclusion of the major processes of vegetation dynamics, including the role of the natural fire regime, and growth, competition and demographic processes.
    - An emphasis on comprehensive evaluation, using the widest possible range of data sets from atmospheric science as well as ecosystem science

3.3. Summary of the interdisciplinary project proposal developed to study the impacts of climate change on forest ecosystems and identify indicators of climate change.

A multidisciplinary project for a duration of 10 years has been envisaged by Head, Climate Change & Forest Influences Division of Forest Research Institute, Dehradun, India to study the impacts of climate change on forest ecosystems and identify indicators of climate change. The strategy devised for such study consists of following:

- Historical Data as reference
- Multi-disciplinary & multi-institutional
- Network for effective collaboration
- International collaboration for capacity building
- Infrastructural Support
- Systematic observations on a continuous basis
- Improved coverage of observations
- Attribution analysis for climate change impact

There are eight components in the project which have been already mentioned under "Introduction" for which separate implementing teams have been constituted mentioned in the succeeding chart. The year wise general objectives have been identified and are shown below:

General Objectives		
1st -2nd years	***3rd - 4th years***	***5th -10th years***
1. To establish a network of partners to make the study broad based. 2. To collect historical data, and undertake retrospective studies for reference. 3. Capacity building & international collaboration. 4. To plan for systematic observations on a continuous basis needed for climate change vegetation study & modeling 5. To understand existing vegetation models	1. To establish and maintain systematic observations on a continuous basis 2. To undertake experiments in the changed environmental scenario 3. To evaluate all existing vegetation /biome/forest models	1. To maintain systematic observations on a continuous basis 2. To continue experiments in the changed environmental scenario. 3. To undertake attribution analysis of the detection signals for climate change 4. To develop & evaluate models for impact prediction and adaptation

The initial presentation was given by Sh. M.P.Singh, Head, Climate Change & Forest Influences Division of FRI, Dehradun, India. Thereafter, each implementing team gave their respective presentations which were discussed and the weakness and improvements were identified for corrections/ incorporation.

SN	Project Component & Division	Implementing Team	Research Aim	Weakness/suggestion
1	Species distribution and range shifts *Systematic Botany*	*Dr. Veena Chandra* *Dr. H.B. Vashistha* *Dr. Anup Chandra* *Dr. Vaneet Jishtu (HFRI)* *Sh. S.R.Baloch*	Assessment of impact of climate on species distribution and local abundances, with an emphasis on linkages to underlying mechanisms of species range shifts	1) Protocols for laying sample plots. 2) Historical data/ herbarium for reference. 3) 1-2 km transition zone 4) CTFS/ STRI
2	Impact on Biogeochemical interactions *FS&LR Division*	Dr. A.K.Raina Dr. S.D.Sharma Dr. M.K.Gupta Dr. H.B.Vasistha Dr. Parul Bhatt	To analyze the interaction between vegetations and environment in time and scale with emphasis on bio-geo-chemical properties of soil and other climatic parameters.	1) Identify 4-5 dominant forest types & concentrate all studies in them
3	Phenological Studies *Botany Division*	*Dr. Subhas Nautiyal* *Dr. Meena Bakshi* *Dr. Manisha Thapliyal* *Dr. P. K. Pandey*	To study the climatic change impact on blooming and fruiting, production and quality of seed, and growth pattern in forest species.	1) Develop PFTs to help phenological studies to run models. The onset, duration and completion as well as the timing of various phenophases can emerge as good bioindicators
4	Genetic diversity and species richness *Genetics and Tree Propagation*	Dr. H.S.Ginwal Dr. Rajesh Sharma, (HFRI) Dr. Santan Barthwal Dr. Anoop Chandra Dr. M.S.Bhandari	Elucidating the response of climate change on genetic diversity and species richness of selected forestry species in natural ecosystem.	1) For genetic diversity, linkages of resilience of species to climate change can be studied with regard to their genetic diversity which would be a separate project.
5	Insect Diversity / abundance / migration Forest Entomology	*Dr. Mohd.Yousuf* *Dr. Sudhir Singh* *Dr. Neena Chauhan*	To study the distribution and local abundances of insects with an emphasis on linkages to migration and habitat change and compilation of list of first indicators.	For insect diversity, only indicator species like beetles/ spiders/ butterflies should be focused which have published literature on their occurrence with regard to temperature/ moisture etc. The life cycle of insects can also be studied, especially the change in food habits and food plants

SN	Project Component & Division	Implementing Team	Research Aim	Weakness/Suggestion
6	Fungal diversity & change *Forest Pathology*	*Dr. N. S. K. Harsh* *Mrs. Ranjana Juwantha* *Sh. Suresh Chandra*	To study composition and dynamics of fungal species vis a vis climate change and identification of first indicators of climate change	No scientist participated in the discussion
7	Bio-chemical Indicators *Chemistry Division*	*Dr. Y.C.Tripathi* *Dr. V.K.Varshney* *Dr. Vineet Kumar*	To study the impact of climate change on major active ingredients of selected medicinal & aromatic plants of Northwestern Himalayan region of India and monoterpene emissions from these plants.	Separate Project
8	Hydrological indicators & process based modeling *CC&FI Division*	*Sh. M. P. Singh* *Sh. T. Johri* *Dr. S.P.S. Rawat* *Dr. Hukum Singh* *Sh. Manoj Kumar*	• Stream and spring discharge • Water yield and regulation • Soil-Moisture Status • Historical reference data • Empirical as well as process based observation	1) Study meteorological parameters be included 2) Modeling studies with the help of NIH, Roorkee 3)The inputs required to be fed for running a model are well defined in the literature. The inputs relevant to the area under study should be identified and data should be collected accordingly which could be later used for running the models

4. Recommendations

Climate change is an inter-disciplinary science and a long term multi-institutional, rather than individual; approach to the study would ensure continuity of the research. Some institutions are already working on one or the other aspect of the subject in a project mode and not in a programme mode. So an All-India Co-ordinated Programme on Forests and Climate Change (FCC) is of utmost necessity. Leads already available on the basis of the work undertaken on the subject elsewhere can be used as starting point.

Apart from the eight components covered in present inter-disciplinary project, the components of forest fires and regeneration status should either be included in the project or a mention may be made that these are being dealt in a separate project of Silviculture division, otherwise they look missing. Inputs from NWFP division should also be included in the programme which would give a socio-economic importance. The potential for carbon stock enhancement & impact of climate change on mitigation are important aspects to be included as a project.

The project on climate change should aim to provide inputs to Green India Mission, Plantations of forest department/ private entrepreneurs, etc. It should clearly identify as to how it is going to help Green India Mission, Management of forests, Working Plans etc. The project should elaborate how findings of the project are going to help in vulnerability assessment and adaptations enhancing the socio-economic aspect of the project. Further a clear plan on publications to be brought out like special editions etc. should be incorporated in the project. Since the project is too big and complex to run successfully, so it should be divided into separate projects dealing with different aspects.

All divisions are required to prepare the new set of objectives relevant to Climate Change, giving the utility of the study, how it will help manage forests in the context of climate impacts along with the methodology of the study, within two months (Mid-January 2012).

A workshop may be organized in February 2012 to discuss the comprehensive proposal calling Ministry of Environment & Forests (Green India Mission) and other external funding agencies in Dehradun. First Phase studies with funding from ICFRE can be undertaken since the beginning of the financial year 2012-13.

Appendix A: Workshop Participants

SN	Name	Designation	Email	Phone No.
1	Dr. V.K. Bahuguna	D.G. (ICFRE)	bahugunaifs@icfre.org	0135-2224333
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4	Ms. Indu Murthy	II Sc.	indukmurthy@gmail.com	09880493926
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Appendix B: Technical Programme

Workshop on

Climate Change & Forestry Research Needs in Himalayas

Date: *24.10.2011 and 25.10.2011*

Venue: *NFLIC Conference Hall, FRI, Dehradun.*

Technical program

24.10.2011

03.00 pm – 03.10 pm	:	Welcome Address by Director, FRI Dehradun
03.10 pm – 03.20 pm	:	Introductory Remarks by D. G. ICFRE
03.20 pm – 03.30 pm	:	Brief Interaction
03.30 pm – 04.30 pm	:	Presentation by Prof. N. H. Ravindranath, IISc. Bangalore on "Research gaps on the forest response to changing climate and modeling perspective"
04.20 pm – 04.40 pm	:	Presentation on Project Proposal, "Impact of climate change on forest ecosystem in Himalayas"
04.40 pm – 05.30 pm	:	Brief discussion

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25.10.2011

9.20 am – 11.00 am	:	Presentation on "Data needs for Modeling" (Ms. Indu Murthy, IISc. Bangalore)
11.00 am – 12.30 pm	:	Detailed discussion with respective Divisions of FRI.
12.30 pm – 01.00 pm	:	Valediction

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