

Chapter VII

RESEARCH AND DEVELOPMENT IN
THE FORESTRY SECTOR





RESEARCH AND DEVELOPMENT IN THE FORESTRY SECTOR

The Ministry of Environment, Forests and Climate Change (MoEF&CC) is the nodal agency in the central government for planning, promoting, coordinating and overseeing environmental, ecological, forestry and wildlife policies and programmes. The primary concerns of the Ministry are implementation of policies and programmes relating to conservation of the country's natural resources including its lakes and rivers, its biodiversity, forests and wildlife, ensuring the welfare of animals, and the prevention and abatement of pollution. The Ministry is also the nodal agency for the United Nations Environment Programme (UNEP), United Nations Conference on Environment and Development (UNCED), South Asia Cooperative Environment Programme (SACEP) and International Centre for Integrated Mountain Development (ICIMOD). The broad objectives of the Ministry for forestry sector are conservation and survey of flora, fauna, forests and wildlife and afforestation and regeneration of degraded areas. There are many organizations under MoEF&CC that conduct research in forestry and related issues. These organizations are also engaged in developing technologies, mostly people-friendly that to be used by poor for subsistence and poverty alleviation.

7.1 INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION (ICFRE) AND ITS INSTITUTES

In 1878, Forest School in Dehradun was established. Government of India founded the Imperial Forest Research Institute on 5th June 1906 for taking forestry research in the country. In 1986, ICFRE was formed for undertaking the holistic development of forestry research through need based planning, promoting, conducting and coordinating research, education and extension covering all aspects of forestry of the country. On 1st June 1991, the ICFRE was declared an autonomous Council under the then Ministry of Environment and Forests. Presently, ICFRE is an apex body in the national forestry research system that promotes and undertakes need based forestry research and extension. The vision of the Council is to increase forest cover and enhancing forest productivity through operationalization of national forestry action programme and national forestry research plan. ICFRE has a pan India presence with its 9 regional research institutes and 5 centres in different bio-geographical regions of the country (Table 7.1.1.). Each Institute has specialised work domain and directing and managing research, extension and education in the states under their jurisdiction. The regional research institutes are located at Dehradun (Forest Research Institute, FRI), Jodhpur (Arid Forest Research Institute, AFRI), Shimla (Himalayan Forest Research Institute, HFRI), Hyderabad (Institute of Forest Biodiversity, IFB), Coimbatore (Institute of Forest Genetics and Tree Breeding, IFGTB), Ranchi (Institute of Forest Productivity, IFP), Bengaluru (Institute of Wood Science and Technology, IWST), Jorhat (Rain Forest Research Institute, RFRI) and Jabalpur (Tropical Forest Research Institute, TFRI) and the regional research centres are at Allahabad, Agartala, Aizawl, Chhindwara and Visakhapatnam. Presently, there are 156 ongoing research projects (plan projects) and 98 externally aided projects. For extending forestry knowledge to the common man, ICFRE runs 26 Van Vigyan Kendras and has 9 Demo villages (one under each institute). Moreover, 18 Indian universities are running forestry courses with the support of council.

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Table 7.1.1. ICFRE institutes and their jurisdiction states

Institute	Establishment year	Jurisdiction state	Website
AFRI	1988	Rajasthan, Gujarat and Dadra and Nagar Haveli	http://afri.icfre.org/
FRI	1906	Punjab, Haryana, Chandigarh, Delhi, Uttar Pradesh and Uttarakhand	http://fri.icfre.gov.in/
HFRI	1977	Himachal Pradesh and Jammu and Kashmir	http://hfri.icfre.gov.in/
IFB	2012	Telangana	http://ifb.icfre.gov.in/
IFGTB	1988	Tamil Nadu, Kerala, Andaman & Nicobar, Lakshadweep and Puducherry	http://ifgtb.icfre.gov.in/

Institute	Establishment year	Jurisdiction state	Website
IFP	1993	Bihar, Jharkhand, Sikkim and West Bengal	http://ifp.icfre.org/
IWST	1938	Andhra Pradesh, Karnataka and Goa	http://iwst.icfre.org/
RFRI	1988	North-east India	http://rfri.icfre.gov.in/
TFRI	1988	Madhya Pradesh, Chhattisgarh, Maharashtra and Odisha	http://tfri.icfre.org/

Objectives

- To undertake, aid, promote and coordinate forestry education, research and their application
- To develop forestry extension programmes and propagate the same through mass media, audio-visual aids and extension machinery
- To develop and maintain a National Forest Library and Information Centre
- To act as a clearing house of research and general information related to forests and wildlife
- To provide consultancy services in the field of forestry research, education and allied sciences
- To undertake other jobs considered necessary to attain these objectives

Achievements

- A. *Environment Impact Assessment (EIA) and related Consultancy Projects*
1. Hydropower projects on EIA and EMP, biodiversity assessment, Cumulative EIA of river basin, CAT plans, etc.
 2. Mining projects on EIA, biodiversity assessment, R&R plans, comprehensive EMP, carrying capacity, environmental audit of coal mines, etc.
- B. *Climate Change & REDD+*
1. ICFRE provides technical and policy support to MoEF&CC in respect of UN (Rio) Conventions related to UNFCCC, CBD and UNCCD.
 2. Developing protocols for measurement, reporting and verification (MRV) and safeguards information systems (SIS) for operationalising REDD+ (Uttarakhand and transboundary-ICIMOD projects)
- C. *Other Important Projects/ Assignments*
1. Sustainable Land and Ecosystems Management (SLEM) – World Bank-GEF
 2. UNCCD Reporting (5th & 6th)
 3. NATCOM of UNFCCC (Reporting)
 4. Assessment of Demand and Supply of Medicinal Plants (NMPB)
 5. Bamboo Technical Support Group (BTSG-ICFRE) to National Bamboo Mission
- D. *Enhancing Green Cover and Wood Production*
1. Development of high yielding bamboo clumps of 10 species with >20% yield gain.
 2. High yielding casuarina germplasm have been planted over 9,000 ha.

- E. *Enhancing Livelihoods and Rural Economy*
1. A bio-polymer based and environmentally safe FRI Jigat for *Agarbatti* making (*Jivi Kalp*) has been patented. Technology transferred to *Anand Agarbatti*, Nagpur.
 2. Production of transgenic salt tolerant eucalypts leading to improved rural livelihoods.
 3. Development of value added products of bamboo shoots for enhancing income of rural communities.
- F. *Biodiversity Conservation*
1. A Germplasm Bank of Red Sanders with 500 accessions collected from eight different wild populations is established at Hyderabad.
 2. Sustainable guggul tapping method developed towards conservation of this threatened species.
 3. Germplasm of highly endangered '*Ashtavarga*' species collected and under multiplication trials.
- G. *Commercial Products*
1. Techniques to make Wood Polymer Composite with lantana and bamboo standardised in PP mode (patent filing under process).
 2. Developed stronger, aesthetically superior thermally modified wood of 4 species- Casuarina, Eucalyptus, Su-babool & Melia
 3. Bio-adhesive from defatted sal seeds developed and it has good potential to use in indoor wood and paper work (patent filed).
- H. *Services to Stakeholders*
1. Supporting SFDs in (i) identification and management of diseases/ insect pests of forest trees (deodar, willow, shisham, chir pine) and nurseries (ii) floristic and ecological studies for preparation of Working Plans.
 2. Providing technical support to farmers for growing trees and medicinal plants.
 3. Supporting wood based industries in identification of wood samples and testing wood properties.
 4. Accreditation and providing technical support to universities engaged in forestry education.
 5. Capacity building programmes for officials from different line departments, judiciary, disaster management departments.
- I. *Patents*
- Five patents have been granted to different institutes of the council and 10 are in pipeline.

7.2 INDIAN PLYWOOD INDUSTRIES RESEARCH AND TRAINING INSTITUTE (IPIRTI)

IPIRTI, an autonomous body of the MoEF&CC is an internationally recognized R&D institution with headquarters at Bengaluru. It was established in the year 1962 as a research laboratory of CSIR at the initiative of the Indian Plywood Industries. Since the inception, the Institute has been closely associated with the development of plywood and panel industry from its infant stage. The Institute continues to remain an industry driven organization with strong relationship and linkages with panel industries and is

the only Institute of its kind in the country. IPIRTI Field Station, Kolkata was established in the year 1963 and IPIRTI Centre, Mohali, Punjab in the year 2008 to meet the testing, training and extension requirements of those regions.

IPIRTI is basically mandated to carry out research and development, training and education, testing and standardization and extension activities in the field of wood and panel products from all sorts of lignocelluloses including bamboo and agro-residues. Multidisciplinary research projects are taken up based on the problems identified by the industry and inputs received from scientists and other interested stake holders. Major achievements of the Institute can be broadly classified as:

1. Development of processes for various resin systems.
2. Development of layered composites.
3. Development of non-wood products.
4. Protection and enhancement of service life of wood and panel products.
5. Development of instruments, accessories and equipments.

Table 7.2.1. Summary of activities of IPIRTI from 2010-11 to 2016-17

Year	Research and development		Training and education		MoU's	Patent filed
	In-house projects	Sponsored projects	PG diploma students	Short term training conducted		
2010-11	32	5	22	0	5	2
2011-12	32	9	20	24	4	0
2012-13	35	10	17	23	8	1
2013-14	37	13	26	16	5	8
2014-15	37	13	22	17	5	8
2015-16	39	36	18	18	18	9
2016 17	50	39	30	15	22	5

Source: IPIRTI, Bengaluru

7.3 STATE FOREST RESEARCH INSTITUTES (SFRI)s

These institutes are located in different parts of India and have broadly catered to the respective states. Information generated by them has high regional value. Some of the major institutes are as follows:

7.3.1 SFRI, Kanpur

Forest research in United Province (present Uttar Pradesh), started way back in 1918 with the appointment of Mr. E.A. Smithies of Indian Forest Service as State Silviculturist. The need for intensive research to increase the overall productivity of the forest was realized and as a result State Forest Research Laboratory was established at Kanpur in 1970. Subsequently, this laboratory was upgraded into the SFRI in 1993. The research wing of Uttar Pradesh Forest Department including the SFRI, Kanpur has following thrust areas:

- Increasing productivity of forest through tree improvement programme.
- Supply of quality seeds.
- Development of suitable planting techniques for refractory areas.
- *Ex-situ* as well as *in situ* conservation of medicinal plants.
- Development of suitable agro-forestry models.
- Ecology and pollution related studies.
- Dissemination of result through training, publications of technical bulletins as well as lab to land leaflets.

Research wing has developed new technologies for clonal multiplications, vermicomposting and afforestation of degraded lands in Uttar Pradesh. It has also developed new technologies for pollution abatement through afforestation.

Achievements

1. Improvement in nursery technology, production of quality seedlings and clonal multiplication of tree species like bamboo, eucalypts, shisham, etc.
2. Development of new poplar clones and research of suitability of poplar clones in different agro-climatic zones.
3. Establishment of seed production area, seedling seed production area and clonal seed orchard of *Acacia nilotica*, *Bombax ceiba*, *Dalbergia sissoo*, *Eucalyptus hybrid*, *Prosopis juliflora* and *Tectona grandis*, etc. Evaluation of azadirachtin-rich neem seeds available in different ecosystems. Supply of quality seed to different forest divisions.
4. Suitable models for afforestation of saline- alkali soils (usar), ravines and brackish water areas of Uttar Pradesh.
5. Determination of calorific values, wood density and burning properties of 100 tree species.

7.3.2 SFRI, Jabalpur

Following the recommendations of 10th Silvicultural Conference held at Dehradun in 1961, the Institute came into existence on 27th June 1963 for the scientific development of forestry sector in Madhya Pradesh state. It was granted autonomy on 29th October 1994 and was registered as a society under M.P. Societies Registration Act on 2nd August 1995. It is dedicated to research on tropical forestry, environment and biodiversity conservation. The vision of SFRI is to function as nodal centre of research in forestry and to provide scientific support to the state and its people on matters related to forestry, wildlife and climate change with emphasis on conservation, sustainable utilization and scientific management of natural resources. Over the years, the institute has developed as a research, educational, training and consultancy organization (Table 7.3.2.1). The research aims of the institute are as follows:

- Conservation of forests and forest resources - soil, water and floral and faunal diversity.
- Preparation of inventory and biodiversity assessment in Madhya Pradesh.
- Enhancement of productivity of natural forests and plantations.
- Mass production of high fruit yielding forest tree species through biotechnological approaches.
- Efficient and sustainable utilization of forest resources and forest products - timber and NTFPs.
- Expansion of tree cover.
- Documentation of existing agro-forestry systems for different agro-climatic conditions.

- Sustainable management of forests involving forest dependent communities and people's participation.
- Monitoring and evaluation of wildlife and their habitats.
- Climate change and its impact on livelihood of rural communities.

Table 7.3.2.1. A brief of activities of SFRI, Jabalpur (2014 onwards)

S. no.	Research branch	No. of project completed		No. of on-going project		No. of newly initiated project		No. of regular activities
		External	Internal	External	Internal	External	Internal	
1	Biodiversity and medicinal plants	7	1	16	3	4	1	6
2	Forest botany	2	0	11	0	3	0	3
3	Forest ecology and environment	11	0	19	2	3	0	0
4	Forest genetics, plant propagation and biotechnology	5	0	11	0	2	1	3
5	Forest mensuration & statistics	2	0	3	0	0	0	4
6	Seed technology	10	3	9	4	1	0	6
7	Silviculture	6	1	6	4	2	0	4
8	Social economics and marketing	11	0	15	1	6	0	0
9	Tree improvement	5	0	11	0	3	0	32
10	Wildlife	5	1	9	0	0	2	0
11	Agro-forestry	0	0	2	0	0	0	0

Source: Official website of SFRI, Jabalpur.

7.3.3 Kerala Forest Research Institute (KFRI)

KFRI, founded in 1975, is conducting research on tropical forests and forestry under the Kerala State Council for Science, Technology and Environment (KSCSTE). KFRI became a part of KSCSTE along with five other R&D centers of the state, when it was constituted in 2002. It has about 25 scientific staff and 100 supporting and administrative staff working in 17 research departments (grouped as nine programme divisions). KFRI is accredited as research center of the FRI Deemed University Dehradun, University of Calicut and Cochin University of Science and Technology for enrolling students for research programme leading to award of a Ph.D. degree. Apart from this, KFRI maintains facilities for long-term

monitoring of environmental process such as permanent plots and weather stations. Secretariats of two international networks funded by FAO, namely, TEAKNET and APFISN, are housed in KFRI. Institute staff over the period of three decades of their field visits to remote forest localities across India has accumulated impressive collections of plant and animal specimens, and pedological samples which are organized as: Arboretum, Bambusetum, Cane and Palmetum, Herbarium, Medicinal plants, Orchidarium, Soil museum, Xylarium, Wildlife museum and Teak museum. The guided nature trails and thematic displays on forestry and environment with the extension and training division deserve special mention.

Part of the information generated by scientists have appeared in the form of 380 research reports, 75 doctoral dissertations, 75 books, 30 information bulletins, 10 softwares/CDs and 1,400 papers in scientific journals. One such instance is a study on the impacts of selection felling and assessment of regeneration status in logged forest areas. The findings of the study played significant role in minimizing felling in natural forests. Similarly, studies at KFRI on the taungya system of plantation raising and the consequent site quality degradation lead to policy decision for discontinuing taungya system. Apart from these KFRI has carried out EIA of several development projects including, multipurpose river valley projects, rail and road communication projects, etc. Through these exercises the Institute could actively intervene in the policy intervention and environmental management. Some of the research highlights (<http://www.kfri.res.in/milestones.asp>) are as follows:

1. *Forest seed on demand*: KFRI joined hands with the Kerala Forest Department and established the Kerala Forest Seed Centre (KFSC), which procures, processes and supplies quality seeds of teak and other plantation species.
2. *Promoting bamboo resources and livelihood of traditional communities*: Bamboo and rattan having tremendous importance to the livelihood of traditional communities was a neglected resource. By taking up an array of research projects exploring into the biology, propagation, extraction, preservation, utilization, economics and value addition of bamboo products, KFRI has been able to help the communities for improving their livelihood. KFRI is now in the forefront of research and training on bamboos earning recognition by INBAR and National Bamboo Mission.
3. *Eco-restoration and ecosystem rehabilitation*: Starting from the establishment of greenbelt around Cochin Refineries, through the establishment of bio-shield along a 32 km long tsunami affected coastline at Vatanappally, phyto-remediation of pollution at Nitta Gelatin Factory (Kadikulam) using bamboo belts, afforestation of Ayyampilly Hills and river bank stabilization at Karassery Panchayath, KFRI exposed the immense potential of green solutions for habitat restoration.
4. *Biodiversity documentation and wilderness conservation*: Situated right within the hill folds of the Western Ghats, KFRI is now a valuable repository of information on the rich biodiversity of the region. Monographs on individual ecosystems of the state such as Sholas, Grasslands, Wetlands, Myristica swamps and Moist deciduous forests by the scientists of the Institute are important baseline documents. KFRI has been instrumental for the study of the biodiversity of most of the protected areas of the State. Floras and wildlife manuals of the sanctuaries and national parks of the state were largely brought out by KFRI. Vegetation maps and analysis of the forest stands were also accomplished. This information is being utilized for the management of the protected areas by the forest department. KFRI also provides the technical support for analysis of the data from State-wide Wildlife Census conducted periodically.

5. *Expert systems for taxonomic identification of flora of Kerala:* KFRI is the first to bring out a comprehensive monograph of the flora of Kerala. The Handbook to the Trees of Kerala, a computer aided software for tree identification and its image bank form an unparalleled information source on the floral wealth. Identifying conservation of the rare species as a top priority KFRI undertook a series of species recovery programmes. The Institute efforts on survey, documentation and conservation of the rare, endangered and threatened plants of the state, particularly trees, has gained high appreciation. Since its establishment, KFRI has documented nearly 70 species new to science.
6. *Ecology of Invasive:* The fact that some of the exotics can turn out really problematic was a later realization in the history of plant and animal introductions. KFRI was the first to organize national seminars on the Western Ghats and the problem of the exotics and to communicate the implications to both forest managers and the public.

7.3.4 SFRI, Itanagar

Arunachal Pradesh situated in the eastern Himalayan range of our country has the largest forest cover next only to Madhya Pradesh. With over 82% geographical area under forest, it has an unparalleled biodiversity in the country accounting for over 50% of the floral wealth and equal number of animal diversity that give this territory the status of one of the 'Biodiversity Hotspots' in the world. This strategically important hilly state has about 16 major rivers and about 150 rivulets/ watersheds that make the state evergreen. This varying climatic situation has favoured the luxuriant growth of vegetation and various forest types. There are over 20 forest types ranging from tropical to alpine situation. A great number of tribes, 25 major tribes and over 100 sub-tribes, inhabit these hills and harness the natural resources taking advantage of the plethora of forest products. With recent developments and changing life style, there is evidence of mounting pressures on the natural ecosystem. This opens up challenges for managing the forest and environment. Systematic research and studies are indispensable for proper understanding, development, management and sustainable utilization of forests in the state. This hilly state's economy revolves around the forests. The abundance of forest resources particularly the wide range of NTFPs has prompted to harness the NTFP in a more sustainable and eco-friendly manner. With the increasing population, day by day there is an increased demand, for forest land and resources. Various factors both natural and man-made cause a serious threat of depletion and degradation of natural forest cover of Arunachal Pradesh. Hence, systematic research and studies are indispensable for proper understanding, development and management of the forests of the state. This warrants higher scientific inputs and institutional arrangement.

Recognizing the need of research and scientific management in the rapidly developing forestry of the state (erstwhile Union Territory) Government of Arunachal Pradesh established a Silviculture Division under the Department of Environment and Forests during 1972. To cope with R&D activities an Institute, namely, 'Van Vigyan Kendra' (VVK) was established at Chessa forest range in the year 1984. Later, the one and only SFRI in north east India was established in 1993 at Itanagar by amalgamating the existing VVK and Orchid Research & Development Center, Tippi. Identifying local needs, the Institute aims to significantly increase the understanding and information levels on biodiversity, its conservation and sustainable use recognizing the contributions of local and indigenous communities to the conservation and sustainable utilization of biological diversity through traditional knowledge, practices and innovations. It also aims to integrate strong elements and guidelines on equitable sharing of benefits with such people arising from the utilization of their knowledge, practices and innovations. In tune with the objectives, the institute has identified areas of work and drawn up different projects / programmes as follows:

- Study biological diversity and maintain and evaluate the germplasms useful in forestry and allied subjects.
- Undertake studies on ex-situ and in-situ conservation of natural resources of flora and fauna.
- Evolve appropriate agro-forestry techniques for restoring degraded forests and environment and to provide alternative means of earning and upliftment of rural economy.
- Breeding, improvement and micropropagation of native as well as suitable exotic species.
- Provide training and extension services to the foresters, researchers and entrepreneurs engaged in forestry activities, forest-based industries, government agencies, local farmers and CSOs.
- Create a data base on forestry and allied subjects.

Achievements

1. Botanical Survey in remote areas highlighting the importance of biodiversity in sustainable development.
2. Establishment of first ever clonal seed orchards of tree species.
3. Establishment of largest bambusetum and canetum in north east India.
4. Vegetative propagation techniques of *Taxus* and *Illicium griffithi*.
5. Application of tissue culture technology and standardization of protocols for 65 orchid species and hybrids apart from 4 tree species.
6. Development of 5 new registered hybrids of orchids.
7. Largest collection of orchid species (over 550 species) in India.
8. Establishment of first ever Orchid Sanctuary in India.
9. Transfer of technology from lab to land and promotion of private venture in orchid farming.
10. Development of orchids as a supplemental economic resource for the State.
11. Screening of forest trees for oil.
12. Development of SALT Model on hill slopes
13. Development of indigenous technique for control of *Michelia champaca* pests in nursery.
14. The second Asian collection of an endangered snakes, viz., *Ophiurus erythrorachis*.
15. First ever attempt on ethno-zoological studies.
16. Establishment of Referral Zoological Museum.

7.4 WILDLIFE INSTITUTE OF INDIA (WII)

WII was established in 1986 as an autonomous institute of MoEF&CC. The Institute has emerged as a premier training and research institute in the field of wildlife and protected area management in South and South East Asia. Its primary mandates are:

- To carry out scientific and applied research on various issues of wildlife and biodiversity conservation.

- To develop wildlife science as a discipline through academic activities.
- To build capacity in the field of wildlife management and conservation planning.
- To provide technical inputs to MoEF&CC and other international organizations.

The institute has been generating quality information and knowledge products in the field of wildlife sciences through research (Table 7.4.1) and mainstreaming it in the capacity building programmes for various target groups and provides advisory support to central and state governments.

Table 7.4.1. Year-wise details of completed research projects in WII

Year						
2010 - 11	2011 - 12	2012 - 13	2013 - 14	2014 - 15	2015 - 16	2016 - 17
13	19	18	8	17	11	19

Source: WII, Dehradun; wii.gov.in.

Achievements

1. Participation of WII in COP-11, Hyderabad, October 1-19, 2012. Hyderabad hosted the COP-MOP6 Cartagena Protocol on Biosafety and XI Conference of Parties (COP11) on Convention on Biological Diversity. It was organized by MoEF&CC, GoI. The Institute participated in an 'Interactive Fair on Biodiversity' during COP-MOP6 and COP 11 held at the HICC-HITEX Complex in Hyderabad during October 1-19, 2012.
2. Implementation of Kailash Sacred Landscape Conservation and Development Initiative, November 11-16, 2013.
3. Preparation of Fifth National Report to the Convention on Biological Diversity and Updation of National Biodiversity Action Plan of India.
4. Indo-German Biodiversity Programme (GIZ).
5. Biodiversity Conservation and Rural Livelihood Improvement Project (BCRLIP).
6. All India survey on dugongs and their habitats.
7. Satellite Tracking of Amur falcons (*Falco amurensis*) from Nagaland, India.
8. Establishing a Centre for World Natural Heritage Management and Training for the Asia and Pacific Region as a UNESCO Category 2 Centre at the WII, Dehradun.
9. India's first Tiger Cell has been set up at WII, Dehradun on 6th August 2016.

WII has also provided about 25 consultancy services to different states of India as well as to other neighbouring countries. Institute has also taken up additional responsibilities assigned by the MoEF&CC, GoI for implementation of activities under National Wildlife Action Plan 2002 - 16. Currently, a country wide tiger and prey base estimation programme is underway in WII as per the requirement of Project Tiger Directorate.

7.5 FOREST SURVEY OF INDIA (FSI)

Forest being an inherent component of our ecosystem, needs a scientific way of their management, for which the Remote Sensing (RS) and Geographical Information System (GIS) technologies play a major role in conservation, management and monitoring of valuable forestry resources. As of today, RS and GIS

technology have a well-established role in forest resource assessment and providing reliable and valuable data on forests to the community. FSI assesses the forest cover of the country on a two-year cycle using satellite data in a wall to wall mapping mode. The main objective is presentation of the information on forest resources of the country at state and district levels and to prepare forest cover maps on 1:50,000 scale with the spatial resolution of 23.5m. With the help of FSI, MoEF&CC is developing a uniform inventory design for information of forest cover, area of plantation, growing stock and related parameters like biodiversity, etc. For effective implementation of the monitoring mechanism, certain steps such as geo referencing of the afforestation areas and digitisation of forest boundaries have been taken. Since 1987, the process has evolved with the evolution of technology of RS. The progress of RS technology in forest cover mapping is given in the Table 7.5.1. Starting from a spatial resolution of 80 M and a scale of 1:1 M, the technology has increased the precision to 23.5 m and a scale of 1:50,000. In the last three decades (1987 to 2017), it has resulted in decrease of the minimum mappable area of 400 to 1 ha.

Table 7.5.1. Progress of RS technology in forest cover mapping

Year/Period	Data	Sensor	Spatial resolution	Scale	Minimum mappable unit (ha)	Mode of interpretation
2013	2010-11	IRS P6-LISS-III IRS-Resourcesat-2 LISS III	23.5 m	1:50,000	1	Digital
2015	2013-14	IRS P6 –LISS-III IRS- Resourcesat -2 LISS III	23.5 m	1:50,000	1	Digital
2017	2015-16	IRS- P6-LISS-III IRS- Resourcesat-2 LISS III	23.5 m	1:50,000	1	Digital

Source: State of Forest Report 2017, Forest Survey of India, Dehradun

Following two are the new initiatives taken by FSI:

1. *e-Green Watch*: It is designed and developed as a web-based, role-based workflow applications and integrated information system which shall enable automating of various functions and activities related to monitoring and transparent use of CAMPA funds and various works sanctioned in the Annual Plan of Operations (State CAMPA) approved by the state authorities.
2. *Decision Support System*: It is a web-GIS based application which has been developed to provide qualitative and quantitative information with respect to forest area. It enables decision makers to take a well-informed decision based on the information generated by the system. This system helps in a big way for taking decisions with respect to proposals under Forest Conservation Act (FSI, 2015). It uses different spatial layers for providing information on different issues related to forest and wildlife areas such as 'Forest Cover Mapping of Tiger Reserves' and 'Real Time Monitoring of Forest Fires'.

7.6 INDIAN INSTITUTE OF FOREST MANAGEMENT (IIFM)

IIFM, located at Bhopal, was founded in 1982 by then MoEF with financial assistance from the Swedish International Development Cooperation Agency and course assistance from the Indian Institute of Management, Ahmadabad. It is one of the leading institutes in the field of management education in forest and allied sectors which aims to provide leadership in professional forestry management for environmental conservation and sustainable development of ecosystems. The Director of the Institute, as its executive head, supervises the activities of the faculty which are directly involved for the various courses like Post Graduate Diploma in Forest Management, Doctoral level Fellow Program in Management, M. Phil (Natural Resource Management), Ph. D. (under FRI Deemed University) under the nine departments of institutes, viz., Communication and Extension Management, Ecosystem and Environment Management, Environment and Developmental Economics, Financial Management, Human Resource Management, Information Technology and Quantitative Techniques, Marketing Management, Sociology and Community Development and Technical Forestry. There were 30 faculty members in the institute as on 31.08.2019.

Research is one of the important activities at IIFM through which the Institute constantly strives to develop frontiers of knowledge in various areas of forest and natural resource management. Research activities at the institute are focused on finding such applications of management concepts, tools and techniques that can assist a forest manager in achieving effectiveness and efficiency in forestry operations. The status of the research projects (completed and ongoing) funded by various agencies under the study period is given in Table 7.6.1.

Table 7.6.1. Status of research projects in IIFM

S. no.	Year	No. of research project	No. of publications
1.	2010-11	09	NA
2.	2011-12	NA*	NA
3.	2012-13	15	NA
4.	2013-14	04	NA
5.	2014-15	04	45
6.	2015-16	07	40
7.	2016-17	8	51
8.	2017-18	2	52

Source: IIFM, Bhopal; <http://iifm.ac.in/category/research-projects/>, accessed on 31.10.2019.

*NA: Data not available.

7.7 BOTANICAL SURVEY OF INDIA (BSI)

BSI is the apex research organization under the MoEF&CC for carrying out taxonomic and floristic studies on wild plant resources of the country through survey, documentation and conservation. It was established on 13th February, 1890 with the basic objective to explore the plant resources of the country and to identify the plants species with economic virtues. Sir George King, the then Superintendent of the Royal Botanic Garden, Calcutta was appointed as first ex-officio Honorary Director of the BSI. After independence in 1954, the department was reorganized by Government of India as a part of scientific institutions of the country. During successive plan periods, the functional base of BSI was further

expanded to include various new areas such as inventorying of endemic, rare and threatened plant species; studies on fragile ecosystem and protected areas; multiplication of EET plants species, wild ornamentals, etc., in botanic gardens and orchidaria; documentation of traditional knowledge associated with plants and development of national database of herbarium specimens/live collection/botanical paintings/illustration, plant distribution and nomenclature, plant uses, etc.

Objectives

- Exploration, inventorization and documentation of phytodiversity (including non-flowering plants) in general and protected areas, hotspots, fragile ecosystems and sacred groves in particular; Publication of national, state and district floras.
- Identification of Red list species and species rich areas needing conservation; *Ex situ* conservation of critically threatened taxa in botanical gardens.
- Survey and documentation of traditional knowledge (ethno-botany) associated with plants.
- Develop national database of Indian plants, including herbarium specimens, live specimens, botanical paintings, illustrations, etc.

Achievements

A good number of flowering plants (7.29%), non-flowering plants (13.83%) and others (14.58%) have been reported from India by BSI (Table 7.7.1) which is 11.90 % of the global biodiversity. It is quite handsome in terms of enumeration.

Table 7.7.1. Total number of plant species (including virus, bacteria, algae, fungi and lichens) and their status in India

S. no.	Type	Number of known species		% of occurrence in India	Number of endemic species	Number of threatened species
		World	India			
I	Flowering plants					
1.	Gymnosperms	1,021	79	7.73	12	7
2.	Angiosperms	2,68,600	18,386	6.84	4,303	1,700
II	Non-flowering plants					
1.	Bryophytes	16,236	2,748	16.92	629	80
2.	Pteridophytes	12,000	1,289	10.74	66	414
III	Others					
1.	Virus and Bacteria	11,813	1,170	9.90	Not known	Not known
2.	Algae	40,000	7,357	18.39	1,924	Not known
3.	Fungi	98,998	15,115	15.26	4,100	580
4.	Lichen	17,000	2,511	14.77	520	Not known
Total		4,65,688	48,655	-	-	-

Source: Chapman (2009) and Singh and Dash (2017).

7.8 ZOOLOGICAL SURVEY OF INDIA (ZSI)

ZSI is one of the renowned organization of MoEF&CC. It was established on July 1, 1916 with the aim to promote survey, exploration and research leading to the advancement of available knowledge of various aspects of exceptionally rich life of the erstwhile 'British India Empire'. It is contributing significantly in the field of research by providing scientific basis for the conservation and sustainable utilization of animal diversity through survey inventory, documentation, taxonomic research and creating environmental awareness. The survey has its genesis in the Museum of the Asiatic Society of Bengal (1814-1875) and the Zoological Section of the India Museum (1875-1916) in Kolkata. To meet the challenges of biodiversity conservation, sustainable utilization and dissemination of knowledge on faunal diversity to all stake holders, since 2010-11, the Survey acquired modern tools and techniques such as scanning electron microscopes, digital stereo zoom microscopes, GIS tools, Data basing tools and the DNA bar coding technology, augmenting the research infrastructure of ZSI. Since 2009, every year ZSI compiled and published animal discovery. Till now eight Animal Discoveries have been published. Animal Discoveries are the only authentic source of faunal discoveries of India.

Objectives

- Exploration, Survey, Inventorying and Monitoring of faunal diversity in various States, Ecosystems and Protected areas of India.
- Taxonomic studies of all faunal components collected.
- Periodic review of the Status of Threatened and Endemic species.
- Preparation of Red Data Book, Fauna of India and Fauna of States.
- Bioecological studies on selected important communities/species.
- Preparation of databases for the recorded species of the country.
- Maintenance & Development of National Zoological Collections.
- Training, Capacity Building and Human Resource Development.
- Faunal Identification, Advisory services and Library Services.
- Publication of results including Fauna of India and Fauna of States.
- Environmental Impact Studies.
- Maintenance and Development of Museum at Headquarters and Regional Stations.
- Development of ENVIS and CITES Centers.
- Research Fellowship, Associateship and Emeritus Scientist Programmes.
- Collaborative research programmes on Biodiversity with other Organizations.
- GIS and Remote Sensing studies for animal diversity as well as for selected threatened species.
- Chromosomal Mapping and DNA finger printing.



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