



Chapter – 7

Research

Research and Development

Environmental Research

Introduction and Objectives

- Research in multi-disciplinary aspects for environmental and ecosystems protection, conservation and management at various universities, institutions of higher learning, national research institutes and non-governmental organizations in identified thrust areas under its Research & Development (R&D) Programme continued to be funded by the Ministry. It is a Central Plan Scheme for supporting research in environment since 1985. The objectives of the scheme are to generate information required to develop strategies, technologies and methodologies for better environmental management. It also aims at attempting solutions to the practical problems of resource management, conservation of natural resources and eco-regeneration of degraded areas. Further, the scheme also aims at strengthening infrastructure to facilitate research and scientific manpower development.
- The environmental research is being supported under various sub-schemes as under:
 - Environment Research Programme (ERP) - Brown Agenda
 - Ecosystem Research Scheme (ERS) - Green Agenda
 - Research Programme for Eastern and Western Ghats - Location Specific

Progress of Activities Undertaken

New Guidelines

- During the year Ministry brought out new guidelines for supporting research clearly indicating the order of priority and broad research themes in the identified thrust areas in the following 3 modes of :
 - Suomoto proposals, which can be submitted at any time of the year.

- Competitive invited proposals to be submitted when called for depending upon the specific needs of policy making including information required for international negotiations and implementation of plan schemes. Selection among the proposals received in response is made competitively on the basis of technical soundness.
- Non-competitive commissioned proposals to be invited directly from one or a network of research institutes depending on the specific needs of policy making etc. Thematic Expert Groups are being setup to examine and recommend research proposals for funding by the Ministry.

- Six Thematic Expert Groups have been constituted by merging various research funding programmes of the Ministry during the year. These are :

• **Prevention, Abatement and Control of Pollution**

Schemes/ Programmes to be covered

- Environment Research
- National River Conservation
- Climate Change/Clean Technologies

• **Conservation and Sustainable Utilisation of Natural Resources**

Schemes/Programmes to be covered

- Eco-System Research
- Eastern & Western Ghats
- Man & Bio-sphere reserves
- Mangroves and Coral Reefs
- Wet Lands
- Biodiversity Conservation

• **Conservation and Management of Wildlife & Animal Welfare**

Schemes/Programmes to be covered

- Wildlife Conservation
- Animal Welfare

- **Natural Resource Management using spatial technology**

Schemes/Programmes to be covered:

- National Natural Resource Management System (NNRMS)

- **Economic & Social Issues**

Though no specific programme will be covered under this thematic group, the group would consider all proposals related to the following topics

- Cost Benefit Analysis
- Socio-economic Issues
- Other miscellaneous issues
- The terms of reference of the Thematic Peer Groups are
 - To determine whether the proposals fall under the identified thrust areas of the Ministry and generally meet expectations Technical Competence of the research team, completeness, and may result in useful research outputs which is potentially publishable in a peer reviewed publication of standing.
 - To identify a minimum of three & maximum of five Expert Peer reviewers, having expertise in the specific research topic to whom the research proposal, as well as the proposed level of effort ("person-months") may be sent for evaluation.
 - To evaluate research proposals considering the reviews received from the Expert Peer Reviewers in each case and determine whether or not the technical proposals may be accepted and to indicate whether the proposed level of effort ("person-months") and equipment / infrastructure to be created by the project are reasonable and necessary.
 - To evaluate Final Technical Reports (FTR).

Environment Research Programme (ERP)

- Environment Research Programme (ERP) deals with problems related to pollution

and development of suitable cost effective technologies for abatement of pollution. Emphasis is laid on development of eco-friendly biological and other interventions for prevention, abatement of pollution and development of strategies, technologies and instruments etc. for control of pollution. Projects are also encouraged for development of biodegradable plastics, to carryout epidemiological studies, strategies to reduce impact of mining, chemical pollution of soils, and hazardous substances including pesticides, heavy metals etc. Projects related to waste recycling and resource recovery from waste along with the development of eco-friendly and cleaner technologies are given priority. The project are supported in the identified thrust area of environment research.

- Under the Thematic Group 'Prevention, Abatement and Control of Pollution', three Programmes / Schemes are covered namely i) Environment Research ii) National River Conservation and iii) Climate Change / Clean Technologies. During the year four meetings of the Thematic Group were held to consider the new / revised proposals & review / monitor the ongoing / completed projects. Sixty nine new projects were considered by the Expert Group. Based on the recommendations of the Expert Group 28 new projects have been sanctioned (Annexure-III) during the period. Progress of 46 ongoing projects was reviewed and monitored during the year. The Expert Group also reviewed the FTR of 17 completed projects during the period.

Ecosystem Research Scheme (ERS)

- Ecosystem Research Scheme is an interdisciplinary programme of research which emphasizes ecological approach for studying the relationship between man and environment. The objective of the

programme is to develop a basis within the field of natural and social sciences for rational use and conservation of resources for general improvement of the relationship between man and his environment. The programme seeks to provide a scientific basis to solve the practical problems of resource management as well as to provide a scientific knowledge and trained personnel needed to manage the natural resources in a rational and sustainable manner. Ecosystem studies become even more important as the Earth's environmental ecosystems are increasingly being affected at all levels. Ecological understanding and research in this area offer tangible hope for addressing extremely complex and potentially devastating assaults on local, regional and global ecosystems. Under the scheme, emphasis is laid on multi-disciplinary aspects of environmental conservation with emphasis on eco-system approach consistent with the identified thrust areas and orientation.

- During the year under Ecosystem Research Scheme five new projects were initiated, (Annexure-III) 14 studies were completed (Annexure-IV) and 33 projects were reviewed and monitored for their progress.

Eastern and Western Ghats Research Programme (E&WGRP)

- The Eastern and Western Ghats Research Programme addresses itself to location-specific problems of resource management in the Eastern and Western Ghats regions of the country. The region is suffering from destruction of habitats of its unique plant and animal life due to floods, siltation, deforestation etc. besides shortage of food, fodder and fuel for rural population and shortage of raw material for the industries. Under this programme, studies relating to Bio-diversity, land use,

impact of developmental activities etc. are taken up to restore the environmental quality of the region.

- During the year under Ecosystem Research Scheme six new projects were initiated (Annexure-III) and four studies were completed (Annexure-IV).

New Thematic Group- 'Economic & Social Issues'

- The Ministry constituted new Thematic Group- 'Economic & Social Issues' during the year. Though no specific programme will be covered under this thematic group, the group would consider all proposals related to Cost Benefit Analysis, Socio-economic issues and other miscellaneous issues.
- One meeting of the Thematic Group was held to consider the new / revised proposals & review / monitor the ongoing / completed (FTR) projects. Four new and one revised projects were considered by the Expert Group. Based on the recommendations of the Expert Group one new project has been sanctioned during the period (Annexure-III). Progress of two ongoing projects was reviewed and monitored. The Expert Group also reviewed the one FTR of completed project (Annexure-IV).

Summaries / Research finding of some of the Projects completed during the year

Physico-chemical ex-situ remediation of soils, sediments or aquifers contaminated by hazardous waste by Dr. Shyam R Asolekar, Centre for Environment Science and Engineering, IIT-Mumbai.

- The objective of the research project was to understand a fairly fundamental interaction at solid-liquid interfaces in nature that is responsible for contamination of natural soils, clays, sediments or aquifers (collectively referred to as "soils" here after in this report) as well

as building tools and estimation of parameter useful for development of ex-situ clean-up of these natural soil-matrixes.

- In the present research project, screening protocol has been developed to assess the effectiveness of various operating parameters in soil washing process. It is hypothesised that the thermodynamic parameters describing sorption-desorption process can be predicted using the quantitative structure activity relationships (QSARs), which can be developed on the basis of modelling of isotherm data. These QSARs are successfully incorporated into the developed models, which potentially minimise the number of laboratory experiments required for estimating the limits of sorption and desorption during the technology development phase of soil washing process.
- Organic pollutants including substituted benzenes and substituted phenols, namely p-Xylene, Ethyl benzene, Nitrobenzene, and 4-Nitrophenol and heavy metals including lead and chromium, were investigated because of their industry and environmental significance. Experiments were carried out to study the effects of natural organic matter (NOM) and background ionic strength on sorption of Pb (II) and Cr (VI). It was observed that Pb as well as Cr-sorption onto soil decreased with increase in dissolved surrogate organic matter. The sorption of Pb as well as Cr onto soil surface was further decreased when concentrations of, both, background dissolved salt and organic matter were increased.
- Sorption and desorption experiments for organic pollutants were carried out using, end-to-end tumbler apparatus. A screening protocol was developed to assess the effectiveness of various soil washing operating parameters such as soil to water ratio, type of extractants.

Recovery of value added products from shrimp processing waste, by N.M. Sachindra & N. Bhaskar, Central Food Technological Research Institute, Mysore

- The major objective of the project was to develop an integrated process that is eco-friendly so as to recover most of the biomolecules from shrimp waste and effectively utilize them.
- From the research work & results obtained by this project it indicates an improvement of skin coloration in fish fed with carotenoid from shrimp waste. The shrimp waste was found to have various non-volatile flavor fractions which can be utilized for enhancing the flavor of fish and fish products or shellfish analogs. The residue obtained from both flavor extraction and fermentation has crude chitin which is largely deproteinized and demineralized. Since, the residue from fermentation is obtained from a milder process, chitin prepared from such material may have better physico-chemical quality characteristics as compared to chitin prepared by conventional chemical methods.
- The plant economics calculated for a plant operational at 1 tonne capacity clearly indicates the economic feasibility mainly because of high value product like astaxanthin rich lyophilized powder which can also serve as probiotic ingredient in aquaculture formulations. The chitin recovered from this process would be better in functionality mainly due to less severity of acids produced during fermentation. The chitin from such eco-friendly process would fetch better price and might yield good quality chitosan.

Assessment of persistent organic pollutants – PCDDs and PCDFs in biological media by Dr. Rekha Kashyap, National Institute of Occupational Health (NIOH), Ahmedabad.

- The emphasis of the project relied on the collection of biological samples (human

milk, blood) from nursing mothers to determine the residue levels of Polychlorinated dibenzo-p-dioxins (PCDDs) and Polychlorinated dibenzo furans (PCDFs). The blood samples were collected from the garbage pickers trying to salvage any discarded materials from the garbage dumps, as they are a high-risk group constantly exposed to the slow burning of the garbage. The second objective of this project was to determine the residue levels of PCDDs and PCDFs in animal food (chicken, eggs) as it is well established that 90% of the exposure to human beings is mainly through food of animal origin. The chicken and egg samples were collected from highly polluted areas near the waste incineration plants.

- The analysis was done for five main congeners of dioxin and furan namely 2,3,7,8, tetra chloro, 1,2,3,7,8, penta chloro, 1,2,3,4,7,8, hexa chloro, 1,2,3,4,6,7,8, hepta chloro and octa chloro. PCDDs and PCDFs exist in the environmental and biological samples as complex mixtures of various congeners, whose relative concentrations differ across tropic. As a result, the concentration of these mixtures changes in the environment and biological samples from sample to sample and region to region. The findings of our study show the contamination of the environment with the residues of dioxin and furan. In the entire sample matrix the concentration of dioxins was greater than that of furans. The mean Toxic Equivalents (TEQs) for total dioxin in egg samples for Ahmedabad, Vadodara and Surat were 7.49, 9.32 and 13.35 respectively. The total TEQs for chickens were 7.05, 9.38 and 7.67 respectively.
- Dioxins are significantly at higher levels in primiparas than in multiparas. A decreasing trend is visible in the residue levels of the dioxin in case of the subjects

who had their second delivery as compared to the first delivery. From the correlation regression analysis it was found that there is a positive correlation between dioxin with the age of the subject. The dioxin residues are negatively correlated to weight; height and Skin fold thickness (SFT). The residues were significantly correlated with the milk fat. Study indicates that there is still need for monitoring of PCDD/F levels in foodstuffs especially non-vegetarian food and biological samples with adequate sample size to know the level of exposure of our population and also the contamination of environment.

Mapping Biodiversity of the Myristica swamps in Southern Kerala

- The project was undertaken to survey and map swamp forests in order to document the animal and plant wealth, to characterize the soil and develop conservation strategy for swamp forests of the region. Sixty swamps were mapped which are spread over 1.5 km². Number of species of different groups of animals were investigated. Quantitative analysis of herpetofauna revealed that the differences in the environmental characteristics inside the diversity and abundances of both amphibians and reptiles. Amphibians were more susceptible to environmental changes. Patterns of diversity and abundance during day and night, across swamps and months changed. The study also highlighted the enormous biodiversity of the Myristica swamp forests. Sources of disturbance recognized and recommendations were made to conserve the swamp forests.

Studies on the biodiversity of shoals and grasslands and their restoration in the Nilgiris Plateau, Southern India

- The study was conducted to suggest means of restoring the Shola forests in the

introduced pine and wattle plantations and to determine the soil characteristics and biodiversity of shola forests in the Nilgiris. The study revealed a programme approach towards adoption of suitable techniques through the removal of topical pines and wattles from areas which once supported shola forests. This would enable the regeneration and subsequent survival of the shola species once the introduced exotic monocultures are removed. The study has also elucidated diversity of microorganisms as well as the flora of the region that would stress the need for conserving sholas of the Nilgiris that are an abode of diversity. Phytosociological work has been carried out.

Effect of Arbuscular Mycorrhiza and beneficial bacteria on Bamboo

- The study was carried out to determine the microbial and biochemical activities in the bamboo rhizosphere. Strains of AM fungi were screened for their efficiency in the bamboo ecosystem. Response was maximum to *Glomus fasciculatum*. High levels of *Azotobacter chroococcum* also gave good results. High inoculum density of *Pseudomonas fluorescens* also proved suitable for bamboo. Subabul growing near bamboo gave better results than *Candelypha*.

Fungal endophytes of medicinal plants in Tamil Nadu forests

- Endophytic fungi growing in different medicinal plants have been investigated. Ten medicinal plants were selected. Estimation and characterization of Taxol from the isolated cultures was carried out. Altogether 80 fungal species were isolated. Greatest diversity was found in senescent leaves following by mature leaves. Three species of fungi have been found to produce Taxol, *Botryodiplodia theobromae* gave best results when collected from *Cinchona* sp.

Research project on Estimating the economic value of forest lands in different Bio-geographic zones in India: A methodology

- Under the project a methodology has been recommended for estimating the value of forest land focusing on the Net Present Value (NPV) of the expected flow of ecosystem goods and services accruing from them. The study has been exclusively carried out in 2 states viz. Himachal Pradesh and Madhya Pradesh.
- The project has developed procedural steps in determining NPV for relevant areas. A general principle for sharing the NPV between different stakeholders is recommended as follows
- Local-100% of NTFP, fuelwood and fodder value; 50% of watershed services and 45% of biodiversity values.
- State – 100% of eco-tourism and timber values, 50% of watershed services, 90% of carbon and 45% of biodiversity values.
- National – 10% of biodiversity and 10% of carbon values.

Thus, the study introduces and dwells at length on ecological and legal aspects of forests into a valuation exercise to make it more policy relevant and to illustrate the limits of a single disciplinary approach or of one instrument in the framing of policy.

- The larger understandings, which emerge from the study, are
 - That valuation if carried out at the relevant scale and using the appropriate techniques is important.
 - That law and economic instruments have their respective domains in policy formulation.
 - That certain critical functions such as life-supporting functions of biodiversity are difficult to put a number on.
 - That knowledge needs to be improved and built on with respect to these

critical functions and the dividing line between these and other ecosystem services which have substitutes.

- That valuation methodology also needs to examine principles for distribution of the value of the capital asset in the event of its conversion to another use.

National Natural Resource Management System (NNRMS)

Introduction and Objectives

- The Scheme of National Natural Resource Management System (NNRMS) involves utilization of remote sensing technology for accurate inventory of resources such as land, water, forests, minerals, oceans, etc. and to utilize this information for monitoring changes in ecological system. A Standing Committee on Bio-resources and Environment (SC-B) has been constituted by the Planning Commission under the Chairmanship of Secy. (E&F) with the following objectives:
 - Optimal utilization of country's natural resources by a proper and systematic inventory of resource availability.
 - Reducing regional imbalances by effective planning and in tune with the environmental efforts
 - Maintaining the ecological balance with a view to evolve and implement the environmental guidelines.
- The Standing Committee on Bio-resources and Environment (SC-B) constituted by the Planning Commission advises on the methods of using the remote sensing technology for optimal use and management of natural resources in the country. In order to streamline the projects. The SC-B has constituted a Technical & Financial Sub-Committee to scrutinize/review all the proposals submitted for funding under NNRMS SC-B from the technical and financial angle.

Only those proposals recommended by the Technical and Financial Sub-Committee are taken up by NNRMS SC-B for financial assistance. The Committee also oversees and monitors the progress of sanctioned projects

Progress of Activities Undertaken

- Since its inception in 1985 NNRMS SC-B has met 21 times and approved 96 projects related to various facets of environment. The NNRMS SC-B had identified 49 priority areas for taking up remote sensing based studies in tune with key environment and ecological issues of the country. Which encompasses forest, grassland, plant and faunal resources, wastelands, land degradation, water and air pollution etc. for information requirements for the Man and Biosphere Reserve Programme and some typical areas like mining, coastal areas, wildlife habitats, etc.
- National projects on Snow and Glaciers, Mapping of Wildlife Sanctuaries /National Parks, Forest Type Mapping, and Coastal/ mangroves/coral reef studies have been initiated after peer review.
- About 30 projects were approved by SC-B during Xth plan and are under various stages of implementation in the broad areas of Forestry & Wildlife, Wetlands, Desertification, Environmental impact of developmental activities, landslides and forest fire etc.
- So far 70 projects have been completed. The potential user agencies for utilizing the outcome/information generated in the projects sanctioned by the Ministry under NNRMS programme are the Central Government Departments/Agencies and the Ministry of Environment and Forests itself including the various organizations under its administrative control like FSI, ZSI, BSI etc.

- During the year two Meetings of Technical and Financial Sub – Committee of National Natural Resource Management System on Bio-resources and Environment (NNRMS SC-B) were held to review the ongoing projects and evaluate the new projects from financial and technical angles. The Sub – Committee recommended three new projects for consideration of Standing Committee of NNRMS SC-B. The Committee also reviewed the recently completed projects and accepted the Final Technical Reports of four recently completed project. (Annexure-IV)
- The projects entitled Forest Type Mapping of India's Forests on 1:50,000 scale (entire country), Mapping of Wildlife Sanctuaries and National Parks on 1:12,500 scale, Coastal Studies (including mangroves and coral reefs) on 1:25,000, and for selected areas on 1:5000 scale, Snow and Glaciers Studies of entire Himalayas (1:250,000 /1:50,000 scales) and National Wetland Inventory and Assessment were also monitored by the Steering Committee of the respective projects.

G. B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora

Introduction

G.B. Pant Institute of Himalayan Environment and Development (GBPIHED) was established in August 1988 by the Ministry as an autonomous Institute with a mandate of achieving sustainable development and environmental conservation in the Indian Himalayan Region (IHR). The Institute executes the mandate through its Headquarters located at Kosi-Katarmal, Almora (Uttarakhand), and its four regional Units located at Kullu (Himachal Pradesh), Srinagar (Uttarakhand), Pangthang (Sikkim) and Itanagar (Arunachal Pradesh). The Institute designs and implements R&D activities on priority

environmental problems; develops and demonstrates best practices and delivers technology packages for improved livelihood of the people of the IHR.

Objective

- To undertake in-depth research and development studies on environmental problems of the IHR;
- To identify and strengthen the local knowledge of the environment and contribute towards strengthening researches of regional relevance; and
- To evolve and demonstrate suitable technological packages and delivery systems for sustainable development of the region in harmony with local perceptions.

Progress of Activities Undertaken

- During the year, R&D activities covered land and water resources, farming systems, ex-situ and in-situ approach for biodiversity conservation, EIA of developmental projects, wasteland restoration, improved NRM practices for livelihood support, etc. The environment-friendly and low-cost technologies so developed were disseminated among a range of stakeholders through organization of over 50 training programmes, workshops, orientation courses on a training of trainers mode across the IHR. Special efforts were also made for the tribal areas of north-east region through involvement of selected NGOs for up-scaling these technologies. Strategy and action plan relating to eco-tourism promotion in Nanda Devi Biosphere Reserve, wasteland restoration for enhanced fodder and fuelwood production and arresting soil erosion and catchment area treatment plans using bio-engineering and vegetative methods were also formulated. Concept of sacred forest and landscape was implemented through Integrated Ecodevelopment Research



Fig.50 *Heracleum wallichii* – an alpine medicinal plant

- Programme (IERP) of the Institute for seeking people's participation in wasteland afforestation in five Himalayan States.
- Institute's VISION-2015 document emphasizes on the need for demand-driven, applied and action-oriented research as emanated through stakeholder consultations at local, regional and national levels. Towards achieving this, the Institute has identified five thematic thrust areas to be addressed during XI plan period. Which are:
 - Watershed Processes and Management;
 - Biodiversity Conservation;
 - Environmental Assessment & Management;
 - Socio-economic Development; and
 - Biotechnological Applications. Knowledge products and capacity building is the in-built component of each of these thematic thrust areas.
 - At the Himachal Unit (Kullu) studies were focused on floristic inventory and resource utilization pattern of the Kais and Manali Wildlife Sanctuaries, ambient air quality assessment, and socio-economic surveys in the hydropower project areas. A capacity building programme 'Community awareness on environmental issues' was organized for Tibetan communities.
 - At the Srinagar (Uttarakhand) Unit, studies on indigenous farmers' practices on soil fertility maintenance, below ground biodiversity, multiplication potential and biochemical assessment of *Hippophae rhamnoides* were carried out. In addition, a field station for demonstration, training and experimentation site for bioresource conservation and management and capacity building was established at Triyuginrayan, Kedarnath valley.
 - At the Sikkim Unit, a 'Rare and Threatened Plant Conservation Park' was established in collaboration with state forest department by plantation of *Swertia chirayita*, *Saussurea costus* and *Rhododendron* species. The Institute collaborated with state forest department with a focus on "Sikkim-biodiversity and environmental conservation and forest management". Capacity building programme for state govt. officials on disaster management was carried out.
 - The Arunachal Pradesh Unit mainly focused on documentation of (i) Fallow management practices among the Tangkhuls of Ukhul District; (ii) Traditional pest management practices among three tribes in Assam, Manipur and Meghalaya; and (iii) Traditional soil and water conservation practices among the Nyishi and Adi tribes of East Siang and West Siang districts of Arunachal Pradesh.
 - R&D activities relating to land and water resources were focused on: soil and water



Fig.51 An alpine orchid of Sikkim

conservation (SWC) in Central Himalaya and jhum cultivation in NE; water sustainability studies in Kumaun Himalayan watersheds; and glacier retreat (Gangotri, Thelu, Dokriyani and Milam glaciers), in the Central Himalaya.

- Status assessment of natural resources and their use pattern in the NE region and settled rural ecosystems in the Central Himalaya were investigated to develop strategies for sustainable resource-use planning. In view of the usefulness of bamboo as a multipurpose species, surveys carried out in over 20 villages. As a result of capacity building training programmes, 20 women so trained earned Rs. 800-1200/month by marketing of bamboo products.
 - R&D efforts for conservation of biological diversity mainly included:
 - up-dating database for the identified Himalayan Biosphere Reserves (BRs) so as to address their research and management issues;
 - assessment of biodiversity in biodiversity rich areas;
 - strengthen field gene-banks as demonstration and training sites; and
 - promote conservation education among the school children using
- arboreta, herbal gardens and other field demonstrations. MAB-Net nomination documents for Manas (Assam) and Kanchenzonga (Sikkim) Biosphere Reserves were submitted to UNESCO.
- The studies under environmental impact assessment focused on assessment of impact of tourism with a particular reference to municipal waste generation and air quality in selected destinations in Uttarakhand and HP; preparation of EIA and EMP of hydropower projects in Central and Western Himalaya; impact assessment of alternative land uses (tea cultivation, introduction of cash crops in Lahul valley of H.P.); and impact assessment of land use and land cover on water quality of springs in Uttarakhand hills.
 - To understand the environmental control on plant's responses and adaptation mechanism of plants to the changing environment, eco-physiological studies on high altitude medicinal plants (*Picrorhiza kurrooa*, *Podophyllum hexandrum* and *Rheum moorcroftianum*) were carried out.
 - Microbiological studies on 21 species of *Penicillium* isolated from the soil collected from IHR for their phosphate solubilizing activity revealed that seven species of *Penicillium* brought maximum solubilization after 15 days of incubation. Isolation of microorganisms in the fermented foods (a wheat based starter culture, balam) used by Bhotiya community recorded 32 microbial isolates. While the spore forming bacterial species belonged to genus *Bacillus*, the yeast isolates were identified as *Sacharomycopsis fibuligera*, *Kluyveromyces maxianus*, and *Sacharomyces* spp.
 - The Institute ensures wider application of its R&D outcomes mainly through a self sustaining Rural Technology Centre (RTC)

at the Institute's HQs and smaller technology parks at regional centres. These centres house about 30 demonstrations on simple low-cost technologies and provide trainings to various stakeholder and trainer groups in different sets of packages. During the year the Institute, during the year, organized more than 50 training/awareness programmes (HQs-26; NE-8; Sikkim-9; Garhwal-4; HP-10) for different user groups wherein over 2300 persons participated.



Fig.52 Rhododendron of Uttarakhand

- Under a programme entitled, 'Institutionalizing Technology Backstopping and Capacity Enhancement within the Tribal Areas of North East', seven partner NGOs from different states of the NE region established technology demonstration parks in their respective areas for demonstration and dissemination of relevant technologies.
- The Disaster Management Faculty at Sikkim Unit conducted capacity building

programmes (6 no; 326 participants) for different stakeholders. Similarly, under the TIFAC Project in Sikkim, the socio-economic condition of hill farming communities improved through specialized training for vegetable crops and their seed production at Central Pandam village in East Sikkim district; Tarku and Chhamgaon villages in South Sikkim district.

- Demonstrations on restoration of degraded wastelands were implemented through restoration of village community degraded land (3 ha) at Kolidhaik village (Distt. Champawat, Uttarakhand); plantation of fodder trees (>10,000 saplings of 15 species) in village wastelands (approx 40 ha) for silvi-pasture development; and collaborative programme on Bhimtal lake catchment restoration (Distt. Nainital).

Research on Wetlands, Mangroves and Coral Reefs

Wetlands

Introduction and objectives

A Research Sub-Committee on Wetlands has been constituted to identify more Wetlands of national importance and to supplement Management Action Plan (MAP) for intensive conservation on thrust areas of research.

Progress of Activities Undertaken

- One Research project on "Effects of pollutants on Biodiversity and reproductive dynamics of ecologically sensitive organisms in the estuarine coastal waters of Chennai" has been sanctioned to Deptt of Zoology, University of Madras, Chennai at a total cost of Rs. 32.49 lakhs for three years.
- Nineteen on-going research projects on various aspects in the field of wetland conservation are operational under Wetland Conservation Programme which are at various stages of execution. Three

research projects have been completed during the year. Details of these projects are given at Annexure-IV.

Mangroves and Coral Reefs

National Institute for Research in Mangroves and Coastal Bioresources

- Based on the felt-need for a separate, dedicated institute for targeted R&D studies on Sunderbans in view of their uniqueness and importance on more than one count, the Ministry has decided that a separate dedicated institute for targeted R&D works for Sunderbans may be desirable. While Sunderbans would be at the centre-stage of work of the envisioned institute, it may also do research in related areas of coastal & marine biodiversity of the entire country, and cater to capacity-building & education, awareness programmes in the region. Accordingly, this Ministry has decided the followings :
 - The proposed research institute may be titled “National Institute for Research in Mangroves and Coastal Bioresources”.
 - It may be located in West Bengal, in proximity to the Sunderbans.
 - Land for the Institute should be provided free of cost and encumbrances by the Government of West Bengal.
 - While Sunderbans will be at the Centre Stage, the proposed Institute may carry out research on Mangroves and Coastal Bioresources throughout the coastal regions and islands of the country.
 - The recruitment of faculty and staff should be on All India basis.



Fig.53 Aerial view of Muthupet Lagoons

- The State Government of West Bengal has already given in-principle approval for providing land, free of cost, for the proposed Institute. The matter regarding acquisition of land is being followed up with the State Government. Meanwhile, the Ministry has engaged GEER Foundation, Gandhinagar, Gujarat as National Consultant for formulating the Detailed Project Report (DPR) for the proposed National Institute and other related issues. An International Consultant is also being provided by IUCN – MFF Secretariat for helping the National consultant in the preparation of the DPR.

Coral Reefs

- The Ministry continued to support R&D activities with emphasis on targeted research on Coral biodiversity, its management including various aspects of pollution in these areas.
- In order to encourage targeted research on both hard and soft corals in the country, the Ministry had earlier established a National Coral Reef Research Centre at Port Blair.
- Four research Projects in the area of Mangroves and Coral Reefs, are recommended by the Expert Group B on ‘Conservation & Sustainable Utilization of Natural Resources’ are being sanctioned by the Ministry during the year.

Biosphere Reserves

Research and development projects are also supported in the designated Reserves and potential sites of the Biosphere Reserves. A number of Research projects have been sanctioned as per Annexure-III and a number of projects completed during the year which provided baseline data helpful in the scientific management of these Reserves. Details of these Projects are given in Annexure-IV.

Forestry Research

Indian Council of Forestry Research and Education (ICFRE)

Introduction

- The ICFRE is the apex body in the national forestry research system mandated to develop a holistic forestry research strategy through appropriate planning, coordination, execution and promotion of research, education and extension covering all aspects of forestry.
- ICFRE has a nation-wide presence through its network of eight research Institutes located in different agro-ecological zones of the country, viz., at Dehradun, Shimla, Ranchi, Jorhat, Jabalpur, Jodhpur, Bangalore and Coimbatore and four Centres, one each at Allahabad, Chhindwara, Hyderabad and Aizawl.

Objectives

- To undertake, aid, promote and coordinate at national level forestry education, research and application thereof;
- To develop and maintain a National Forestry Library and Information Centre for forestry and allied sciences;
- To act as a clearing house for research and general information relating to forests and wildlife;
- To develop forestry extension programmes and disseminate the same through mass media audio-visual aids and other extension techniques;

- To provide consultancy services in the field of forestry research and education, and allied sciences;
- To discharge other responsibilities considered necessary to attain these objectives.

Progress of Activities Undertaken

In addition to strengthening scientific forestry management in the country, ICFRE has made several path-breaking advances in the field of forestry research and allied disciplines. Some of the significant achievements are listed below.

- Gall insect problem in Eucalyptus caused by *Leptocybe invasa*, a wasp was recorded for the first time in India, and strategy and extension plan to control the pest evolved.
- ICFRE has been granted Observer Status of United Nations Framework Convention on Climate Change (UNFCCC), and was accordingly admitted as an Observer to the Conference of Parties and its subsidiary bodies at the Tenth Session of the Conference of Parties (COP10) on 6th December 2004 in Buenos Aires.
- ICFRE has been granted ISO 9001: 2000 certification.
- Control measures for Sal heartwood borer (kairomone application), and for dying of Kail (J&K, HP) and Deodar (HP) developed.
- Physical and mechanical properties of more than 500 species of Indian timbers and about two dozen species of bamboos stand evaluated.
- Air and kiln seasoning behaviour of more than 200 species have been studied.
- Protocols developed for propagation of important medicinal plants.
- Woodworking and finishing qualities have been evaluated for more than 70 timber species.



Fig.54 *Idaides cloanthus* - commonly known as glassy blue bottle

- Introduced exotics like Eucalyptus, Poplar, Tropical pines, Casuarina and Acacias and developed high yielding clones and hybrid of these species.
- Various World Class Wood Preservatives have been developed.
- Design of solar heated kiln has been developed and standardized for accelerated seasoning compared to air drying, and to substitute the thermal energy requirement for drying in steam heated kilns by solar heating. About 200 commercial units have so far been installed.
- Forest Research Institute developed a wide range of panel products through its work on plywood research by using ligno cellulosic material.
- Ammonia fumigation technique developed to bring out grain structure of and to give coloration to wood of Eucalyptus, Silver oak, Babul etc.
- Simple vapour phase ammonia plasticization technique developed for bending woods of Silver oak, Rubberwood, Eucalyptus etc. to produce novelty bentwood furniture. The process has been patented.
- Seventy fascinating shades of eco-friendly dyes prepared from Poplar, Eucalyptus, Lantana, Parthenium etc.
- Identified high oil yielding provenances of Jatropha and established germ plasm bank in each institute.
- Bamboo Propagation Macroproliferation technique developed for multiplication from 1 to 64 plantlets in one year.
- Developed and transferred eco-restoration technologies for rehabilitation of mined areas by using ecologically suitable species of herbs, grasses, shrubs and trees.
- Bioremediation of Industrial effluents using Fungi has been undertaken for Pollution Management.

- Carried out pre-fire vegetation survey and fuel load determination, analyzed soil organic carbon of sensitive sites and
- Bioshield of Casuarina planted in North Andaman, Long Island and Rangat as steps to Disaster Management.
- Rajpath and Central Vista Tree Conservation Project in New Delhi and development and maintenance of tree avenues in Commonwealth Games Village etc. are being executed as Heritage Conservation.
- Wood Anatomy Information System has been developed for wood identification for various user agencies.
- Forest fungi collection hosting over 1,000 forest fungi isolates at FRI.
- ICFRE has completed Environment Impact Assessment (EIA) studies for various developmental projects like hydroelectric, mining, construction etc. and also evaluated number of forestry related projects for various ministries/organization of Government of India and State Governments.
- National Forest Library and Information Centre has a document collection of 1.65 lakh. It also houses 200 foreign and 418 Indian periodicals.



Fig.55 *Costus speciosus*, popularly known as spiral ginger

- Three hundred and nine preservation plots have been established all over the country.
- A computerized herbarium database for 900 specimens of economically important forestry species has been developed. About 3,000 herbarium plant species were uploaded into the 'Image Analyzer' programme and are available to the entire country through website.
- Sawing and conversion technique of Eucalyptus spp. and Poplar.
- Utilisation of Poplar for doors and windows.
- Technology for utilisation of juvenile wood of Poplars/Eucalyptus for furniture and joinery.
- Preservative treatment of secondary species (especially Eucalyptus timber).
- Seasoning of timber, setting up of solar and energy efficient desiccant based kilns.
- Plasticization of wood and bending techniques.
- Colouring and ammonia fumigation of wood.
- Use of Poplars and Paulownia spp. for pencil making.
- Macropropagation of bamboos.



Fig.56 Clonal propagation technology of *Podocarpus neriifolius* at FRI

- Jigat substitute.
- Natural dyes from forest biomass.
- Preparation of flocculants for backwater treatment in paper making.
- Process for detoxification of *Jatropha curcas* seed oil.
- Preparation of adhesive from biopolymers.
- Preparation and use of *Cassia tora* gum.
- Process for the preparation of katha from *Uncaria gambiar*.
- Process for the preparation of compost from the plant biomass.

Indian Plywood Industries Research and Training Institute (IPIRTI)

Introduction

The Institute, established in 1962 as a co-operative research laboratory at the initiative of the Indian Plywood Industry with participation of the Council of Scientific and Industrial Research is an autonomous body under the Ministry. Since its inception, the Institute has been closely associated with development of plywood and panel industry in the country and is instrumental in the growth of plywood industry. The Institute has established a strong relationship with the plywood & panel industries and continues to remain an industry driven organization,

Objective

The Institute has the following objectives

- Research on all aspects of production of sawn timber, manufacturing plywood and other allied engineered and reconstituted wood or lignocellulosic products, including improvement in manufacturing processes, machinery and appliances, Time and motion studies and standardization of the methods of working in factories.
- Imparting of technical education and training at undergraduate, postgraduate and other levels on the technology of forests products utilization including adhesives, paper laminates, synthetic finishing and machinery used in processing.
- Inspection, certification and testing of all forest products viz. plywood, wood, timber, hardboard, particleboard, chipboard, furniture, glue-lam, compreg, doors, panel doors, block board, flush doors, veneered panels, veneers, laminated panels, composite boards, and the products of allied trade and industry,
- Extension activities which include information dissemination through technical reports, quarterly news letters, research reports, participation in exhibitions, seminars, conferences, workshops, visit of scientists and technology transfer to the industry.

Besides the Institute has a vision to become an apex institution of international repute by equipping itself with concurrent state-of-the art technology and develop inhouse frontline expertise so as to carryout necessary R & D towards advising and/or providing competitive consultancy to the academia as well as wood & other lignocellulosic based panel industry sector regarding the conservation of natural forests through development and adoption of efficient technologies in the field of wood and panel

products from renewable fibres including plantation timbers and bamboo while meeting the vital needs of the developing society.

Progress of Activities Undertaken

Development of technology for construction of two storey bamboo housing system

IPIRTI has demonstrated the feasibility of creating affordable, safe, secure and durable shelter using bamboo in conjunction with other locally available materials. This type of housing system could be ideal for earthquake and other disaster prone areas. The project was taken up to study the feasibility of using bamboo and bamboo based products in the construction of multistoried buildings. A two



Fig.57 A two-storey bamboo housing system – a technology developed by IPIRTI, Bangalore

storey building was constructed for demonstration purpose at IPIRTI campus.

Development of Phenolic Resins for bonding high moisture content veneers

- The importance of this project was to bond high moisture content veneers for the manufacture of BWP grade plywood. This study would bring economy in plywood production by increasing the production capacity and input of less energy for drying.
- Tannin extended phenol formaldehyde resin formulation was developed to bond veneers of moisture content ranging from

14 % - 16%. The process parameters for pressing of plywood like open assembly time, press temperature and the curing time were worked out. The species studied were Silveroak and combination of Gurjan with Eucalyptus.

- The output of this project are
 - 25% cost reduction in the adhesive compared to conventional Phenol Formaldehyde resin adhesive.
 - An increase in the production capacity with shorter hot press cycle.
 - Economy in production by input of less energy for drying the veneers.
- With short supply and ever increasing price of phenol, tannin, it could find a choice as a substitute of phenol in phenol based wood adhesive being a renewable bio-material.

Development of modified flush door shutter using jute skin as face and jute stick/wood particle board as filler

The aim of this project was to develop flush door using agro residues like Jute. In this study Jute skin was used as face and the jute stick /wood particle board as filler in the flush door to reduce the cost. Resin formulations and process parameters were optimized on pilot plant scale and the flush door developed was found to be suitable for use in toilets.

Development of Adhesives from Bio-Materials

- The main objective of this project was utilization of Bio-materials obtainable from natural renewable source for development of adhesives for panel products.
- A tannin extended resin formulation was developed to manufacture Boiling Water Proof (BWP) grade plywood and the same was successfully demonstrated on industrial scale for commercialization
- Pilot plant trials of fragmenting the black liquor was carried out for the molecular weight ranging greater than 5,000–

10,000, greater than 20,000 and 10,000 – 20,000. The same were used for the partial replacement of the phenol with the percentages optimized on laboratory scale. It was found that molecular weight 5,000 – 10,000 black liquor replacement by 25, 30, 35% confirmed to BWP grade panels as per IS 848: 2006. Molecular weight of black liquor greater than 20,000 replacements in the adhesives confirmed to Boiling Water Resistant (BWR) grade only with 25% replacement. Work on the molecular fraction of 10,000 – 20,000 was being continued.

- The outcome of this project is
 - Reduction in the use of petroleum based chemicals, phenol, in phenol formaldehyde resin.
 - Reduction in cost and disposal of industrial wastes for better utilization, thereby reducing the pollution problems.

Setting up of demonstration unit for Bamboo mat manufacture in collaboration with M/s Sri Kateshwara Multipurpose and Credit Co-operative Society Ltd, Magadi

A demonstration unit for bamboo mat manufacturing was planned to be set up in collaboration with M/s Sri Kateshwara Multipurpose and Credit Co-operative Society Ltd, Magadi, Bangalore with technological assistance by the Institute

Machinery layout was prepared for M/s Sri Kateshwara Multipurpose and Credit Co-operative Society Ltd, Magadi. Construction activities taken up by the society to build the necessary sheds for the unit was nearing completion.

Development of Ridge Cap for Bamboo Mat Corrugated Sheets [BMCS]

- One unit in Meghalaya viz. M/s. Timpack (P) Ltd is presently manufacturing BMCS. Since use of BMCS have already started in the housing activities as roofing material, it



Fig.58 Bamboo mat ridge cap developed by IPIRTI, Bangalore

has become very much necessary to develop Ridge cap for covering the top/corners of roof made out of BMCS.

- The existing practice for covering roof top/corners of the buildings with BMCS is with 2 ply Bamboo Mat Board. The BMB which is a flat panel will have to be bent over the ridge of the roofing sheets at the top/side corners to cover the joints. In order to make the panel flexible for fixing it as Ridge cap, the thickness of panel should not exceed 2mm which possesses lesser strength and reduced durability. Therefore a 4 ply moulded ridge cap was developed to enhance the strength properties. In this connection Moulding Dies for ridge cap were fabricated, installed and commissioned in the existing Hydraulic hot press. Trial production was taken up. The quality of the product was found to be satisfactory.

Development of Pre-fab modular housing system using bamboo based composites

- Over the last two decades, disaster management has shifted its objectives from "Relief & Response" to "Prevention & Preparedness". Some of the issues that emerge again and again are the design and development of re-construction programme particularly in housing. Therefore, there is an urgent need in

developing prefabricated housing system in the context of handling emergency housing after disasters.

- A prototype and a model house pre-fabricated structure with attached toilet was designed and fabricated using ISA sections and INSTACOM as structural frames and Bamboo Mat based composites as wall cladding, flooring and roofing panels. A proto type house was exhibited in India International Trade Fare (IITF), in New Delhi. It was found that, there is a great demand for these types of houses in Northern part of India especially in hilly areas where construction of conventional houses is too costly.

Development of Particle Board from Plantation Grown Timbers like Eucalyptus and Poplar

The aim of this project was to utilize timber of plantation origin (soft and hard) to manufacture particle board. Optimization of process parameters in chipping, milling, drying, segregation of particles for face and core were completed. Resin formulation and the process of glue blending, mat forming and pressing parameters for making particle board were standardized for Poplar species with relevance to the Indian standard specification.

Infrastructure Development

- Computer controlled Thermal conductivity apparatus Computer controlled Thermal conductivity apparatus to determine thermal conductivity of panel products.
- Computer operated Smoke density apparatus Computer operated Smoke density apparatus for measuring relative amounts (Density) of smoke produced by the burning (combustion) or decomposition of wood and panel products from wood and other lignocellulosics under controlled and standardized conditions.

- Digital Multi gloss meter Digital Multi gloss meter to assess the aesthetic appearance of the coating/finish applied on panel products.
- Acoustic Pulse Testing Equipment Acoustic Pulse Testing Equipment for testing following acoustic properties of wood, wood based panel products and panels made from other lignocellulosics.
 - Sound absorption coefficient,
 - Acoustic impedance and admittance,
 - Transmission loss coefficient
- Paper impregnation plant for overlaying particle board, mdf and other panel products was established keeping in view of the larger demand for overlaying.

IPIRTI Centre, Mohali, Chandigarh

IPIRTI centre at Mohali was set up during the year to cater the needs of the Industries in the North West region as a Joint Venture project of IPIRTI Department of Industries & Commerce (DIC), Govt. of Punjab and Northern India Plywood, Manufacturer's Association (NIPMA). Various officials of DIC, Punjab were trained at IPIRTI, Bangalore on "Testing of panel products"

Indian Institute of Forest Management (IIFM), Bhopal

Introduction

The IIFM, Bhopal an autonomous institution of the Ministry and a management institute in the forestry sector, conducts research activities of applied nature. Drawing on the strength of diversified faculty, the institute promotes research projects of multidisciplinary nature. Some of the key research areas of the institute include Sustainable Forest Management, Management of Non-wood Forest Produce, Joint Forest Management and Community Forestry, Protected Areas and People, Marketing of NWFP and MIS, Forest Grazing and Livelihoods, Wetlands Solid Waste Disposal, Remote Sensing and GIS application in Forestry etc.

Progress of Activities Undertaken

- While the Institute completed 14 research projects and eight consultancy assignments, 21 research projects were being continued during the year.
- The study conducted on rehabilitation of lepers in Chhattisgarh state found that income generating activities through natural resource management particularly sericulture, floriculture, bamboo plantation and marketing, lac cultivation, farm forestry and nursery management are most effective and successful in rehabilitating the lepers.
- The study on marketing system of Non-Timber Forest Produce (NTFPs), found that the 'Sanjeevani' outlets formed by forest samitis by Madhya Pradesh Minor Forest Produce Federation function as an alternate system of marketing channel to save the collectors from getting exploited by the middlemen.
- The case study on forest grazing and livelihood revealed that access regulations for the common property resources are generally favourable to the settled community. The local communities and the forest officials attribute degradation of forest and fodder resources in the forest areas of Madhya Pradesh and Chhattisgarh to the migratory cattle/sheep herders.
- The process of documentation study on formal and informal institutions with reference to JFM in Chhattisgarh found that the women self-help groups promote active women participation in JFM and also support JFM implementation particularly related to protection and forest resource management.
- The study sponsored by Department of IT, Biodiversity & Biotechnology, Govt. of M.P. on the wildlife habitat connectivity between Kanha and Pench National Parks in Madhya Pradesh based on the derived movement model, has generated three corridor path scenarios to identify the most promising corridor route suited for Tiger movement between Kanha and Pench National Parks. The study showed two distinct Tiger movement zones between the two National Parks and recommends special attention through community based ecotourism to ensure corridor connectivity.
- The study on micro-enterprise development for NTFP collectors of Madhya Pradesh concluded that the socio-economic status (SES) of households and success of micro-enterprise had significantly close relationship and the entrepreneurs with higher SES score were found to be more successful as compared to those having low SES score.
- During the year, the Institute conducted 34 Management Development Programmes (MDPs) and 23 workshops/seminars, which include the programmes conducted through major long-term externally funded projects.
- The Institute, during the year brought out following publications
 - Articles in Journals – 22
 - Books – 1
 - Contributed Chapters in published Books – 7
 - Conference/Seminar Papers and Proceedings – 39
 - IIFM Publications including Research Reports and Monographs – 22
 - Teaching Cases developed – 2
- IIFM has been ranked 2nd best sectoral management institute in the country and stands within the top 15 national-level management schools which were evaluated based on different institutional parameters like faculty strength &

contribution, infrastructure, placement, training & research, national & international network, etc.

Wildlife Research

Introduction

Increasing human induced changes are posing new threats to conservation of wilderness resources today. The forests harboring wild animals are deteriorating in terms of quality and quantity (fragmentation) thereby threatening survival of species particularly mega/endangered species like elephants, tigers, rhinos, etc. As habitats shrink and populations become increasing isolated, factors like poaching, disease, population structure (sex-ratio) and stochastic events like droughts, fire and floods which once were part of natural processes causing manageable oscillations are now becoming limiting and critical factors. The situation is throwing enormous challenges to managers and policy makers alike particularly in managing the wildlife of the country.

Progress of Activities undertaken

- Wildlife research activities/projects envisaged in the National Wildlife Action Plan (2002-2016) adopted by the Government is the basis for delineating and providing thrust to the research programme. This is to support through scientific inputs to provide adequate protection to wildlife including multiple use areas, such as farm lands, waste lands, wet lands, coastal habitat etc., that form corridors linking up the protected areas and providing for genetic continuity between and among them.
- The grant is provided to research institutes, universities, NGOs and other organization of repute engaged in the wildlife research both at the field and laboratory levels. Major activities supported inter alia include taxonomies, population estimation, wildlife conservation & management, restoration of degraded ecosystems etc. which can



Fig.59 Asian elephants – require protection from poachers

provide input and facilitate in the conservation efforts of the Ministry.

- About 20 projects in various discipline of wildlife management are at various stages of implementation. The thematic group on Conservation and Management of Wildlife and Animal Welfare in its meeting held on October 31, 2007, identified 08 proposals for further peer reviewing for consideration of providing funds.
- The Wildlife Institute of India (WII) so far completed 128 research projects undertaken in different biogeographic zones of the country. The Institute also continued 55 projects at present.
- One of the major projects during the past

two years was on the "Monitoring of Tigers, Co-predators, Prey and their Habitats" entrusted to the Institute by the Project Tiger Directorate of the Ministry. This collaborative project between WII, Project Tiger Directorate and State Forest Department of 17 tiger states aimed at developing improved methodology for the evaluation of tiger population on an all India basis and its implementation. The project findings will result in country wide distribution and relative abundance mapping of tigers, co-predators and their prey. It will provide a basis for prioritization and evaluating habitats for tiger conservation and for guiding land use policy at varied scales of landscapes and small forest patches.