Development of Effective Training Program for the Specialists of Developing Countries in Wood Science

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1. Visiting Professor of International Cooperation Center for Agricultural Education (ICCAE), Nagoya University, Japan: April 20 - July 19, 2001

FOREWORD

This treatise serves as a document prepared by the author as a Visiting Fellow during the period 20 April - 19 July 2001 at the instance of the International Cooperation Centre for Agriculture Education (ICCAE), Nagoya University. The theme of the visiting programme is "Developing effective training programme for the specialists of developing countries in the field of wood science and technology". The document was prepared, in line with the rationale of ICCAE, presenting briefly the scenario of forestry education in the Asia Pacific Region in general and the Indian situation of forestry/wood science in particular appending with available information on course curricula.

The International Cooperation Center for Agricultural Education (ICCAE) was established in 1991 with the generous support from Nagoya University, the Ministry of Education, Science, Sports and Culture (Monbusho), the UN Centre for Regional Development, Japan International Cooperation Agency (JICA) and the Aichi Prefectural government. As the theme is to focus on developing training programme in wood science, the concerned lead/core institutions and the availability of human resources are indicated in the Appendix to facilitate the future networking. As the attempt was made based on the readily available sources within a relatively short period, it is not necessarily exhaustive and complete. This should be updated as and when more information is forthcoming.

The rationale of ICCAE includes:

- There is a large demand for international cooperation in the field of agricultural education in the context of increasing poverty, food shortage and environmental devastation in many developing countries.
- Develop human resources and create a new strategic science, by unifying the intellectual power, for developing a long-term plan for building a database for researchers and for developing various networks among agricultural schools in Japan.
- It will serve as the international center for developing human resources through agricultural education with the continued support and cooperation received from various national and international organizations.

I take this opportunity to sincerely thank Professor Hiroyuki Takeya, Director of ICCAE for inviting me, as a visiting fellow, to participate in this challenging programme that also provided me a window to look into the Japanese culture. Particular gratitude is expressed to the staff of ICCAE, particularly Professor Katsuhiro Kitagawa, Professor Tetsuo Matsumoto, Associate Professors Mutsuyo Kadohira and Yutaka Takeda who, with their traditional Japanese hospitality, not only made me to "feel at home" but also provided various opportunities for closer interactions and for looking deeper into the values of the rich cultural heritage of Japan. I am also deeply indebted to my long-associated colleagues: Professor Takashi Okuyama, Hiroyuki Yamamoto, Associate Professor and MasatoYoshida, Assistant Professor of Biomaterial Physics Laboratory, Graduate School of Agricultural Sciences for extending generous study facilities, scientific interactions and close cooperation throughout my stay in Nagoya for making visit very fruitful and memorable. At last but not least, my sincere thanks are due to Ms. Kyoko Kato, Ms. Emiko Kawamura, Ms. Ikawa and Dr. Daigo Makihara for helping me in various ways to feel comfortable. I am also indebted to Dr. J. K. Sharma, Director, Kerala Forest Research Institute India for granting me leave to complete this assignment.

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EXECUTIVE SUMMARY

Lack of adequate training is recognized as one of the major causes of mismatch of the technology with the real needs of end-user communities particularly in rural areas of many developing countries. While attempting to develop an effective training programme for specialists of developing countries in the field of wood technology, the scenario of forestry education was briefly reviewed in the Asian Region in general and Indian situation of forestry/wood science in particular.

Existing system of forestry education

The brief review of forestry education in developing countries of Asian Region reveals that inadequacy of staff strength is a constraint in countries like India and Pakistan. However, staffing pattern was noted to be adequate and often superfluous causing managerial problems in some countries, viz. China, Indonesia, Malaysia and Philippines. The short-term courses being offered in the region include: computer application in forestry, quarantine training, landscape gardening, satellite remote sensing and aerial photo interpretation, resource and environmental conservation, forestry planning, agroforestry, watershed and wildlife management, forest products engineering, timber identification, social forestry and forestry extension. Variability of forestry education curricula in the region is often so wide that there is a need to standardize the professional forestry courses to achieve a degree of comparability and commonality. Unlike many other countries, in India the forest education in higher level was under the control of Government of India while in lower levels State Governments managed the schools.

The major problems identified in the existing system are given below:

- Inadequacy of funds and staff with suitable educational background/qualifications remains as a major constraint to forestry development in India both in the context of new plantation establishment and resource management.
- Due to the fact that major part of forests has state ownership, education and training programmes are limited to the personnel of the Forest Departments.
- A large number of trained personnel is required for development of a large scale forestry sector in vast country like India.
- Non-recognition of the potential of non-wood forest products in the existing curricula of education and training.

Although some of the recommendations of Indian National Agriculture Commission (1976) are being implemented with wider education courses in agricultural universities, some of the problems afflicting the developing countries are encountered in India, on varying levels of severity in inadequacies of institutions, technological weakness, insufficiency of investment funds, lack of meaningful participation of the people and so on.

The possible solutions and new strategies include:

- Forest research development funds be created by tapping the resources of various financial institutions for meeting the needs of research and education
- Central, regional and the state level research/education organizations be strengthened according to the recommendations of the National Commission on Agriculture (1976)
- The courses at the existing management institutes including Indian Institute of Forest Management should be

availed to increase managerial efficiency

- Suitable courses for continuing education and training of the serving forestry/research personnel should be evolved by various institutions including Indian FRI and Colleges

Aspects to be considered in developing effective training programme

For the problems of Southeast Asia, a newly designed programme should work in the context of "sustainable development in an environmentally sound, economically viable and socially acceptable way".

- Although utilization of trees and forests is inherent aspect of forestry, tourism, recreation, non-wood forest products (NWFPs), water and wood production aspects in the context of sustenance should be considered.
- While obtaining the graduate/postgraduate qualifications in the universities, the degree courses should include sections on the design, scientific conduct of research, monitoring and evaluation of research.
- Role of Regional Networks should be realized and implemented, comprising industry linkages and inter-disciplinary and inter-institutional collaborations.
- It should be multidisciplinary in nature including genetics and biotechnology, resource mensuration, biodiversity and sustainable management, appropriate silviculture, harvesting, economics and resources evaluation and social sciences.
- There is a tremendous need for research into all aspects of technology entailed in the utilization of NWFPs.

Model Training Network

While proposing a model training network in the field of wood science and technology for developing countries, an Indo-Japanese bilateral training programme is illustrated as a case example, particularly for establishing the training consortium by the ICCAE. In doing so, lessons drawn from the success stories of two regional networks, viz. FORSPA (Forest Research Support Program for Asia Pacific) and INBAR (International Network for Bamboo and Rattan) are highlighted. Also documented are the potential lead/core institutes of Japan and several developing countries indicating the availability of human resources in the field of wood science and technology to build partnerships and facilitate the establishment of effective training network by ICCAE.

Mission of ICCAE - Training network

The proposed model training network of ICCAE in wood science shall foresee:

- Building country capacity in training and technology transfer and enhancing the technical capabilities of rural communities, farmers, forest resource managers and small-scale forest-based industrialists in responding effectively to the changing social, economic and environmental needs.
- Assisting in building capacity in national institutes through training program planning, human resource development, increasing access to information, and facilitating technology transfer and adaptation.
- Developing training networks which lead to greater collaboration among the institutions within and between the countries.
- Providing technical and managerial support for networking, organization of meetings and seminars, development of databases, and publishing of newsletter, case studies and monographs.
- Initiating problem-oriented training programmes of regional and local importance.
- Assisting in twinning arrangements to promote inter-institutional collaboration, sharing of knowledge, and transfer of know-how and technology.

Chapter 1

Forestry education in developing countries of Asian region: a brief overview

It was estimated that about 122 forestry schools have already existed in the 1980s in the Asia Pacific Region, spread over in 17 countries, to impart professional forestry education at graduate and post graduate levels (FAO, 1989). Although some structural changes did occur, Japan had the maximum number of schools accounting for 34. Country-wise education and training institutions are given in the Appendix. According to FAO (1989), the following countries are yet to develop training facilities/organizations in the region:

1. Bhutan
2. Cook Islands
3. Democratic Kampuchea
4. Democratic Republic of Korea
5. Fiji islands
6. Islamic Republic of Iran
7. Laos
8. Maldives
9. Solomon Islands
10. Tonga
11. Vanatu
12. Western Samoa

Chronologically, the oldest institutions established before 1970s include those in China, India, Indonesia, Pakistan, Philippines and Thailand. During the period 1970-80s, the main institutions started operating include: Forestry Department of Shanxi Agriculture University, China, Faculty of Forestry of the Universiti Pertanian Malaysia, Forestry Department of in the University of Technology, PNG and many Forestry Colleges of Philippines. Relatively recently, during 1980s, many forestry colleges were opened under the Agriculture Universities in India to give formal degree programmes in forestry while professional training organizations were established in Bangladesh and Nepal (FAO, 1989).

1.1 Staff capacity

While inadequacy of staff was recognized as a constraint in older set ups in India and Pakistan, in countries like China, Indonesia, Malaysia and Philippines staffing pattern in most forestry colleges was noted to be adequate as seen from the following staff strength:

China

Beijing Forestry University - 590 members with 9 Ph.Ds
Northeastern Forestry University - 914 members with 33 Ph.Ds
Nanjing Forestry University - 663 members with 9 Ph.Ds
Fujian Forestry College - 324 staff members with 9 Ph.Ds.

Indonesia

Faculty of Forestry, Gadjah Mada University - 67 members with 7 Ph.Ds.

Faculty of Forestry, Bogor Agriculture University - 98 members with 21 Ph. Ds

Malaysia

Universiti Pertain Malaysia - 45 members with 9 Ph.Ds.

Philippines

College of Forestry (UPLB) - 67 members with 28 Ph.Ds

Thailand

Faulty of Forestry, Kasetsart University - 62 members with 28 Ph.Ds

In India, the staff shortage was compensated by the teaching responsibility taken over by the research staff although new staff capability is being built recently in various agricultural universities.

1.2 Intake of students/trainees in forestry education

Generally, 12 years' schooling including often pre-university/junior college courses will suffice to enter into the B.Sc (bachelor's degree) course in forestry through entrance examinations. In India and Pakistan, recruitment into forest service through competitive examination precedes the entry into the training institutions while in Philippines, Indonesia and Thailand, 10 years basic education is the requirement for entry to be made by the University Entrance Board or by the Ministry of Education as the case may be.

The number of annual intake of students is below 100 in countries like India while it is relatively high in China (500-550) and other South East Asian countries like Indonesia and Thailand (124-200).

Foreign students are admitted in countries like India, Pakistan and PNG, where media of instruction is English, while foreign student entry was restricted in China and other South East Asian countries due to the language problem. However, for advanced or higher studies there was no problem where no much course work is involved.

Short courses are being offered in various institutions of the Region for in-service professionals and often for foreign students with the aid of international aid agencies like ICRAF and IDRC.
A few recent courses organized are given below (FAO, 1989).

1.3 Short-term courses on the themes of current relevance offered in the region

Venue/Country	Course/Subject	Beneficiaries
Department of Forestry, South China	Computer application in forestry Quarantine training Landscape gardening	In-service professionals

Beijing Forestry University, China	45 different short training courses	
Indian Forest College/State Forest Service Colleges, India Indian Institute of Remote Sensing	Refresher courses on topics of current relevance Satellite Remote Sensing	In-service forest officers Open
Faculty of Forestry, Gadjamada University, Indonesia	Forestry Planning	
Universiti Pertanian Malaysia	Agro-forestry	Open
Pakistan Forest Institute, Peshawar	Watershed and Wildlife Management Forest Products Engineering	Open
University of Technology, PNG	Wood identification Aerial photo interpretation	Open
Faculty of Forestry, Kasetsart University, Thailand	Resource and environmental conservation	
Institute of Forestry, Tribhuvan University, Nepal	Forest conservation Fodder trees	Farmers
College of Forestry, Laguna (UPLB), Philippines	Social forestry, Agroforestry, Forestry extension, etc.	In-service and others

1.4 Variability of curricula of forestry education in developing countries of the region

Although changes are expected from country to country depending the local importance, a suggested model curriculum (FAO, 1989) has essentially the following elements:

1. Basic sciences and humanities, including languages - 20%
2. Forestry and Forest Products - 70%
3. Electives and/or research - 10%
4. Field experience - During vacation period although it is a pre-requisite

Each of the above course may be quantified in terms of credit hours to measure the depth of a subject. For instance, a 50-minute lecture hour or a 2-3 hour laboratory/field work is considered equivalent to 1 credit hour. Thus a 3 credit hour course may consist of :

a) 3 lectures per week or
b) 2 lectures + 1 lab / field work per week or
c) 1 lectures + 2 lab / field work per week or
d) 3 lab /field works per week

Often there is a wide variation in the number of credit requirements for graduation in different institutions. For instance, it is only 123 in Malaysia as against 192 in recently introduced forestry courses of agriculture universities in India. Therefore, it is felt that there is a need to standardize the professional forestry courses of the Region to achieve a degree of comparability and commonality.

Although the course duration generally for basic degree in forestry is 4 years with 16-18 weeks per year, it varies in some countries. For instance, the University of Malawaram Samarinda in Indonesia runs 5 year course with 10 semesters and the final being devoted to the research work. Whereas in Indira Gandhi National Forest Academy (Formerly Indian forest College) Dehra Dun, B.Sc. being the entry qualification, the professional course runs only two years with a postgraduate diploma. However, it is not recognized as equivalent to M.Sc. degree of forestry in other countries. Pakistan had both B.Sc. and M.Sc. degree courses of 2 years duration each. In Nepal, successful science graduates undergo a "pre-requisite Course" of 3 months to get exposed to biological aspects of forestry before entering into the 2-year forestry course work. Alternately, practicing foresters or persons with a 2-year proficiency certificate in forestry can obtain entry after one year service experience in the Department Forestry, soil conservation and wildlife. If selected, they can take one year of science course work followed by two years of forestry course work.

The number of subjects taught and the emphasis given also vary considerably from country to country. The coverage of basic sciences including humanities may vary from 15% to 46%, the average being 20%. In Indian universities, the element of agricultural sciences plays greater role in the context of the recent agro-forestry and social forestry practices. Modern subjects including Information Technology (IT) and Biotechnology also find their way gradually into the curricula.

Chapter 2

Education and training in forestry and wood science: Indian scenario

In contrast to many countries of Asia Pacific Region, in India till recently the forest education in the higher level was under the control of the Government of India while in the lower levels the State Governments had run schools and utilised the facilities available in the neighbouring states to train their personnel. In 1988, the Indian Council of Forest Research and Education (ICFRE) was established by the Government of India under the Ministry of Environment and Forests as an independent body to focus greater attention on research and education programmes of the country. The Forest Research Institute and Colleges at Dehra Dun, the main institution formerly responsible for education and training of the officers for Indian Forest Service (IFS), was made the headquarter of ICFRE with six different regional institutes of the country. Recently, the ICFRE was granted the status of deemed university to recognise graduate, post graduate and Ph.D. degrees. However, the two-year IFS course, followed by 4-month probationer training course was entrusted to a separate organisation as Indira Gandhi Forest Academy, Dehra Dun. Under the Ministry of Environment and Forests, three State Forest Service Colleges located in Dehra Dun, Burnihat and Coimbatore also run two-year courses for Assistant Conservatory of Forests (ACF) to cater to the needs of the State Forest Services, for which competitive examinations are conducted by the respective State Public Service Commissions.

2.1 Forestry education structure in India

Level	Course Duration	Minimum Entry Level	Location
Forest Guard	3-6 months	High School	State
Forester	1 year	Pre-University (Science)	State
Ranger	2 years*	Pre-University (Science)	Ranger Colleges of different regions
State Forest Officer (ACF)	2 years	Graduate	Dehra Dun, Burnihat and Coimbatore
B.Sc.-graduate level	4 years	Pre-University (Science)	State Agricultural universities
IFS Officer	2 years	Graduate	Dehra Dun
Postgraduate	2 years	Graduate in Forestry	Dehra Dun, State Agricultural universities

* Recently reduced to one year

Till recently, there were four colleges offering graduate study facilities in forestry. There were (*a*) Indira Gandhi Forest Academy, Dehra Dun, (*b*) Forest College at Burnihat, Meghalaya, (*c*) Forest College Coimbatore and (*d*) Forest College Dehra Dun. In the former, the officer probationers of Indian Forest service and students from foreign countries coming for advanced study are admitted and in others candidates of Provincial Forest Service are admitted. Both the colleges run a two year study programme leading to the diploma AIFC (Associate of India Forest College). The curriculum of this course is given in Appendix.

The Forest Research Institute Dehra Dun has recently got the status of Deemed University with post graduation and doctoral programmes including wood science and technology.

There were six colleges at the undergraduate level. They include Forest Rangers Colleges at Dehra Dun, Coimbatore, Kurseong, Chanda, Angul and Balaghat. Some colleges offer two years certificate courses, with intermediate/pre-university course of Science as minimum educational qualification of the students and others one year certificate course with Bachelor in Science as the minimum qualification for candidates seeking admission.

In recent years especially 1980s, some agricultural universities of the country have started forestry study as a subsidiary subject in agriculture colleges (Appendix).

Graduate and postgraduate studies

The Indian Forest Service (IFS) probationer officers, selected through the national level competitive examination conducted by the Union Public Service Commission, are trained in the Indira Gandhi Forest Academy, Dehra Dun. The State Forest Service (SFS) candidates enter after getting through the competitive examinations conducted by the State Public Service Commissions and undergo two-year training course in forest colleges located in Dehra Dun, Burnihat and Coimbatore.

The reconstitution of the I.F.S in 1966 was a positive step towards better forest management as it attracted brilliant students of the country selected on All India basis to join the service. But the changes made in the education pattern to fit into All India Services rules and regulations created situations in which the standard of forest education, it is a apprehended, may come down.

The graduate forestry courses with B.Sc. degree, introduced in several agricultural universities in the 1980-90s, have basically four-year programme with semester systems. (Appendix). Currently, opportunities do exist in the universities at postgraduate level (M.Sc.) for specialisation in the fields of silviculture, agro-forestry, tree physiology and breeding, forest management, wood science/utilisation, wildlife, etc.

Undergraduate study (for forest range officers)

The sixth undergraduate colleges called Forest Rangers College, train forest technicians on regional basis. For example, all candidates of the northern states are sent to the Northern Forest Rangers College, Dehra Dun, for training. The northern states have temperate forest with conifers in the Himalayas which is quite uncommon to the other parts of the country. Similarly each region has its own speciality which has been taken into consideration while drafting the study programme in the colleges. However, the main frame work of the course remains the same and candidates of all colleges get opportunity to visit all types of forests and get themselves acquainted with them.

Out of the six colleges, at present, the colleges at Dehra Dun and Coimbatore are very well equipped and have good traditions in forest education and training. The other colleges have been recently started and will take some times to get themselves established. India is a vast country and requires a large number of forest technicians for managing the forests. With intensification of forest management and opening of other avenues in the spheres of forest based industries, social forestry, nature conservation, departmental working of forest and for managing the Forest

Development Corporations which are public sector projects, more and more personals will be required in future. Hence, establishment of new forest colleges will be welcome but not without a note of caution. It is not enough to start a college in an applied field science like forestry. The infrastructure requirements must be sufficient to maintain a good standard. The performance of Burnihat and Kurseong colleges till now is not very satisfactory. It is hoped that the experience gained will make planning for forest colleges in future more realistic.

Entry requirements to Ranger Course

Intermediate science of an Indian university or its equivalent (minimum 3 semesters study in the university after higher secondary examination of European universities.) in basic science has been kept as the minimum educational requirement of candidates seeking admission into the undergraduate colleges offering two years certificate courses. Where the courses durations is one year the entrance qualifications prescribed is Bachelor in Science (pre-degree or 4 semesters study of European universities). The Director of Forest Education, Dehra Dun, contacts a qualifying examination and candidates are selected on the basis of the results of that examinations. An oral examination is held in addition to the written one. Physical fitness standards are prescribed including working of 25 kms in 4 hours time which must be fulfilled in order to be finally selected for Ranger's training.

The number of candidates to be selected in any year depends on the posts likely to fall vacant during two years of the training period in the college so that by the time the candidate finish their study and return to the states there will be a post vacant for them. Once selected the candidate is educated and trained at State cost and assured of a job after the successful completion of the course. The inter-seniority of the candidates is determined on the basis of their performance in the forest college. Failing in the examination or not confirming to the standard would make a candidate liable to be expelled from the college and in such an event the candidate not only looses his job but also has to return all money spent for his education at the forest college of State Government. In the forest college the students are taught the fundamentals of silviculture and management, forest mensuration, protection, forest products and their utilization survey and engineering. Besides these main subjects, other subsidiary subjects like forest botany, wild life management, entomology, soil science, soil conservation are also taught. At the end of the course an examination is held and successful candidates are awarded certificate.

After the college education part is over the candidates return to their respect states and are appointed as forest range officers. To undergo practical training, they are first attached to a senior range officer for one year, during which time they get acquainted with all types of forestry work. They are now deemed fit to hold independent charge of a Forest Range. Within two years of service, the range officers are required to pass a departmental examinations in Financial Accounting, Forest Law and Land Revenue Matters.

Though the minimum educational qualification prescribed is Intermediate Science. Due to unemployment problems persons having M.Sc. degrees also come for ranger's training. Hence the educational background and forestry training of this class of officers are generally good. They constitute the back-bone of India's Forest Resources Management.

Lower level courses

The Foresters

The range officer is assisted in his field work by technical assistants called foresters. These technicians are trained in

the Forest Schools of the States. The minimum educational requirement of a Forester candidate is a pass certificate of the higher secondary stage. Recruitment is done at forest division offices. Those who possess the minimum physical fitness of height and chest are allowed to sit for a written test. Those who come out successful in the written test are allowed to appear in an oral examination which is held by a committee consisting of three Deputy Conservator of Forest for final selection of the candidates. Those who provisionally qualified, undergo walking test of covering 25 kms in four hours. Successful completion of this test finally qualifies a candidate for appointment in the forest department as a Forester. The same walking test is prescribed for candidates of all rank and file of forest officials beginning from A.C.F. down to Forest Guards.

After two-three years of practical work in the field, the Foresters are sent to the Foresters Schools for training. The experience gained in the field helps them to understand and assimilate the subject better. During the course period more stress is laid in the practical aspect of the study than on the theoretical aspects. Among the subjects taught, survey, forest mensuration, plantation and nursery techniques, road and building works, practical aspects of silviculture and forest management, forest products and their utilization and identification of trees and shrubs constitute the main subjects. Public liaison, forest rules and regulations, wild life management, first aid are also taught a subsidiary subjects. The students travel all over the state and also to states nearby, and acquire knowledge on the practical aspects of forest management.

At the end of the course a written and oral examination in all subjects and practical examination in survey, Engineering and field Botany is held. The Deputy Conservator of Forests of the States examine the students. Orissa and Bihar appoint at least one examiner by convention from the forest schools of either states. The successful candidates get a certificate. In Orissa the candidate who stands first in the examination in order of merit automatically gets the chance of being sent to the Forest Rangers College for further study.

The Forest Guards

They are selected for appointment in the same manner as the foresters but with a less minimum educational qualification. They are also sent for training after two-three years of practical field work. The duration of training is 6 months. The course consists mainly of all types of field work and the students learn as they do the works themselves. They also travel extensively in-side the state and are required to appear in an examination at the end of the course.

2.2 Problems and constraints in the existing system

The major problems identified in the existing system include:

- Inadequacy of funds and staff with suitable educational background/qualifications remains as a major constraint to forestry development in India both in the context of new plantation establishment and resource management.
- Due to the fact that major part of forests have state ownership, education and training programmes are limited to the personnel of the Forest Departments.
- A large number of trained personnel is required for development of a large scale forestry sector in vast country like India.
- Non-recognition of the potential of non-wood forest products in the existing curricula of education and training.

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2.3 Possible solutions/ New strategies

- Forest research development funds be created by tapping the resources of various financial institutions for meeting the needs of research and education
- Central, regional and the state level research/education organizations be strengthened according to the recommendations of the National Commission on Agriculture (1976)
- The courses at the existing management institutes including Indian Institute of Forest Management should be availed to increase managerial efficiency
- Suitable courses for continuing education and training of the serving forestry/research personnel should be evolved by various institutions including Indian FRI and Colleges

2.4 Aspects to be considered in developing effective training programme

For the problems of Southeast Asia, in newly designed programme should work in the context of "sustainable development in an environmentally sound, economically viable and socially acceptable way".

- Although utilisation of trees and forests is inherent aspect of forestry, tourism, recreation, non-wood forest products (NWFPs), water and wood production aspects in the context of sustenance should be considered.
- While obtaining the graduate/postgraduate qualifications in the universities, the degree courses should include sections on the design, scientific conduct of research, monitoring and evaluation of research.
- Role of Regional Networks should be realised and implemented, comprising industry linkages and inter-disciplinary and inter-institutional collaborations.
- It should be multidisciplinary in nature including genetics and biotechnology, resource mensuration, biodiversity and sustainable management, appropriate silviculture, harvesting, economics and resources evaluation and social sciences.
- There is a tremendous need for research into all aspects of technology entailed in the utilizations of NWFPs.

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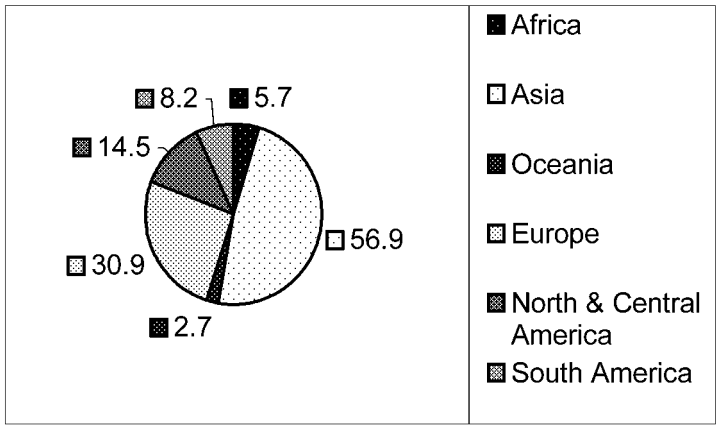
Chapter 3

Changing pattern of plantation resources and training needs for sustainable utilization of tropical forest products: India - a case study

3.1 Global trends

With the approach of 21st century, it seems, gone is the era of wood utilization from large trees of natural growth. Numerous recent estimates of global supply and demand suggest that forest plantations will significantly increase roundwood supply to the year 2010 and beyond (Whiteman and Brown 1999). The global forest plantation area estimated for the year 1995 is approximately 119 million ha while half of it is located in Asia with major shares from China, India and Japan (Fig. 3.1). According to one predictive model, the current level of potential roundwood supply from plantations is around 370 million m^3 per year, which is 25% of global industrial roundwood production and is expected to increase to around 30-33% of total supply in the year 2010, pointing to the range of production of 560-620 million m^3 per year depending on different assumptions of rate of change in plantation growth. With the assumption of significantly higher rate of planting, the predicted proportion of future potential supply from plantations is much greater by 2050 (Whiteman and Brown, 1999).



Source: Whiteman and Brown (1999)

Fig. 3.1 Global distribution of forest plantation resources by main regions in the year 1995 (million ha)

While plantation programmes are expected to continue in many countries especially Argentina, Brazil, Chile, China, India, Indonesia, Morocco, Thailand and Uruguay, the Asia Pacific Region leads the world in tropical forest plantation development in addition to most of the world's 26.5 million ha of non-forest plantations of rubber, coconut and oil palm trees as fibre resources. (FAO, 1999). Of the total plantations of 42 million ha in 1995, 19 million ha are represented by tropical plantations with annual planting rate of 3.3 million ha. Industrial roundwood production is, however, expected from only 14 million ha with annual planting rate of 1.5 million ha. Species wise, eucalypts constitute the largest area (30%) of hardwood industrial plantations, followed by acacias (12%) and teak (7%) while pines make up most of softwood plantations. However, teak constitutes about 75% of high quality hardwood plantations that receives increasing attention in investing on plantation programmes in the context of sustainable forest management (SFM), in many tropical countries including Brazil, Costa Rica, Ghana, India and Malaysia (Keogh 1999).

The recent trend in the Region is that the trees outside forests (TOF) will emerge as an important source of industrial roundwood in addition to wood residues of 1,000 million m^3 with the composition of 70% logging residues, 10% industrial residues, and 20% non-wood/recycled fibres (Fig. 3.2). It is estimated that 80% of all woody biomass harvested in tropical forestry operations ends up as logging or processing residues, 50% of tree wood volume is left behind on the felling site (as branches, bark, etc.) and another 30% as residue (slabs, sawdust, trimmings/shavings, etc.) after conventional wood processing (FAO 1998). The current potential wood and fibre supplies from industrial forest plantations, TOF and other sources are summarised in Table 3.1.

Table 3.1 Current potential of wood and fibre supply (million m^3 EQ) trends in Asia Pacific Region

REGION	FOREST PLANTATIONS		TOF		WOOD RESIDUES		RECYCLED / NON-WOOD FIBRE
	Sawlog	Pulp / fuel wood	Sawlog	Pulp / fuel wood	Logging	Mill	
Industrialised countries	40	15	NA	NA	25	15	55
Newly industrialised countries	5	<5	NA	NA	<10	<5	20
North Asia	35	70	80	360	150	25	85
Southeast Asia	8	-	30	175	380	35	15
South Asia	2	25	35	165	150	13	13
Oceania	-	-	NA	<5			

Source: FAO (1998)

The annual global production of roundwood as well as wood product production and consumption are expected to increase at an annual rate of 1.7% to the year 2010 amounting to 1.9 billion m^3 of roundwood equivalent with highest rates of growth in Asia and the Pacific (Whiteman and Brown, 1999). While North and Central America will remain the largest producing and exporting region, it will remain behind Asia in terms of its share of global consumption. The Asian Region is expected to continue to produce more finished products than industrial roundwood and remain as a net industrial roundwood importer.

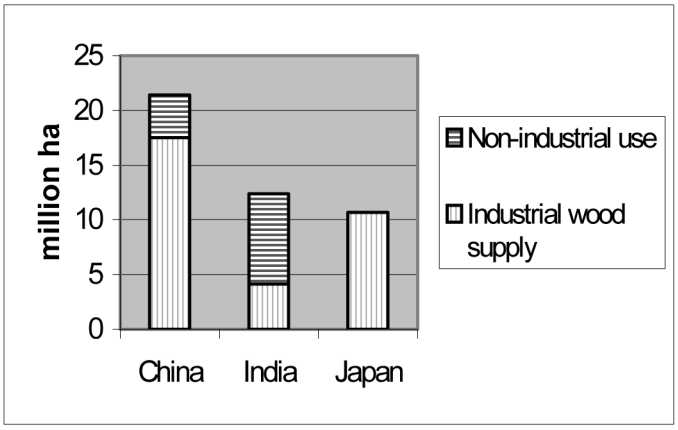
Supply-demand models for wood products indicate that paper and paperboard is expected to grow faster than other products to the year 2010 with an annual increase of 2.4%. Supply and demand for solid wood products is expected to grow with an annual rate of 1.1% for sawnwood and 1.3% for wood-based panels while reconstituted panel products are expected to grow highest (Whiteman and Brown, 1999). In terms of wood products, the Asia Pacific Region is characterised by (FAO, 1998):

- relative stagnation of sawn wood consumption in view of shortage of suitable timbers/large diameter logs and substitution of solid wood products by reconstituted products in furniture, joinery, etc.

- improved roundwood utilization due to better conversion efficiencies, enhanced utilization of wood residues and recycled fibres in paper manufacturing and increased reconstituted/composite product manufacture especially in more industrialised countries.

3.2 Indian scenario

In contrast to 80% and 100% in China and Japan respectively, in India only 33% of plantation area, accounting for 4.1 million ha, is estimated to contribute to the total industrial roundwood production with 9:1 ratio of hardwoods and softwoods (Fig. 3.2). With an annual increase of 8% in total roundwood production, the major share of 92% goes as fuelwood and a meagre 8% (about 25 million m^3) as industrial roundwood (FAO, 1998). The slower rate of annual increase is mainly due to the decline in round wood production from the state forests especially from natural forests.



Source: Whiteman and Brown (1999)

Fig. 3.2 Proportion of industrial roundwood supply from plantations in three major Asian countries

The total area of forest brought under plantations of economic species was 4.75 million ha by the end of the 7th Five-Year Plan (1985-1991) (ICFRE, 1995). This is about 7% of the total forest land in the country. Most of the teak and plywood or matchwood species plantations have merged with the natural forests and mixture of natural species between them. Inventory data for agro-forestry sectors of only selected districts of Haryana, Madhya Pradesh and Orissa are currently available (FSI, 1997). The DBH classes of 10-20 cm, 20-30 cm, >40 cm were recognised in farm forestry, block plantations, roadside plantations and village woodlots which include species such as eucalypts, babul (*Acacia* spp.), poplar, mulberry, shisham (*Dalbergia* spp.), teak, mango, etc. The average growing stock of wood in agricultural land is estimated at 3.42 m^3/ha.

There is an increased dependence on plantation grown timbers and non-forest resources such as rubber wood and palm stems (coconut and oil palm) which are grown for non-timber purposes (Fig. 3.3). The areas of coconut palm and rubber plantations in India are estimated at about 1.632 and 0.523 million ha respectively (Krishna Kumar, 1997; Markose, 1997). Evidently, TOF will be increasingly recognised as an important element in industrial roundwood production. For instance, in southern states like Kerala for the year 1993-94, State forests including plantations accounted for only 9%, in contrast to 46% by households/home-gardens and 31% by estates with 14% imports of industrial roundwood (Chandrasekharan, 1997). For the year 2000 the projections for Kerala indicate 56% from homesteads, 17% from estates, 17% from state forests/public lands and 10% from imports (Krishnankutty, 1990).

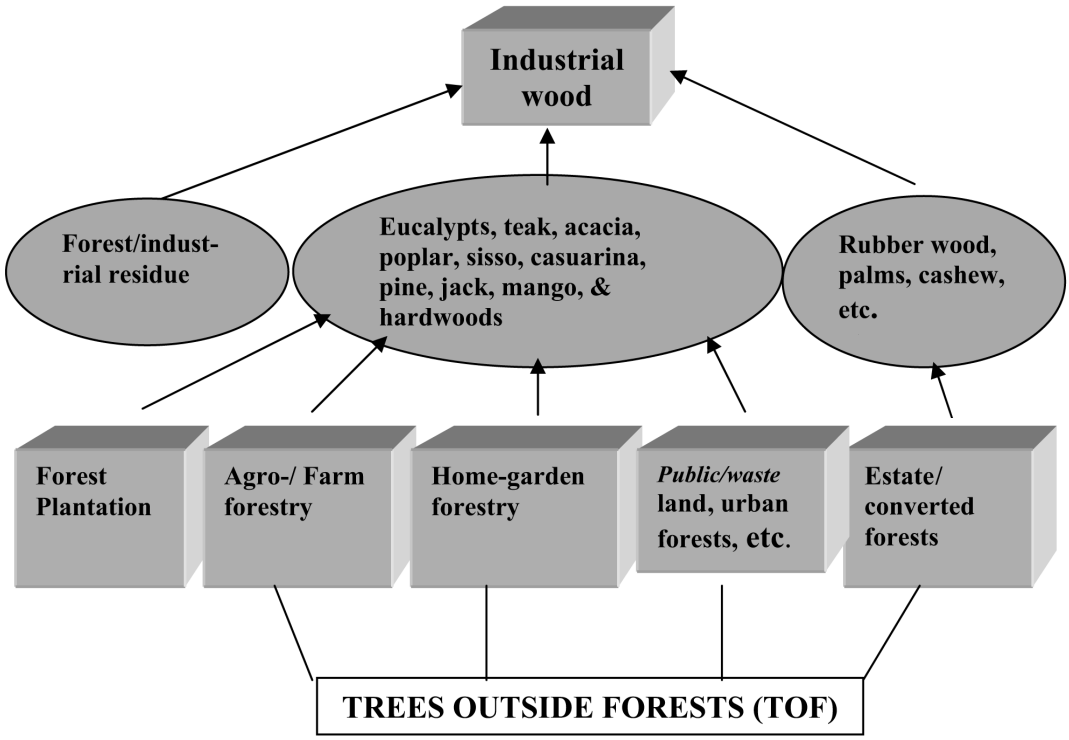


Fig. 3.3　Major sources of futuristic industrial wood supply in India (Bhat, 2000)

The total wood requirements and production by forest and non-forest plantations estimated for the country by FSI (1996) are given in Table 3.2. It is important to note that small woodlots (of less than 25 ha) together could account for 16 million ha of forest area, about 25% additional area to the official figures given for roundwood production, contributing to 72% of the total supply in India (NFAP, India, 1999), not accounted in the Forest Survey of India Report. For the country, at least 60% of industrial roundwood production will be expected from such non-forest lands while import will maintain at the level of 15-16% (FAO, 1997).

Table 3.2　The medium term demand and potential production trends of industrial roundwood in India

(million m^3)

Year	Total industrial wood demand	Production source		
		Forest	Plantation	Farm forestry
1996	64	23	10	31
2001	73	26	11	36
2006	82	29	13	40

Source: FSI (1996)

The estimated average annual industrial growth was 8-9% during the period 1985-2000 (FAO 1998). The contribution of manufacturing sector to the gross value added would have increased from 15% to 20% by 2000. The general production, consumption and trade patterns estimated by FAO (1999) are presented in Table 3.3. India will also increase dependence on import for all industrial wood products by 2010, at least 16% of industrial roundwood, 18% of sawn wood, 28% of wood-based panels, 9.2% of paper and paper-board and 11.6% of fibre furnish in the country

(FAO, 1998).

Table 3.3 Production, consumption and trade patterns of timber products in India

(1,000 m^3)

End-use sector	Production	Import	Export	Consumption
Fuelwood and charcoal	279,359	0	7	279,343
Industrial round wood	24,989	336	23	25,302
Sawnwood	17,460	17	27	17,450
Wood-based panels	348	20	20	348
Pulp	1,870	265	3	2,132
Paper and paperboard	3,025	350	6	3,369

Source : FAO (1999)

The demand and shortfall of different products estimated for the years 1990 and 2000 are given in Table 3.4. The values indicate that there is an increased deficit of industrial roundwood and wood products in spite of expected increase in supply from plantations. Of the 20,000 sawmilling units estimated, 99% are considered to be small-scale and very tiny units and only 1% may be considered to be medium size. There are about 300-400 large, medium and small-scale units of plywood manufacture in the country. Their production has gone down and capacity utilization has reached near critical levels as shown in Table 3.5.

Table 3.4 Estimated demand and shortage trends of wood in India from the year 1990 to 2000

PRODUCT	1990		2000 (ESTIMATED)	
	Demand, million m^3	Shortfall %	Demand, million m^3	Shortfall %
Roundwood	272.61	-1.2	335.15	-5.3
Industrial roundwood	28.22	-4.8	40.39	-15.9
Fuelwood & charcoal	243.81	-0.5	293.65	-3.5
Sawlog & veneer logs	22.37	-6.3	34.30	-20.5
Sawnwood & sleepers	24.48	-11.6	53.60	-40.1
Other industrial roundwood	4.90	-1.0	6.13	-5.7
Plywood	0.57	-17.4	1.49	-52.3
Wood-based panels	0.65	-11.8	1.54	-44.9
Particle board	0.031	34.4	0.036	61.6
Fibreboard	0.068	14.5	0.164	-49.9

Pulp & Paper	Demand, million MT	Shortfall %	Demand, million MT	Shortfall %
Pulp	1.41	-18.3	3.49	-49.3
Chemical	0.70	-17.4	1.7	-49.6
Dissolve grade	0.28	3.3	0.41	9.2
Other fibre pulp	3.05	-19.9	8.62	-56.3
Paper & paperboard	2.60	-18.1	4.87	-36.2
Newsprint	0.51	-34.8	0.74	-20.3

Source: The Price of Forest, CSE Computed on linear projection, Economic Times

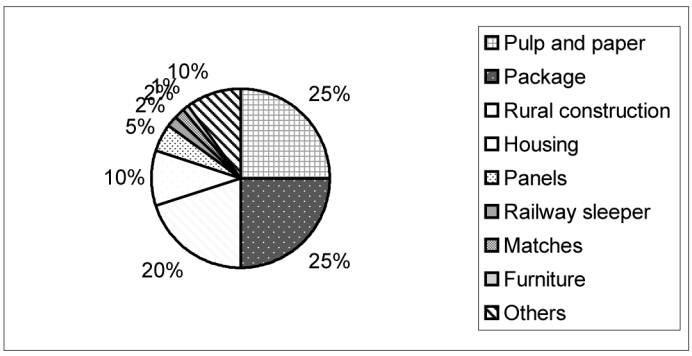
Table 3.5 Generalised patterns of industrial wood consumption during 1990-2000

Industry	Estimated number of units	Installed capacity in 1,000 m^3	Production (1990), 1,000 m^3	Capacity utilization, %
Sawmilling	20,000	48,000	17,460	36
Veneer	13	15	4	27
Plywood	400	1,011	640	63
Particle board	11	116	51	44
Fibreboard	3	55	49	89
Pulp and Paper	250**	4,051.7*	2,350*	58

Source: Ganapathy (1992) ; * in tonnes, ** Exclusive of many small mini-scale/sick units

There is a general agreement among the estimates over the requirements for paper and pulp being in the range of 24-27% (5 to 8 million m^3) of the total demand (Fig. 3.4). As observed in southern India, other major consuming sectors include packaging (roughly 25%), agricultural implements and temporary construction (20%) and housing (about 10%) (Bajaj and Bhat, 1996). Smaller but still significant end users include wood-based panels (3-7%), railway sleepers (1.8%), matches (1.5-3%) and furniture and panelling (about 1%). The remainder 10% of wood is shared between multifarious users including makers of fishing boats, truck bodies, sport goods, bobbins, shoe lasts, pencils, toys, and handicrafts, etc. generally concentrated in a few regions or centres.

The recent estimates (FAO, 1993) suggest that overall production and import and therefore by implication, consumption have remained more or less stagnant over the last decade and there is little evidence to suggest large scale departures from the above pattern of utilization in recent years. The trends of growth in the economy suggest some increase in the share of wood based panels, furniture and construction at the expense of artisans and rural users. The recent wood user survey (Bajaj and Bhat, 1996) established beyond doubt that the sawmilling, which processes 70-80% of industrial wood, is the major sector of roundwood consumption.



Source: Bajaj and Bhat (1996)

Fig. 3.4 Current pattern of wood uses in southern India

Limitations to wood utilization in India

- The National Forest Policy (1988) recommends for: reduction of wood supply from forest sources, import for shortages, substitutes and utilization of marginal farm lands for production of pulpwood to meet the future demands. Accordingly, forest-based industry should raise the raw material needed for its own requirements, by establishment of a direct relationship between the factory and individuals who can grow the raw material by supporting the individuals. As the result, panel and pulp industries established based on past industrial policies are struggling to keep up their production. For instance, the outlook study by the Hindustan Newsprint Ltd. (1999) estimates that the forest raw material availability in Kerala state is sufficient to meet only 50% of the requirements of two main pulp mills of the state.
- India is one of the world's 12 mega-biodiversity countries. The objective of National Forestry Action Programme (NFAP) is to enhance the contribution of forestry and tree resources to ecological stability and people-centred development through qualitative and quantitative improvement in investment on sustainable conservation and development of forest resources (FAO, 1997).
- According to FSI (1997), only 19.3% have forest cover, although nearly 22% or 65 mill. ha, of the land have been recorded as forests, which is much less than the goal of 33% set by the National Forest Policy (FSI, 1997).
- According to some predictive models (Kale, 1995) the percentage production from forest raw materials for pulp and paper production to the total will be expected to gradually decline to 27% by 2010 because of reduced felling of trees in government forests as a result of the implementation of Forest Conservation Act 1980, as amended in 1988 and prescriptions of National Forest Policy 1988.
- Non-forest trees (rubber wood, coconut wood, etc.) and tree-crops (multipurpose species from farm lands/ homesteads) will emerge as significant volume of industrial fibres. For instance, in Punjab (India), farm trees account for 86% of the state's growing stock (FAO, 1998).
- The fragmented low-capacity marginal farm lands call for higher investment, dispersed supervision, higher cost of transport, inability to apply modern technology, larger extent of land to meet the gap in availability, problems of legal arrangement with owners for supply of raw material, difficulty in flow of credit, higher supervisory and protection costs, etc.
- India cannot afford to divert better farm lands for tree crops for fear of shortfall of agricultural production. The best available natural resource is therefore degraded forest land.
- Disproportional increased investment in the forestry sector with substantial qualitative changes in terms of

country capacity in the absorption and planned use of the resources (FAO, 1997).

Future targets for wood utilization in India

Industrial wood is increasingly in short supply in India and the situation is likely to worsen further. One of the strategies to lessen the wood shortage is to substitute wood with alternative materials such as aluminium, steel, cement in construction uses. Appropriate fiscal measures (excise duties, tax, and royalties) and policies have been adopted to encourage competitiveness, enhance cost effectiveness, and promote greater use of wood substitutes.

Efficiency in wood production and utilization has generally been low and the following measures have been taken to increase output from the declining domestic wood flow (Pande, 1995):

- promoting and supporting the use of juvenile/thinning wood from plantations and trees outside forests (TOF) especially from farm/agroforestry sectors and non-forest plantations.
- adoption of improved processing techniques, better logging practices, and use of small dimensional timbers.
- improved use of low quality timbers in plywood and veneer, by substituting high quality timbers such as teak and rosewood.
- improving the productivity of plantations, processing of smaller trees, opportunities for increased use of wood residues and recycled fibres and efficient utilization of non-timber crops.
- Trade policies are designed to fill the gap between supply and demand, encourage wood substitution, and increase the indigenous supply of raw materials for forest-based industries. The objectives are to support value-addition, enhance income and employment generation, make use of local knowledge, reduce dependence on foreign supplies of critical commodities, and ensure growth and development of village-based and small industries.
- The plantations raised in strips along roads or canals or railways are managed under clear felling system with a rotation of 8-15 years for eucalypts and poplars, 15 years for acacias, and 50-years for relatively slow growing species such as Dalbergia sisso and teak. Raising large-scale captive plantations of high yielding varieties on degraded forest and Government forest lands in the vicinity of existing and/or new industrial units should be expected to maintain the current level and future demands. The plantations would become viable only if technological advances in production forestry are practised so as to optimise the outputs from high silvicultural inputs from 15 m^3 to 70 m^3 MAI per ha as shown in Brazilian pulpwood plantations. This will mean that the requirement of raw material can be met in 15-20% of the area required 2 decades ago (Adkoli, 1995).
- While the timber supply for industries will be mainly from homesteads, farm-/agro-forestry, converted forests/estates of private holdings, large industries have now accepted the model of involving small farmers in the production of raw materials especially for pulp mills. For instance, it is estimated that by 2010 the farmers in Andhra Pradesh can supply 1 million MT of pulpwood while the major portion of current consumption of 0.6 million MT is met by them. Because of clonal technology and involvement of farmers in the supply model, the area of agricultural tree crops is expected to increase considerably by 2010. The annual increase of 8% in roundwood production is expected due to large areas of plantations raised under various social forestry schemes, regular teak plantation programmes and the existing eucalypt plantations of State Forests which will be due for harvesting during the period of first decade of 21st century.
- The production of wood from estates/non-forest plantations, is also expected to increase although from

homesteads/private holdings, it is likely to decline due to reduced stock of the tree crops despite the positive indication of regenerating the stock in the latter. The area under rubber plantations for replanting in Kerala alone is assumed to increase at a range of 3-5% compound per annum. The future production from state forests and public lands is also assumed to increase by 4-5% of current level of production in Kerala (Krishnankutty, 1990).

- ❖ Agro-forestry efforts have to be vastly increased along with improved technologies for clonal pulpwood production and root trainer nurseries for the supply of quality seedling to farmers as has been done in many states like Andhra Pradesh and Orissa with the contract between the pulp industries and farmers (JK Corp., 1999).

3.3 Research and training vs. plantation and utilization technology

There seems to be no substitute for research as it is a vital tool for knowledge-based society in achieving sustainable development in the new millennium. While reviewing the evidence and future prospects of global plantations, Evans (1999) was optimistic about increasing the productivity of plantations by appropriate management methods including intensive silviculture and relatively long-term genetic improvement programme. Biotechnology seems to play a crucial role in genetic alteration and clonal multiplication of trees for higher yield of tailor-made wood. There is therefore a need for different type of plantation technology instead of traditional methods of managing plantations in the tropical developing countries.

The major options to meet the increasing product needs are (FAO, 1998):

- Increase productivity of plantations
- Improve harvesting and conversion efficiency of low-quality/small dimensional materials for new/value-added products and utilization of logging and mill residues
- Improved utilization of non-forest wood and non-wood forest products including recycled fibre from waste paper
- Implementation of structural changes of the industries especially in developing countries with technology transfer.

Plantation technology for wood production

There is an increasing awareness that *wood quality/processing aspect is an integral part of total plantation technology* for high quality timber from sustainable forest management (SFM). For quality sawlogs, it is important to consider minimising the timber defects such as fluting, bole taper, knots, etc. right from the stage of seed selection (appropriate provenances/genetically superior individual trees/clones as a part of breeding programme for planting material) at grower's level. This would save considerable efforts, energy and resource at processing stage to overcome the timber defects for high quality products. Common plantation species, viz. teak, eucalypts and acacias seem to have potential to meet sawn wood requirements from relatively short rotation plantations in view of maturity of timber strength and often durability, in a relatively short period of 15-20 years (Kumar et al., 1987; Bhat, 1999 & 2000; Bhat and Maria Florence, 2000). Although eucalypts are planted mainly for pulpwood production with 5-8 year rotation, trees allowed to grow up to 14-15 years were found suitable for excellent furniture, wall panelling, etc. (Bhat, 1992). Studies also indicate their responsiveness for genetic selection and clonal multiplication for increasing plantation productivity (Bhat and Benny, 1995). Preliminary assessments of the mechanical properties of timber from a 7-year-old *Acacia*

auriculiformis and 8-year-old *Acacia mangium* plantation showed that the strength is low for the lower aged material (Jayaraman *et al*., 1992; Dhamodaran and Chacko, 1999), when compared with the strength values reported for higher age groups. This indicates that the structure - property - end-use correlation's are also equally important and worth considering in fixing the rotation age. As sawlog production is expected to be very critical in many developing countries, especially for high quality solid wood uses, these recent findings have far reaching implications for timber management. Some aspects of timber quality such as figure (colour, grain, texture), natural durability, preservative treatment of sapwood, as well as quality standards/grading rules for fast growing plantations species merit due consideration in R & D programmes as they directly influence the market value of the end products.

Processing of non-conventional timbers

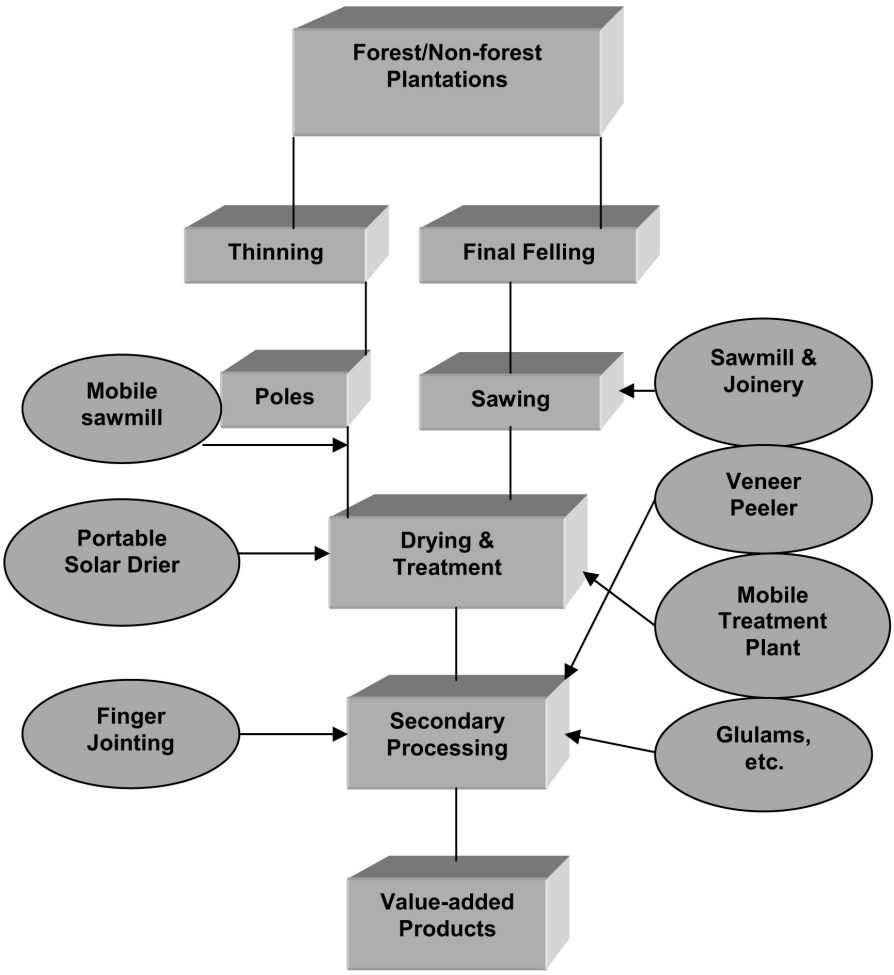
Recent work in Kerala on enhancing the service life of non-conventional timbers such as rubber wood and coconut wood and their processing offered considerable promise for developing appropriate processing technologies (Dhamodaran and Gnanaharan, 1994 ;Dhamodaran, 1996, 1999). India is one among the leading rubber growing countries in the world. According to the estimates of Rubber Board of India (RRII, 1992), the total annual wood production is about 1.27 million m^3, of which 60% is stem wood and the remaining 40% branch wood. A study conducted by Krishnankutty (1989) showed that rubber wood, excluding sawmilling, accounted for about 65% of the total consumption of industrial wood in Kerala, implying significant contribution to the industrial economy of the State. The consumption pattern of rubber wood in India, as reported by the Rubber Board of India (RRII, 1992) clearly shows the need for more value addition and more efficient utilization, as is evident form the insignificant share (3.9%) of processed rubber wood in the total consumption. Similarly considerable progress has been made on preservation and conversion methods of coconut wood in Kerala (Gnanaharan and Dhamodharan, 1988 a & b, 1989 a & b).

Technological interventions and structural changes in wood industries

Advances in processing technologies allow the use of smaller and younger trees. In Europe, North America, Japan and Oceania processing machines have been developed to efficiently process and utilise small diameter logs for finger-jointing and glulams that could find application in both structural and non-structural uses such as joinery, furniture, etc. (Barbour et al., 1997; Willitis et al., 1997). Though the manufacturing cost is higher, the quality of wood products manufactured from small-diameter trees is generally as good or better than that manufactured from the traditional timber resource. Modified equipment in processing for sawn wood/veneer recovery from small diameter logs has been suggested for many plantation grown timbers. For instance, peeling lathes should be capable of handling logs up to a minimum diameter of 7 cm (Sivanada, 1992). An arbitrary model showing scope for technological interventions in the down-stream processing for manufacture of value-added products from low quality/ small diameter trees given in Fig. 3.5.

Modification of sawmilling equipment and installation of portable processing units

The opportunities seem to exist for advanced technologies in both plantation and processing sites. For instance, small portable or mobile sawmills (with a capacity of 5,000 m^3 log intake) with portable solar kilns and preservative treatment plants (for sapwood), that can be easily moved from site to site during thinning or final felling operations of small land holders, may be appropriate for improved utilization of small timber (FAO, 1981). This can facilitate the supply of sawn wood requirements of rural communities, building contractors, and furniture manufacturers of remote areas, apart from promoting the handicraft potential from small dimensional materials in toys/wooden souvenirs by



Source: Bhat (1999)

Fig. 3.5 An arbitrary model showing scope for technological interventions for greater processing efficiency in manufacture of value-added (non-pulp) products from small dimensional timber resource of tropical plantations

employing rural artisans. This may promote the supply of sawn wood to meet the small timber demands of rural communities from road-side/railway development and agroforestry plantations. The building contractors and furniture manufacturers of remote areas will be the major users in addition to the handicraft industries which employ skilled rural artisans. However, it demands initial one-time capital investment (capital cost of such a mobile sawmill estimated in 1981 was $226,200 with a working capital of US $ 8,000) for installation of imported mobile sawing equipment.

Erecting a preservation plant, easily accessible to the felling/thinning sites, with the possibility of using "simple" methods of preservation (with local know-how) including sap displacement techniques would enhance the durability of poles and high proportion of sapwood of short rotation timber. Simple dipping of poles in trenches filled with preservatives and covered in polythene sheets (sap displacement technique) would give often adequate protection as demonstrated by the Institute of Wood Science and Technology, Bangalore. Based on the work done in Indian Plywood Industries Research and Training Institute, simple cost-effective prophylactic and end-coat treatment techniques are available in India. The code of practice as per the Bureau of Indian Standards (IS 9104), provides guidelines for protection of logs in felling site, during transportation and storage.

Installation of cost-effective solar kilns with @ Indian Rs. 400 per m^3, approximately US $10 for *nomad* solar kilns with an annual capacity of about 200 m^3 timber in remote areas would be appropriate to meet the seasoning requirements of small farmers in village level (Plumptre and Jayanetti, 1996). The initial cost of installation would be to the tune of US $7,000-8,000.

Modernisation of industry demands improved skill and know-how at all organizational levels in the industry by providing training to use suitable machinery, proper production flow, and material handling and sound sawmilling (Muraleedharan and Bhat, 1990; Noack, 1995). The basic conventional band saw machines are to be newly designed for processing small dimensional materials. Prototypes of such machines developed in India are being demonstrated through training programmes organised in Indian Plywood Industries Research and Training Institute (Damodaran, 1996).

Installation of machines for glulam/wood panel composites

Recently, selected processing sectors have introduced semi-automatic finger-jointing machines, that are manufactured locally with imported cutters, or planned to invest on automatic imported machines for manufacture of jointed and glue-laminated structures. Often poor quality fingers and weak joints were noticed due to the vibrations of cutter spindle and movement tables.

Attention should be focused on low-cost mechanization in general and the finger-jointing, glulam and peeling and ultra-sonic veneer grading techniques in particular for the improved utilization of small dimensional material of tropical plantations. Related to this, strict quality control, both internal (by the manufacturer) and external (e.g. by a standards institution), is a need of the hour to gain acceptance for finger-jointed timber and to maintain confidence in the product (Bhat, 1999). Standards or codes of practice are an integral part of most external quality control systems. The thrust areas of technology transfer include: development of glue spreading devices and gluing technology, non-destructive testing and criteria for engineered uses (laminated timber/veneer; light-frame construction) and non-engineered uses, optimum length of joints and long finger-jointed members, new production techniques and equipment.

3.4 Challenges of 21st Century - Investment needs and industrial structural changes

Apparently, industries in developing countries have not yet geared up for efficient processing of small dimensional logs with the current structural set up and machinery. The comprehensive analysis of Asia Pacific Forestry sector indicates that total annual investment needs for plantation development and structural changes of the industries in South Asia alone range from the level of US $891 million in the year 1994 to US $1,237 million to the year 2010 (Table 3.7). Additionally, 10-15% of these figures are estimated for institutional infrastructure/support, research, training/human resource development, technology development and dissemination. International/regional networking approach both within and between the countries, with the participation of FORSPA, IUFRO and APAFRI, is suggested to pool the limited available resources for research and technology, that would facilitate sharing knowledge and avoid duplication of efforts. This would increase the opportunities for mobilisation of support from national/international developmental agencies including private forestry sectors (Enters et al., 1998).

The major challenge is - *how the industries will respond to the changing pattern of wood supply for adopting and implementing codes of conduct in the context of sustainable utilization through plantation management practices,*

Table 3.7 Estimated annual investment needs (US $ millions) for plantation development and structural changes of the industries in South Asian Region

INDUSTRIAL SECTOR	YEAR 1994	YEAR 2010
Forest plantation development	303	398
Non-forest (TOF) resources	160	240
Wood harvesting	123	186
Sawmilling	83	166
Wood-based composites/panels	34	37
Paper and paperboard sector	188	210
Total	891	1,237

Source: FAO (1998)

technology transfer and investments? As Leslie (2000) puts it, tropical forestry must somehow react and perform quickly in the following lines, failing which rapid decline and low returns and outputs are inescapable:

- the market R and D for identification, characterization and implementation of the high-value strategy.
- the production, distribution, marketing and quality control systems to capture the high-value market will become the norms and reality in the industries.

Conclusions

The industrial roundwood supply from plantations is expected to increase from the current level of 25% to 33% of total global supply in the year 2010 and beyond. With the major shares in China, India and Japan, the Asia Pacific Region leads the world in forest plantation development in addition to its most of the world's 26.5 million ha of non-forest plantations of rubber wood, coconut and oil palms as fibre resources. Apart from forest plantations of eucalypts, teak, acacia and pines, the recent wood supply is from the trees outside forests (TOF) especially farm lands, estates/ converted forests, small woodlots, etc. Additional sources of industrial wood identified are logging and mill residues as well as recycled fibres. Extensive research work has been carried out in the region including India for characterization and enhancing the service life of most these wood resources as industrial material. The changing pattern of wood supply, however, calls for a new approach for integrating wood research with plantation technology for wood farming and for increased conversion efficiency of small diameter logs in the manufacture of value-added/new products. Because most of the technologies are available in industrialized countries, technology transfer/adoption appears to be a need of the hour in developing countries including India. The current situation demands considerable investments on plantation development and structural changes of the industries for processing small dimensional materials with new or modified machinery for sawmilling, veneer production and manufacture of reconstituted products, including glue-laminated composites/finger-jointed structures and pulp and paper. Regional networking approach is suggested to pool the limited available resources and share infrastructure/expertise for research, training and technology transfer and to mobilise support from national/international developmental agencies including private forestry sectors. The major new challenge is - how industries respond in implementing the voluntary codes of conduct through management practices, technology transfer and investment.

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Chapter 4

Training network for wood specialists of developing countries: Basic areas of training requirements in wood technology

The following three basic areas are proposed to meet the training requirements of wood specialists of developing countries (Fig. 4.1).

1. NWFP-Net (Non-wood Forest Product - Net)

   Mission: Production, harvesting, processing and utilization of NWFPs (bamboo, rattan, phyto-chemical and pharmaceutical products, gums, resins, tannins, etc.)
2. Timber-Net

   Mission: Timber quality modification - by Silviculture and/or genetics (GMOs), bio-chemical modification - application of biotechnological tool, harvesting and processing technology for small diameter logs (from short rotation plantations/thinnings, TOF including non-conventional timbers like rubberwood, palm stems), grading and marketing
3. Residue Utilization-Net

   Mission: Utilization of agro- and forest/logging residues, industrial mill residues and recycled products, manufacture value-added composite boards, panels, etc.

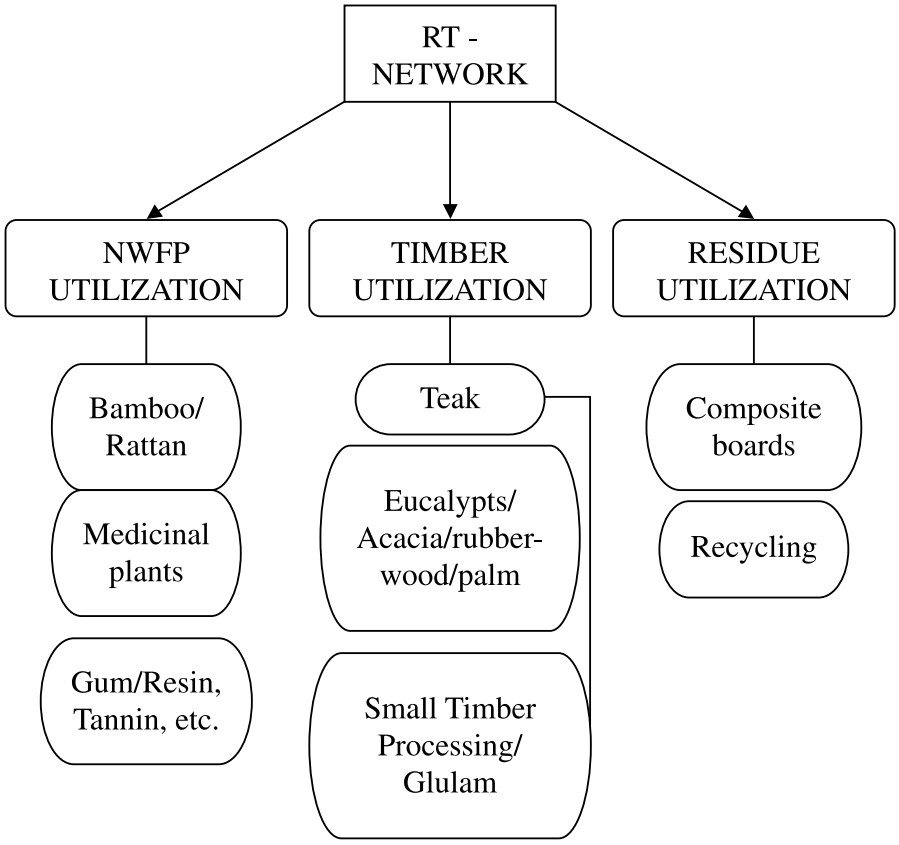

Fig. 4.1 Major areas of Research and Training needs of developing countries in Asia Pacific Region

4.1 Strengths of the core institutions for training in wood science in three major countries' players of the Asian region for forest-based industries: China, India and Japan

CHINA

I. Research Institute of Wood Industry (Chinese Academy of Forestry: CAF)

Established in 1957, the Chinese Research Institute of Wood Industry (CRIWI) being the largest research and development center for wood science and technology in China, is mainly engaged in applied research, development research and applied basic research related to wood industry. CRIWI is capable of offering post doctoral program, Ph.D. program and Master degree program.

The Major objective of CRIWI is to develop technologies of utilizing wood raw materials rationally and economically so as to make better use of forest resources and meet the needs of national economy and people's livelihood.

With 161 staff including 140 research and technical personnel, CRIWI consists of 6 research divisions such as Wood Property, Wood Drying, Wood Protection, Wood-based Panels, Wood Adhesives and Panel Surface Finishing, as well as Machinery and Automation. Additional two units, viz. Department of Civil Engineering Designing and National Quality Monitoring and Testing Center for Wood-based Panels provide further support. The Technical Committee for Wood-based Panels Standardization, the Chinese Society of Wood Industry and the the Basic Technical Committee for Wood Standardization are also attached to CRIWI.

II. Research Institute of Chemical Processing and Utilization of Forest Products (RICPUFP)

The National Engineering and Technology Research Center of Forest Chemical Industry is the only specialized centre of forest chemical technology and industry in China. Taking efficient utilization of forest resources and their by-products in down-stream processing, the Centre has chemical engineering of aspects of natural organisms. Priorities are given to chemical properties, chemical technology, chemical engineering, biotechnology, the application of new products, etc. in tree extractives, and development and utilization of new forest resources. The Centre is also responsible for working out national standards for various silvi-chemical products and quality inspection and supervision of forest chemical products in China. The Research Institute of Chemical Processing and Utilization of Forest Products (RICPUFP) in the Chinese Academy of Forestry (CAF) affiliates to the Centre. RICPUFP keeps in possession of the First, Second and Third Classes Certificate for the designing of pressure vessels. Chinese Society of Forest Chemical Products and Engineering; National Scientific and Technological Information Centre for Chemistry and Chemical Engineering of Forest Products; Quality Inspection and Supervision Station of Forest Chemical Products, Ministry of Forestry; and Forest Product Chemical Industry Consultation and Services, Ministry of Forestry are all attached to the Centre.

With the advantage of outstanding specialists and technicians engaged in research and development, design and trial, the Centre has great potential in undertaking national key projects and offers study programs for graduates at master's and doctor's degree levels in the specialty of chemical processing of forest products. In addition, a postdoctoral station is set up here. The Centre includes the following sessions: Engineering and Technology Committee, Nanjing General

Company for Science and Technology Development and an administrative office. In view of the major basic and technical problems existing in forest chemical industry, the Centre, depending on its research and development superiorities and abundant funds, has frequently transferred the research achievements and high-value new products to the production so as to promote the scientific and technological advancement and the forest chemical industry and its relevant industries on the upgrade.

Main research fields:

1. Pulping and paper-making from wood and non-wood fibers. With internationally advanced refining pilot plant and determination instrument, carrying on the research of wood properties, fiber anatomy, pulping and paper-making technology, effluent treatment and products determination. Research and Development Center of Pulping and Papermaking of CAF is set up here.
2. Chemical utilization of Oleoresin. Mainly working on the research of chemistry and chemical processing of rosin and turpentine, from which having developed many kinds of products such as modified rosins, rosin resins and turpentine resins, as well as surfactants and plasticizers.
3. Chemical utilization of forest resources. Studying the separation and identification of valuable chemical components of plant materials in forest, mountain and desert areas. Having gotten many scientific achievements in the development of series products from plant tannin, pine needles, popular bark, ginkgo leaves, Gynostemma Longipes and Adeaophora, as well as the processing of woody plant oils and natural essential oils.
4. Activated carbon and wood-based energy (The Institute is the council of National Activated Carbon Association).
5. Adhesives. Having developed the series products of emulsion adhesives, urea formaldehyde and phenolic resins, polyurethane adhesives for wood working and other industries (The Institute is the council of the Chinese Adhesive Association).
6. Manufacture of Furfural and Furfuryl Alcohol by hydrolysis of plant cellulose materials, and Chemical modification of cellulose.

Forest chemical engineering and equipment. The Design Institute of Forest Chemical Engineering of CAF is set up in RICPUFP, and it has the Second Class Certificate of engineering consulting and design, and specific engineering design for environmental pollution control, and the qualifications of design of pressure vessels of 1st to 3rd class. Institute of Scientific and Technical Development Company of NRCFCET (National Research Centre of Forest Chemical Engineering and Technology) is responsible for the routine management and comprises the following branches as:

1. Management Department
2. Production Department
3. Marketing Department
4. Research Department of Adhesives
5. Research Department of Activated Carbon
6. Nanjing Longyuan Natural Polyphenol Synthesis Factory
7. Nanjing Ambition Chemical Plant
8. Nanjing Natural Fine Chemicals Company

9. Jiangsu Phyto Company.

Other Accessory Institutions:

1. Quality Inspection and Supervision Station of Forest Chemical Products.
2. Chinese Society of Forest Chemical Products and Engineering, Chinese Society of Forestry.
3. National Scientific and Technological Information Center for Chemistry and Chemical Engineering of Forest Products.

III. Bamboo Research and Development Center (BRDC)

Bamboo Research and Development Center (BDRC) of State Forestry Administration, located in Hangzhou, Zhejiang Province, was established in November, 1995 and attached to Chinese Academy of Forestry. At present, there are 9 staff in BDRC, of which 6 are scientific and technical personnel including 5 senior ones. The main task of BRDC is to research and develop the bamboo resources in the following lines:

- To drive and promote industrial development of China in bamboo-related areas.
- As an international cooperation industrial exchange programme, BRDC organizes the scientific research and technical development programs in cultivation, utilization and development of bamboo, resources especially through practical training and techniques for both domestic and overseas' organizations.
- It will provide research and training with excellent working conditions. It also organizes the programs for scholars and experts in the field of bamboo research to conduct the international economic and technical cooperation.
- BRDC is a standing direct unit of the Council of South Cooperation Network and it undertakes periodically the training program and projects assigned by UNDP, Ministry of Foreign Trade and Economic Cooperation of P. R. China and other ministries.

INDIA

I. Forest Research Institute (FRI), Dehra Dun

Established in 1906, the Forest Research Institute, Dehra Dun, is the pioneering institution concerned with forest research and education in India. Set in a lush green estate spread over 450 hectares, it has well equipped laboratories, library, herbarium, arboreta, printing press and experimental field areas for conducting forestry research. Forestry research in the FRI is organized under fourteen divisions. The Institute's achievements in forest products research, particularly during the world wars, have contributed valuably to the development of forest-based industries in the country. The Arsenic-Copper Chromate treatment for wood preservation, developed by the Institute, is now widely adopted throughout the world. The Institute has also pioneered the process of pulping bamboos for paper making. Notable among achievements in Forest Genetics are the development of hybrids of Eucalyptus, capable of producing a larger biomass, viz, FRI-4 and FRI-5, creation of model seed orchards of teak and semul, and tissue culture of eucalyptus. Xylarium, with a collection of over 18,000 wood specimens from India and abroad, qualifies the Institute as the best source of reference for wood identification.

Status of Deemed University

On the basis of recommendation of the UGC (University Grant Commission), the Ministry of Human Resource Development (Government of India) declared the Forest Research Institute to be a Deemed University in December,1991.

The Forest Research Institute 'Deemed University' conducts the following academic activities:

- Ph.D. programmes for postgraduates students.
- Specialized courses - Postgraduate Diploma courses in Pulp and Paper Technology, Wood Technology and Plantation Technology have commenced from 1992.
- Networking with other training institutions involved in the field of forestry education.

II. Indian Plywood Industries Research and Training Institute (IPIRTI), Bangalore

An autonomous body of the Ministry of Environment and Forests provides training in saw-milling and plywood industrial sector to improves skills, upgrade products quality, optimize production cost and enhance international competitiveness of the products. The institute has a sanctioned staff strength of 104 and regional centers in Calcutta and Tinsukhia (Assam) in addition to the main facility in the head quarter at Bangalore.

Thrust Areas

- ❑ Finger-jointed and glulam structures from plantation grown timbers and bamboo mat boards from bamboos
- ❑ Training in mechanical wood industries and processing small diameter logs

Recent Achievements

- ➢ Developed new products like bamboo mat boards and application in various uses for housing

III. Institute of Wood Science and Technology (IWST), Bangalore

Initially established in 1938 as a Forest Research Laboratory by the erstwhile state of Mysore and later in 1956 taken over by the Govt. of India and made a Regional Research Centre of the FRI and Colleges, Dehra Dun. IWST was declared, in April 1988, as an independent Institute under the ICFRE to cater to the research needs of the states of Karnataka, Andhra Pradesh, Goa and Daman and Diu. The Institute maintains three field stations for forestry research in Karnataka state, and two outstation marine centres at Vishakapatnam and Cochin (Kochi). The current areas of forest products research include:

- Processing/utilization of lesser known timber of plantation species.
- Development of indigenous substitutes for imported raw material in perfumery industries.
- Utilization of alternative timbers for catamarans, the traditional craft of poor coastal fishermen of A.P.

IV. Kerala Forest Research Institute (KFRI), Peechi

Kerala Forest Research Institute (KFRI) was established in 1975 as a registered society under the aegis of the Science and Technology programme of the Kerala State government. In the context of fulfilling the economic, social and environmental objectives of forestry, the institute conducts research and training in all aspects of forestry, wildlife management and wood science and technology. The overall control, administration and management of the institute are vested in a Governing Body appointed by the state government while day-to-day administration rests with the Director who is also appointed by the government. The institute has 14 Research Divisions with 48 scientists in addition to Library and Engineering services.

Profile of Wood Science Division, KFRI

The Division of Wood Science at Kerala Forest Research Institute has well qualified scientists, all with Ph.D degree and overseas training in specialized areas of wood technology and non-wood forest products (NWFPs). The multidisciplinary expertise of scientists covers: biology, anatomy, material quality, preservation, harvesting and processing of both wood and non-wood forest products including bamboo and rattans.

The main mandate of the Division of Wood Science includes:

(a) Project identification and conduct of research in problems relating to production and efficient utilization of wood and non-wood resources.

(b) Technology transfer to forest-based industries and impart of training/technical advice to all end-user sectors for optimum utilization of forest resources.

(c) Facilitation of adoption of quality standards in processing and marketing of forest products in the context of sustainable of utilization of forest resources.

(d) Advancement of knowledge in pursuit of academic excellence in forest products and allied fields.

Commercial activities/services offered to wood users

1. Timber and bamboo/cane identification and certification for quality assurance
2. Wood testing for moisture content, specific gravity, chemical preservatives, etc.
3. Consultancy in various fields of wood technology including bamboo/cane product manufacture

Recent Research and Developmental Activities of practical relevance to user agencies

- Economic schedule for preservative treatment of rubber wood
- Utilization of wood from wilt-diseased coconut palms
- Pulpwood quality of eucalypts from short rotation plantation
- Protection of pulpwood in storage
- Rural technology for rattan (cane) curing
- Grading rules for rattan (cane)
- Harvesting tool for reed bamboo
- Harvesting tool, preservative treatment and storage methods for reed bamboo
- Local tools, equipments and technologies for processing bamboo and cane
- Wood quality of fast grown teak and other plantations species

Recent Activities of Technology Transfer and selected beneficiaries

1) Transfer of oil curing technology to sole-cane supplier of East and North-eastern India for quality products of cane furniture manufacture in cottage industries of Southern India.
2) Simple preservative treatment technology was transferred to numerous rubber wood processing industries in Kerala (Aspinwall & Co., Plantation corporation of Kerala, etc.) and other states.
3) Utilisation technology for rubber wood, coconut wood and other conventional timbers in low cost buildings of Nirmithi Kendra, Thiruvananthapuram and Costford, Thrissur.
4) Sawmilling (processing), seasoning and preservation technology to many industries like Kerala Wood Industries, Poabson Industries, Thiruvalla, Forest Industries Travancore Ltd, Aluva, etc.

5) Storage techniques for bamboo/reeds and pulpwood raw materials to industries like Hindustan Newsprint Ltd., Gwalior Rayons, etc.
6) Coconut wood utilization technology to Coconut Development Board, Cochin.
7) Appropriate Sawing technology (SDR Technique) for processing eucalypts was transferred to: Wood processing unit of Gujarat State Forest Development Corporation, Vadodara.
8) Rural technology for cane (rattan) curing and steam bending was transferred to:
   a) Karnataka Forest Department (in Honnavar Forest Division) - 1989
   b) For different cane furniture manufacturers through field demonstration programme at KFRI Sub-centre, Nilambur 1991-92
   c) Bondage Industries, Ahmedabad - 1993
   d) Shiney Indoors, Aleppy - 1995-96
   e) Kothari Cane Industries, Calcutta - 1998
9) Project Report prepared for Forest industries Travancore Ltd., Alwaye on Establishment modern cane furniture manufacturing unit.
10) ICFRE technology was transferred for solar drying, ammonia plasticization in bent wood furniture, ammonia fumigation for better colour of furniture products and cost effective preservation techniques to various wood industries by conducting wood technology clinics in different parts of the state.

Courses/Training being offered to Students/Forestry Professionals

1. Timber/bamboo/cane identification and wood quality assessment
2. Wood preservation, drying and processing
3. Oil curing/product conversion technology of canes under the UNDP Program
4. Any customized training programme in wood technology

New Areas of Training Needs

Lack of adequate training in newly emerging areas of wood energy sector and product manufacture or/and testing especially wood composite products/glulams and building codes from jointed structures, pulp modification with hydrolytic enzymes/biotechnology and gene transfer technology for desired wood quality and Chemical processing for product development from NWFPs. Equally important area is the role of tropical plantations in carbon sequestration and environmental issues.

The Ministry of Environment and Forests in India recognized the institute (KFRI) as the **Centre of Excellence for Non-wood Forest Products (NWFPs) like Bamboo and Rattans**.

V. Agriculture Universities and Other Organizations

In addition to the above Core institutes; the following agricultural universities and institutions, where the course of wood science was recently introduced at different levels, may also serve the purpose of education and training purposes within the network, but needs immediate human resource development programmes. Additionally, for specific needs of technology modification and transfer through inter- and multi-disciplinary programmes, Indian Institutes of Technology from Chennai, Kanpur and Mumbai can also be involved.

1 COLLEGE OF FORESTRY, KERALA AGRICULTURAL UNIVERSITY
Vellanikkara, THRISSUR, KAU POST 680 656
Tel: +91-487-370050
Fax: +91-487-370019

2 COLLEGE OF FORESTRY, UNIVERSITY OF AGRICULTURAL SCIENCE
Ponnampet 571216, Karnataka
Tel: +91-8274-49370
Fax: +91-8274-49365

3 DEPARTMENT OF FORESTRY, COLLEGE OF AGRICULTURE, P. K. V., AKOLA
Punjabrao Krishi Vidyapeeth, Krishinagar, Akola 444104
Tel: +91-26841/42/43 (PBX)
Telex: 0725-025

4 DR.Y.S. PARMAR UNIVERSITY OF HORTICULTURE AND FORESTRY
P. O. Box Nauni-173230, Solan (H.P.)
Tel: 333 (Solan)
Fax: +91-1792-2288

5 TAMIL NADU AGRICULTURE UNIVERSITY, FOREST COLLEGE AND RESEARCH INSTITUTE
Mettupalayam-641301, India
Tel: +91-425-42010
Fax: +91-422-41672

6 UNIVERSITY OF AGRICULTURAL SCIENCE, DEPARTMENT OF FORESTRY
Bangalore 560 065, Karnataka
Tel: +91-80-330153
Fax: +91-80-320840

7 UNIVERSITY OF SHIMLA
Himachal Pradesh

8 NORTH-EASTERN RESEARCH COUNCIL, WOOD SCIENCE DEPARTMENT, ITANAGAR
Arunachal Pradesh

JAPAN

I. Division of International Environmental and Agricultural Science, Graduate School of Agriculture, Tokyo University of Agriculture and Technology

Thrust Area:

1. Mechanical wood processing, industrial safety, etc.

II. Graduate School of Bioagricultural Sciences, Nagoya University

Division of Biological Material Sciences : Biomaterial Physics (BMP)

The major research objective is to understand the physical behavior of biological materials and the process of tree growth, from a physical point of view. Methodology extends over the physical, mechanical, chemical and computing

methods.

Generation processes of the physical properties and the growth stresses of biological materials are investigated by means of the field measurement in the worldwide forest, laboratory research involving material testing, electron-microscopic observation, X-ray and UV spectroscopy, image analysis, chemical analysis and other instrumental analysis as well as theoretical modeling. On the other hand, some applied research is carried out especially on the reduction of residual stresses in logs, the quality of tropical fast growing species as well as non wood forest resources, and about some problems on environmental functions of dwelling.

Thrust Areas:

1. Growth stresses and wood quality, anatomy, reaction wood, lignin formation in wood, etc.
2. Wood physics

III. Graduate School of Agricultural and Life Sciences, University of Tokyo

Thrust areas:

1. Utilization of agricultural residues like rice straw, pulping, recycling of wood resources
2. Bio-polymer chemistry, bleaching and lignin chemistry

IV. Asian Natural Environmental Science Center (ANESC), University of Tokyo

The Asian Natural Environmental Science Center was established in April, 1995 as one of the Cooperative Education and Research Centers of the University of Tokyo. The Center, composed of two Divisions, one of which is the Division of Biological Environment Assessment (DBEA), promotes cooperative studies on sustainable utilization of bio-resources in the Asian Region. Its activities will be coordinated with environmental conservation aimed at preventing the exhaustion of bio-resources and environmental destruction now obvious in many are around Asian region. The staff of DBEA have responsibilities to develop novel systems for land use based on regional characteristics, and the effective and sustainable utilization of untapped bio-resources. The development of novel and low-energy-input systems to increase the quantity of bio-resources will be undertaken by the staff of the DBEA using symbiotic and stress-tolerant functions of plants.

Global changes, especially in the Asian region, occasioned by the population explosion, exhaustion of bio-resources and environmental destruction, requires the urgent development of countermeasures through short- and long-term programs to increase the output of food while improving the utilization of bio-resources in the Asian region, it is also true that the developments foreshadowed will not control effectively the destruction of regional and global environments.

Of course, the accumulation of bio-resources depends heavily on the characteristics of the diverse ecological situations (forests, cultivated land and coastal areas) which are closely linked with one another. It is essential to devise ways of appropriately using land, taking into consideration the mutual relationships between their ecologies and the effective utilization of bio-resources without environmental destruction. Novel and low-energy-input systems are needed to increase the quantity of bio-resources. This may be achieved by augmenting the symbiotic relationships between plants and microorganisms. In addition, it is very important to search for plants in the global genetic pool that are resistant to

environmental stress, pathogenic microbes, viruses or pests, which would be useful in the development of bio-resources. The Center has been established to investigate, in a comprehensive way, the effective utilization of bio-resources, and has been constituted to cover these subjects as widely as possible. The activities of the Center and will promote and integrate investigations by scientists in this university and other institutions in Japan. In addition, collaboration with institution in the Asian region will be promoted through the activities of the Center.

V. Forest Tree Breeding Centre (FTBC)

This is an organization of Forestry Agency, the Ministry of Agriculture, Forestry and Fisheries (MAFF). FTBC conducts various forestry-related surveys, research, and technical guidance, and generally promotes Japan's forestry industry. FTBC operates in five blocks throughout Japan, in Hokkaido, Tohoku, Kanto, Kansai, and Kyushu. Each block has each Breeding Office. Also, in order to promote overseas technical cooperation, the Iriomote Tropical Tree Breeding Technical Garden was established in Okinawa Prefecture in 1996. The Center was changed into an Independent Administrative Institution on April 1, 2001.

Thrust Area :

One of the areas is breeding for wood quality with application of gene transfer technology with DNA markers and clonal multiplication.

VI. Institute of Wood Technology (IWT), Akita Prefectural University

Research Thrust Areas and available expertise:

1. Manufacture and application of cylindrical laminated veneer lumber (LVL) and properties and manufacture of composite panels
2. Machinery development for processing plantation thinnings (specialized machines for flaking mill and veneer production)
3. Drying technology
4. Preservation of all lingo-cellulosic materials including wood
5. Chemical modification of lingo-cellulosic materials and charcoal production from agro-forestry residues

VII. Faculty of Agriculture, Kyoto University

Thrust Areas:

1. Wood and heartwood formation in fast growing tropical hardwoods
2. Anatomy of palms, bamboo, monocotyledons, etc.
3. Genetic engineering of bamboo
4. Anatomy, ultra-structure, quality of tropical woods and biomass utilization

VIII. Wood Research Institute (WRI), Kyoto University

1) Laboratory of Structural Function, Division of Wood Material Science

The laboratory aims to develop new wood composites harmonized with both global and regional environment by making use of the functions of wood as a cellular solid;

1. Fundamental methodology, machines and systems for producing the high-performance of wood composites and their characteristic functions

2. The development of wood carbon materials with new functions by thermal conversion and the technology for bio-energy
3. The development for improving fire-resistant performance of wood composites.

The projects taken are as follows:

1. Lumber Composite Products
   a. Continuous production process of cylindrical LVL
   b. Numerical analysis of mechanical properties of cylindrical LVL and paper pipe
   c. Prediction of mechanical properties of oriented materials from different element sizes based on fracture mechanics
   d. Development of joint plates with compressed LVL
   e. Grading and fire-resistant performance of tropical fast-growing species
   f. Production technology of stick-lumber and stick-ply
   g. Production of thick LVL/fiber-reinforced LVL using continuous steam-injection press
2. Panels Products
   a. Development of kenaf boards
   b. Kenaf binderless board and its composites
   c. Production and properties of vertically oriented fiberboard (VOF)
   d. Properties of the sandwich panels with VOF core
   e. Production and properties of high performance bamboo fiberboard with a hollow structure
   f. Shear performance of sandwich panels
   g. Development of reed/wheat-straw board
   h. Development of food attractant particleboard for termites using steam-injection pressing
   i. Improvement of dimensional stability for panel products by using steam pretreatment
3. Acoustic Materials
   a. Acoustic properties of wood for musical instruments
   b. Improvements of acoustic properties of wood by use of chemical treatments
   c. Production of soundboards from Japanese cedar logs with a small diameter
4. Bio Oil & Wood Vinegar
   a. Pyrolysis of chromium-copper-arsenate treated wood at low temperature
   b. Fast pyrolysis of chromium-copper-arsenate treated wood in a fluidized bed reactor
   c. Energy from wood biomass by fast pressurized heating equipment
   d. Chemical components and anti-fungal efficiency of wood-vinegar-liquor prepared from different species
5. Biomass Carbon Materials
   a. Adsorption and desorption of wood charcoal carbonized at high temperature
   b. Investigation of microstructure formed in wood charcoal during carbonization - observation by electron microscopy andalysis by XPS
   c. Development of wood-based carbon materials by direct pulse sintering
   d. Micro structural investigation of bio carbon composites
   e. Catalytic carbonization at high temperature of biomass carbon by aluminium oxide
   f. Improvement of fire resistant performance of wood composites by overlaying the carbon materials

6. Densification/High-strength Wood Plastic Composites
   a. Politicization of wood by use of wood rotting fungi
   b. Changes in thermal softening behaviors of wood due to removing of wood constituents
   c. Production of plastic-like wood flour molding
   d. Plastic-like molded products made from Radiata pine bark or its extractives
   e. High strength and bio-degradable moldings made from pulp
   f. Selective densification of wood
   g. Production of high strength wood based materials
   h. Production of natural plant fiber reinforced plastic
   i. Densification, drying, and impregnation by roller-press
7. Mineral Bonded Composites
   a. Rapid curing technology of cement bonded particleboard with mineral additives
   b. High-performance cement bonded particleboard and fiberboard by curing with carbon dioxicide
   c. Production of cement bonded fiberboard from oil palm fibers
   d. Durability and weathering of cement bonded particleboard
   e. Study on wood-based materials with multi-functions
   f. High-performance gypsum bonded particleboard
   g. Propose to new methods of cement bonded boards' manufacture - search for alternative solutions to the high specific gravity problem
8. Adhesive Resins/Durability of Adhesion
   a. Properties and durability of MDI (Methylene Diphenyl Diisocyanate) resins
   b. Bonding properties of gluco-mannan
   c. Durability of urushi coating films
   d. Production of high durable wood adhesives from bark of fast growing trees
   e. Decomposition with lactic acid of wood and utilization of the fragment to adhesive
9. Integrated Projects
   a. Life cycle assessment of wood composites
   b. Zero-emission processes for oil palm residues
   c. Total processing and utilization system of domestic small-diameter low-grade logs
   d. Durability of timber construction and wooden cultural properties
   e. Development of bio energy from chromium-copper-arsenate treated waste wood.

2) Laboratory of Gene Expression, Division of Wood Bioscience

The institute undertakes studies on gene expression in woody plants to elucidate function of target genes. They are also studying transformation for better understanding trees and for developing new traits.

Thrust Areas:

1. Cell wall loosening
   This study focuses on the structure and function of endo-1,4-beta-glucanase.
2. Biosynthesis of cellulose
   Molecular and cell biology of cellulose biosynthesis in higher plants

3. Characterization of genes in woody plants
   One of the aim is to understand gene expressions in the secondary metabolism and is to discover unique genes or expression that are characteristic in woody plants. The others are to serve those genes for new traits.
4. Research and development of transgenic trees
   This project focuses on introducing new traits into a tree. Gene transfer systems for woody plants have been developed to produce useful substances and traits.

The Wood Research Institute (WRI), Kyoto University, will serve as a core university to coordinate the activities of collaborating universities, institutes and individual researchers in Japan and to plan and actually implement the activities hand in hand with the counterpart core institute, R & D Centre for Applied Physics, Indonesian Institute of Sciences (LIPI), Indonesia.

WRI and the R & D Centre for Applied Physics, LIPI, have been conducting a cooperative research on "The characterization and efficient utilization of wood and forest residues" as part of the Cooperative Program of JSPS since 1983. A new program started in 1996 under the "Core University System", for the following three activities in the fields of wood science and technology;

1. Organization of cooperative research
2. Exchange of scientists
3. Organization of symposia.

Scientific activities in this program cover all fields of wood science and technology including material science, physics, chemistry, biology, genetics and environmental science. Leading scientists from 17 Japanese and 15 Indonesian universities and institutes are expected to join this program.

4.2 Lessons from success stories of regional/international networks: FORSPA and INBAR

I. What is FORSPA?

The Forestry Research Support Programme for Asia and the Pacific (FORSPA) is an FAO Program that was established in 1991 to assist research institutions in the Asia-Pacific Region to strengthen their science and technology capabilities in forestry research.

FORSPA Phase I (Nov. 1991 to Dec. 1994) was funded by Asian Development Bank, with an Intermediate Phase (1995) supported by AusAID and the United Kingdom's ODA. Seeing the need for continuing support for the enhancement of national forestry research systems and based on the lessons learned in Phase I, Phase II was launched in January 1996. The project document signed by the Dutch Government envisaged the provision of support for 19 countries in the Asia Pacific Region, viz. Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Fiji, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Solomon Islands, Sri Lanka, Thailand, Vanuatu and Vietnam. The Phase II (1996-2000) is being funded by the Netherlands Government.

FORSPA's Mission

To promote conservation and sustainable management of forest and tree resources in the Asia Pacific Region by building country capacity in research and enhancing technical capabilities of communities, farmers and forest resource managers in responding effectively to the changing social, economic and environmental conditions facing them.

How FORSPA Operates

FORSPA does not undertake research. It supports:

- By developing research networks which lead to greater collaboration among researchers in the region;
- By providing technical and managerial support for networking, organization of meetings and seminars, development of databases, and publishing of newsletter, case studies and monographs;
- By initiating topic-specific research studies of regional importance;
- By assisting in capacity building of national institutes through research planning, human resource development, increasing access to information, and facilitating technology transfer and adaptation; and
- By assisting in twinning arrangements to promote inter-institutional collaboration, sharing of knowledge, and transfer of know-how and technology.

Project Objective

The long-term objective of FORSPA is to promote conservation and sustainable management of forest and tree resources in the Asia Pacific Region. This long-term objective is to be achieved through country capacity of communities, farmers and forest resource managers in responding effectively to the changing social, economic and environmental conditions confronting them.

Immediate objectives of FORSPA Phase II are:

i. To support networks on topics of national and regional significance and undertake studies with regard to development and adaptation of technologies by disadvantaged groups like women and to sensitive

researchers and users of research to incorporate the social, economic and cultural dimensions of technologies on conservation, management and utilization of forest and tree resources;

ii. To assist capacity building in forestry research in countries with insufficiently developed research systems through research planning support, training, increased access to information and supporting the establishment of twinning arrangements to facilitate technology transfer and adaptation; and

iii. To develop and strengthen the Asia Pacific Association of Forest Research Institutions (APAFRI) through providing technical and managerial support for networking, including organization of meetings and seminars, development of supporting databases, publication of monographs, case studies and newsletters.

Project Philosophy

FORSPA's working method is based on the belief that there is enough know-how and potential in the region to deal with the many problems and challenges that lie in the filed of forestry research. Many of the problems are common throughout the region, and so it will be much more effective if the know-how and information on common issues can be shared and problems are solved jointly. This is the reason for the strong emphasis on regional networking. FORSPA's efforts are directed to establish durable forestry research networking platforms, in which the Asia Pacific Association of Forestry Research Institutes (APAFRI) should play the central co-operation role.

This concept forms the basis for the approach applied in FORSPA's activities to enhance the forestry research capacity of countries with insufficiently developed forestry research systems. The activities are mostly implemented in line with the South-South co-operation. Expertise is sought within the region for strengthening the capacity of the weaker forestry research institutions in specific countries.

FORSPA's Activities

FORSPA engages in activities at regional and country levels as following:

- **Regional Level Activities (regional networking):**
  - o Asia Pacific Association of Forest Research Institutions (APAFRI)
  - o Topic specific networks
  - o Regional studies relevant to R&D development
- **Country Level Activities (strengthening national forestry research systems):**
  - o Research Planning Support
  - o Human Resource Development
  - o Information Support Services
  - o Twinning Arrangements

Overview of Accomplishments

The overview of accomplishments can be judged from the distribution of FORSPA's resources to the different activity types, for the implementation period (1996-2000) as given below.

- ➤ Country capacity building
- ➤ Regional networks (APAFRI, TEAKNET, etc.)
- ➤ Regional meetings and studies
- ➤ Regional Databases.

II. What is INBAR ?

The International Network for Bamboo and Rattan (INBAR) is an international organization established by treaty in November 1997, dedicated to improving the social, economic, and environmental benefits of bamboo and rattan. INBAR connects a global network of partners from the government, private, and not-for-profit sectors in over 50 countries to define and implement a global agenda for sustainable development through bamboo and rattan.

As of March 2001, INBAR's Establishment Agreement has been signed by 22 countries: Bangladesh, Benin, Bolivia, Canada, Chile, China, Colombia, Cuba, Ecuador, Ghana, India, Indonesia, Kenya, Malaysia, Myanmar, Nepal, Peru, the Philippines, Sri Lanka, Tanzania, Togo and Vietnam. Following a recent review by INBAR, the number of potential members is about 75-80.

Why Bamboo and Rattan?

- A sixty-foot tree cut for market takes 60 years to replace. A sixty- foot bamboo cut for market takes 59 days to replace.
- Over one billion people in the world live in bamboo houses.
- The world trade in bamboo and rattan is currently estimated at 14 billion US dollars every year.
- The majority of bamboo and rattan harvested for market is harvested by women and children, most of whom live at or below subsistence levels in developing countries.

How INBAR came into existence

Recognizing the socioeconomic importance of bamboo and rattan to the developing countries in the tropics and sub-tropics, the International Development Research Centre (IDRC) has, since 1979, fostered research efforts aiming to better understand, utilize and develop these resources, principally in the Asian region.

National research institutions and NGOs were linked in an informal network involving funding of over US$ 8 million in the past decade. In 1990, an IDRC-sponsored meeting of interested donors and organizations recognized that research investments in bamboo and rattan have substantially benefited the poor in developing countries of the tropics and sub-tropics. The resulting study on the strategic needs for further research identified key areas and also suggested the creation of a formal network to consolidate and strengthen existing research activities in the region and broaden their scope. Acting on these recommendations, IDRC, with support from the International Fund for Agricultural Development (IFAD), established the International Network for Bamboo and Rattan (INBAR) in 1993.

Chronology

- o In 1979, IDRC initiated support for research aimed to better understand, develop and utilize bamboo and rattan resources.
- o In 1984, the national programmes were linked together into an informal network to provide a forum which was sustained by IDRC until 1993.
- o In 1991, IDRC, IFAD, the Rockefeller Foundation and the Overseas Development Administration (ODA, UK), commissioned a review of past research and requested recommendations for future action. The study recommended that the research be reoriented and there should be an independent, autonomous International Network for Bamboo and Rattan (INBAR) established either within or outside of the Consultative Group on

International Agricultural Research (CGIAR) system.

- o In June 1993, INBAR was established by IDRC and IFAD.
- o In May 1995, senior research managers from Asia and representatives of IDRC and IFAD met with the INBAR network to discuss and recommend institutional and funding options. At that meeting the representative from China, Prof. Chen Tongai, President of the Chinese Academy of Forestry (CAF), offered to host a headquarters for a new independent international centre for bamboo and rattan. As a result, Dr. Keith Bezanson, today ex-President of IDRC, convened a Task Force to explore the way ahead.
- o In August 1995, the recommendation that INBAR work toward achieving independent international status was endorsed by a task force struck by IDRC.
- o In September 1996, IFAD approved US $900 thousand funding for a Phase II programme of INBAR.
- o In October 1996, IDRC approved a US $1.6 million grant for the Phase II activities of INBAR and a further core grant for US $750 thousand in January 1997.
- o In January 1997, the State Council of China formally approved the establishment of INBAR and made a commitment of at least US $4 million support in kind to the new institution. The President of IDRC constituted an interim board of INBAR to oversee the transition into an independent centre.
- o On November 6, 1997, representatives from 10 countries, including Canada, signed the international treaty to establish INBAR as the first international research and development organization headquartered in the People's Republic of China.

Achievements of INBAR

Resource Improvement and Management

- o Creation of Anji Bamboo Garden, in China - largest in the world, extending over 20 hectares and including 221 species. This garden has produced over 40,000 offsets for cultivation in China and elsewhere. Visited by 10,000 researchers, producers and tourists each year.
- o Five thousand hectares of rattan plantation established in China. A rattan herbarium of over 1,000 species established.
- o Rattan incorporated in 7,000 hectares of rubber plantations in Malaysia.
- o A 500-hectare demonstration bamboo plantation was established in Bangladesh.
- o Investment/return ratio on rattan plantation increased by more than 25% by employing technology developed by the INBAR.
- o Intensive bamboo management technology developed through INBAR research was adopted in 72,000 hectares in Southeast Asia resulting in income of US $50 million to farmers.
- o Improved vegetative propagation techniques developed in Bangladesh and India.
- o Protocols developed for in-vitro propagation in Bangladesh, India, Philippines and Thailand.
- o Six national bamboo and rattan living collections were established.
- o Remote sensing techniques and Geographical Information Systems (GIS) interventions were applied for resource assessment in India and Thailand.

Processing and Product Technology

- o Various improvements were made in the preservation process and utilization of bamboo shoots, resulting in improved profitability for processors and farmers alike.

- o Developed economical preservative treatment methods for bamboo in Bangladesh and India.
- o Simple preservative treatments were standardized for bamboo culms ("stems") used as support for agricultural crops in India.
- o A simple rattan pole dryer, using local materials was developed in the Philippines.
- o Twenty-five bamboo and rattan processing technologies and machines were developed/designed, 11 of which were patented in Malaysia.
- o Improved bamboo mat board was developed in India.
- o Bamboo container floorboard was developed in China.
- o A cement-bonded, rattan-residue building board was developed in the Philippines.

National and International Policy

- o Listing of bamboo as a priority planting species in Bangladesh as a result of data generated in network-supported research.
- o Recognizing the successes of INBAR, Indonesia established a national version of the network.
- o Inclusion of bamboo research, as an area for assistance to developing countries, by the Department of Foreign Affairs of China.
- o Bamboo was included for the first time in the National Five year Plan (1995-2000) of China as a result of the thrust given by network- supported research.

Human Resources Development

- o Thirty-four training courses were conducted for entrepreneurs in bamboo and rattan based enterprises (700 people trained) in Malaysia.
- o Training in bamboo cultivation techniques for 5,000 people (foresters, farmers, NGOs) in Bangladesh.
- o Nine hundred local and 200 foreign people trained in bamboo cultivation in China.
- o Based on network-supported research, a cane training and technology centre was developed in India.
- o INBAR workshops conducted in India demonstrated bamboo and cane craftsmanship.
- o Three INBAR Information Centres (two for bamboo and one for rattan) were established and maintained in Malaysia, China and India.
- o Sixteen INBAR publications and eight issues of INBAR's quarterly newsletter were published.

4.3 Concepts of arbitrary model training network of ICCAE in the field of wood science

It is evident from the foregoing account of success stories of networking organizations that effective training programmes can be developed by stronger partnerships built, both within and between the countries, by pooling the limited available resources and share infra-structure and expertise to mobilize the support from among various international and national donor/ developmental agencies including private sectors. For instance, a tentatively established teak wood network integrates the collaborative efforts of IUFRO 5.06.02 Working Party (Timber quality from teak plantations) with other teak institutions such as TEAKNET and TEAK 2000 with the participation of various Research and Development Organizations possibly within the umbrella of IUFRO and APAFRI.

Mission of ICCAE - Training Network

The RT-network of ICCAE shall foresee:

1. Building country capacity in Training and Technology Transfer and enhancing the technical capabilities of rural communities, farmers, forest resource managers and small-scale forest-based industrialists in responding effectively to the changing social, economic and environmental needs
2. Assisting in building capacity in national institutes through training program planning, human resource development, increasing access to information, and facilitating technology transfer and adaptation
3. Developing training networks which lead to greater collaboration among the institutions within and between the countries
4. Providing technical and managerial support for networking, organization of meetings and seminars, development of databases, and publishing of newsletter, case studies and monographs
5. Initiating problem-oriented training programmes of regional and local importance
6. Assisting in twinning arrangements to promote inter-institutional collaboration, sharing of knowledge, and transfer of know-how and technology.

How ICCAE Training Network will Operate?

Within the each basic network area, viz. NWFPs, Timber net and Residue Utilization, formation of several sub-networks are suggested to meet more specific objectives and training requirements (Fig. 4.1).

- It is envisaged to develop training programmes at two levels to be effective in order to deliver the goods and reach to the level of users and rural communities (Fig. 4.2)

  Level I - Trainer's Training and

  Level II- End-user's training for rural communities.
- Each such sub-network, for instance, TEAKNET, has clearly defined activities to accomplish the targeted training needs with participation of lead/core institutions and their identified resource persons (See Appendix V) through net-workshops, training programmes and by awarding internships/fellowships. This will serve the purpose of Trainer's Training Needs.
- Subsequent follow up action might be warranted from ICCAE to transfer and implement the technology at grass-root level by using the human resource developed through the first level trainer's training programmes. To organise the second level training effectively, trainers of various organizations of developing countries obtain requisite expertise and orientation to effectively transfer the technology from lab-to-land and lab-to-industry in order to improve the living conditions of the rural poor communities as shown in the general

multilateral training network model (Fig. 4.2).

- The first level HRD (Human Resources Development) can be achieved by developing training programmes through exchange programmes of wood specialists of North-South and South-South Cooperation basis. Once this is achieved, local lead organizations can arrange a variety of rural training programmes as relevant to local conditions. In later stages, even to tackle the common problems of similar nature, South-South Cooperation can be promoted by ICCAE.

International Net-workshops for Training Consortia

To establish the training consortium, ICCAE shall organise the net-workshops of environmentally crucial and socially relevant themes with the participation of the experts of both developing countries and Japanese lead/core institutes and donor agencies. Frequent such net-workshops will help to develop the documents/publications of strategic training plans to meet the specific requirements of the concerned countries.

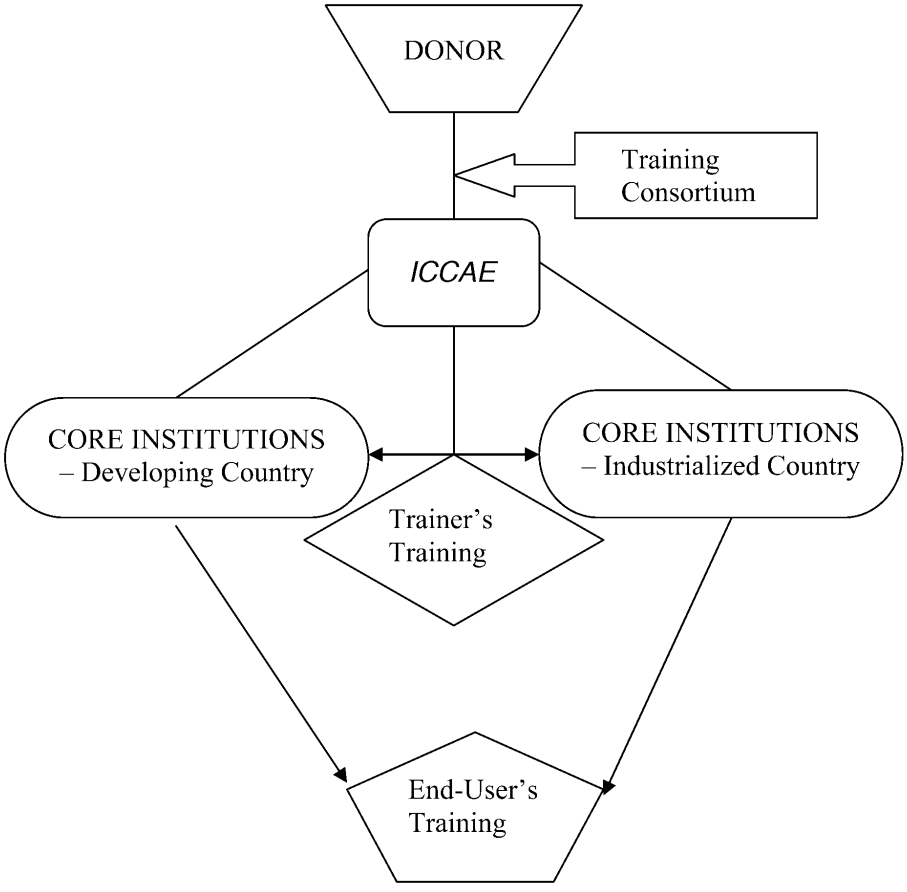

Fig 4.2　Arbitrary model of ICCAE's multi-lateral training network

4.4 Strategic plans for proposed Indo-Japanese bilateral training programme

I. Establishment of Training Consortium

1. ICCAE will initiate to organise the Net-workshops with the representatives of potential donor/government agencies of India and Japan, and the Directors/Research Managers of the Lead Institutes identified with the objective of establishing Training Consortium.
2. Prior to this, if found necessary, Consultative Group Meetings will be held to receive the ideas/technical inputs from the experts of the identified Lead institutes of both countries to set the training priorities that may need the approval of donors for establishing the training consortium in the net-workshops. The potential participants can be identified from the list furnished in this document elsewhere. Such Consultative Meetings will also be useful to establish databases in critical areas of training needs in the form concrete documents.

Decision making bodies/ Government agencies

The main concerned Indian decision making and government bodies include: Ministry of Human Resource Development (MHRD), Ministry of Environment and Forests (MoEN), Ministry of Science and Technology (MS&T) and University Grant Commission (UGC).

In Japan, as already identified, Nagoya University, the Ministry of Education, Science, Sports and Culture (Monbusho), the UN Centre for Regional Development, Japan International Cooperation Agency (JICA) and the Aichi prefectural government appear to be the potential donors for establishing the consortium.

Core institutions and their linkage for training network

Depending on the identification of base nets and the defined activities potential experts can be chosen from the list furnished in this document for the first level of trainer's training programmes.

The second level of user's training programmes will be organized by the lead institutions of India in the rural community levels. Wherever necessary, for instance, in the modification of machinery of wood processing industries, North-South Cooperation will be sought to participate the Japanese institutions (Fig. 4.3).

II. Institutional Linkages for Potential Training Networks : Japan and India

From the list of lead/core institutions and the availability of human resources from them (Appendix V), various networks can be established to meet the specific training requirements. The linkage of potential institutions in different thrust areas are indicated below. This represents only arbitrary list and more organizations can be involved in the network if they have the proven record of scientific achievements in the concerned areas. It is also strongly recommended that human resources from various other countries/institutions, as identified in the Appendix V, can be employed and the expertise shared to render effective training programme.

Similar networks of multilateral training programmes can be arranged by employing the human resources available in the Asia Pacific Region as given in the Appendix V.

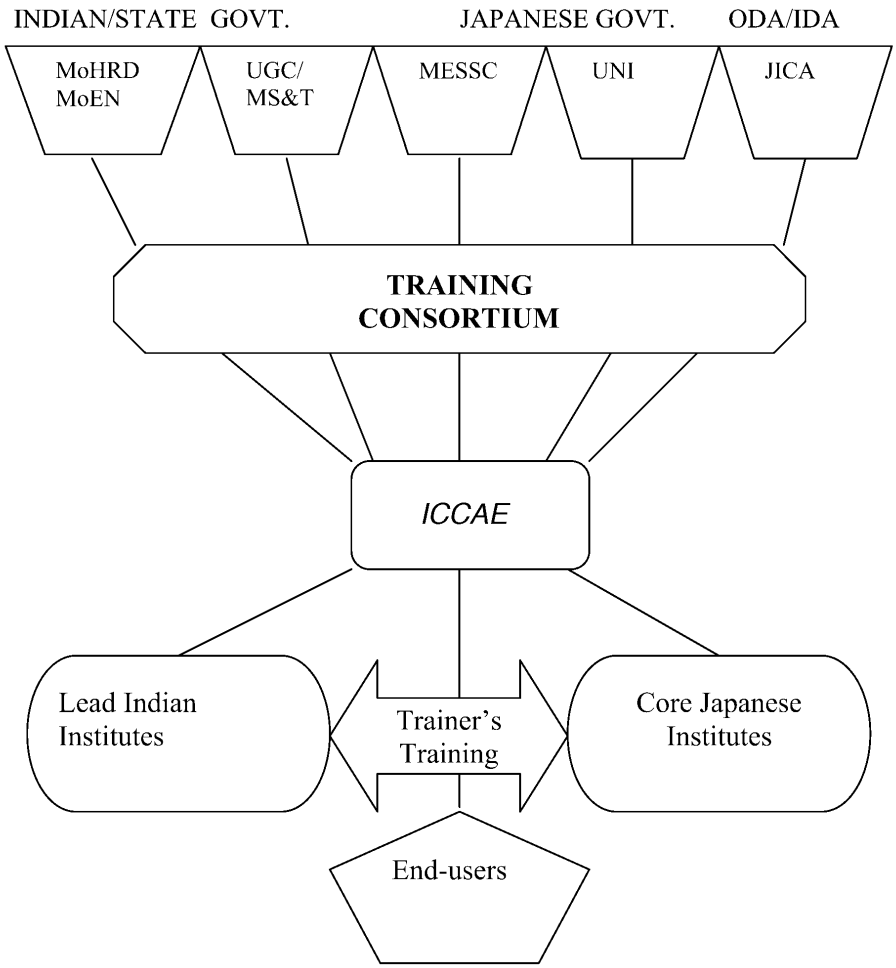

Fig. 4.3　Proposed Indo-Japanese bilateral training network in Wood Science

NWFP Utilization - Potential Training Networks			
Training Activity and sub-networks		Lead Institutes-India	Core Institutions-Japan
Bamboo and Rattan	Bamboo production / genetic engineering, harvesting, properties, processing, product development, marketing	KFRI, IPIRTI, FRI, IWST, IFGTB	ANESC, FA-KytU, BMP-NU, FA-SHZU
NWFPs	Extraction and Chemical processing of plant constituents	IWST, FRI, KFRI	FA-GIFU, FA-YU

TIMBER TECHNOLOGY - Potential Training Networks			
Training Activity and sub-networks		Lead Institutes -India	Core Institutions-Japan
Timber quality improvement /modification	Growth stresses and quality of fast grown wood	KFRI, IWST, FRI	BMT-NU, FA-KytU
	Breeding for wood quality in Teak	KFRI, IFGTB, IWST	FTBC
	Eucalypts, Acacia/other hardwoods	IWST, IFGTB,	FTBC
	Gene Transfer Technology/GMOs	KFRI, IWST, IFGTB	WRI-KytU, FA-KyshU
	Timber preservation/protection	FRI, IPIRTI, IWST, KFRI	FA-KytPU, FA-KyshU
Carbon sequestration through tropical plantation management	Carbon inventory/dynamics of teak/eucalypt/acacia plantations	KFRI, IWST	ANESC
Mechanical Processing of small diameter logs and industrial safety	Sawmilling, saw doctoring, Finger-jointing & Gluing, Glulam and composite products/panels, etc.	IPIRTI, FRI, IWST, KFRI	TUAT, KytU-WRI, FA-IU, FA-KyshU, FA-SZKU, FA-TU, FSE-SHIU
	Grading of timber from TOF	IPIRTI, IWST, FRI, KFRI	KU-WRI
	Marketing of Tropical timber/wood products	FRI, IFM, KFRI, IPIRTI, IWST	Kyt-U
Chemical properties, Processing, Utilization	Utilization of wood phenolics/extractives, constituents	IWST, FRI, KFRI	FA-GIFU, FA-KytPU, SA-EhU, SA-KochU

RESIDUE UTILIZATION - Potential Training Networks			
Agro-, logging- and mill-residues	Developing composite boards	IPIRTI, FRI, IWST, KFRI	GSALS-UT, FA-SHZKU, FA-TotU

* No adequate information is readily available on the human resources of agricultural universities in India

Multilateral training programs

The proposed bilateral training network can be extended depending on the needs by involving the concerned countries for developing the human resources and sharing the existing expertise. Such a network can be built up by choosing the institutions identified in the Appendix V.

Merits and Demerits of Networking Approach

A. Merits

1. Partnerships offer more scope for higher productivity for given/limited resources (human and financial resources) and avoid duplication of wasteful efforts
2. Cultural exchange/diversity may yield more fruitful outputs and even minimize the effects of racism and xenophobia

B. Demerits

1. Competition between the institutions/countries for sharing resources and credibility
2. Reduction in self reliance and credibility

Appendix I

List of educational/training institutions for forest management and forest service in India

Sl. No.	Organization/Address	Year of Establi-shment	Areas of Teaching/ Training	Teaching Staff Strength
1	ASSAM FOREST GUARDS' SCHOOL Makum JN, Tinsukia, Assam Tel: 0091-5685	1980	Forest Management, Silviculture, Wild life	Lectures 6
2	CENTRAL FOREST RANGER'S COLLEGE Mul Road, Chandrapur 442401 Maharashtra Tel: 0091-2519	1976	Forest management, Silviculture, Law, Protection, Wild life	3
3	FOREST RANGERS' TRAINING COLLEGE Balaghat (M.P.) Tel: 0091-2549	1907	Forest Management, Silviculture, Law	7
4	FOREST TRAINING SCHOOL, SEPAHIJADA P. O. Sepahijada, P. S. Bishalgarh, West Tripura 799 102 Tel: 0091-227 (BSL)	1969	Silviculture, Forest Management	4
5	FORESTRY TRAINING INSTITUTE P. O. Box 24, P.O Haldwani Dist. Nainital, UP 263 139 Tel: 20653	1979	Forest Management, Silviculrure	8
6	GUJARAT FOREST RANGERS' COLLEGE Vadia Palace, Rajpipla, Dist. Bharuch, Gujarat, Pin No:393145 Tel: 11, MSTD-0264012	1979	Silviculrure, Mensuration, Forest Management	4
7	INDIAN INSTITUTE OF FOREST MANAGEMENT P. O. Box 357, Nehru Nagar, Bhopal 462003, Madhya Pradesh Tel: 0091-755-65998 Fax: 0091-755-555751	1982	Forest Management	18
8	KERALA FOREST SCHOOL Walayar Dam, Palghat, Kerala Tel: Walayar 62260 Cable: Kerala Forest School, Walayar	1961	Forest Management, Mensuration, Silviculrure, Social Forestry, Law	5
9	ORISSA FOREST RANGERS' COLLEGE P. O. Box Angul Dist. Dhenkanal, Orissa Tel: 0091-6764-454	1979	Silviculrure, Forest Management, Protection, Wildlife	8
10	SOCIAL FORESTRY, FOREST SCHOOL, SHIUPURI Shiupuri 473551, Madhya Predesh Tel: 2610		Silviculrure, Protection, Mensuration, Law, Social Forestry	7

11	STATE FOREST SERVICE COLLEGE P. O. New Forest Dehra Dun 248006 Tel: 26168	1981	Watershed Management, Economics, Policy, Law, Silvicultrure, Entomology, Pathology, Timber Harvesting, Forest Soils, Protection, Social Forestry	8
12	STATE FOREST SERVICE COLLGE- TAMIL NADU R. S. Puram, forest compound Coimbatore 641002, Tamil Nadu Tel: 42605	1981	Forestry/Fundamentals of Wood Science	6
13	TAMIL NADU FOREST COLLEGE Vaigai Dam P. O.: 626 512 Andipatti Taluk, Madurai District, Tamil Nadu Tel: 2236	1961	Environmental Conservation, Mensuration, Forest Management, Silviculrure, Law, Forest Soils	9

Appendix II

List of Agriculture Universities offering graduate/post graduate courses in forestry in India

Sl. No.	Organization/Address	Year of Establi-shment	Areas of Teaching/ Training	Teaching Staff Strength
1	COLLEGE OF FORESTRY, KERALA AGRICULTURAL UNIVERSITY Vellanikkara, THRISSUR KAU POST 680 656 Tel: +91-487-370 050 Fax: +91-487-370 019	1986	Forestry, Wildlife, Wood Science	14
2	COLLEGE OF FORESTRY, UNIVERSITY OF AGRICULTURAL SCIENCE Ponnampet 571216, Krnataka Tel: +91-8274-49370 Fax: +91-8274-49365		Forestry, Wood Science	3
3	DEPARTMENT OF FORESTRY, COLLEGE OF AGRICULTURE, P. K. V., AKOLA Punjabrao Krishi Vidyapeeth, Krishinagar, Akola 444104 Tel: +91-26841/42/43 (PBX) Telex: 0725-025	1985	Silviculrure, Tree Improvement, Forest Management, Wood Technology, Agro-forestry, Social Forestry	5
4	DR.Y.S. PARMAR UNIVERSITY OF HORTICULTURE AND FORESTRY P. O. Box Nauni-173230, Solan (H.P.) Tel: 333 (Solan) Fax: +91-1792-2288	1985	Forest Management, Silvicultrure, Forest Product Technology	
5	H.N.B. GARHWAL UNIVERSITY, DEPARTMENT OF FORESTRY P. O. Box 59, Srinagar (Garwal) 246174, U.P. Tel: 2143	1974	Forest Management, Silviculrure, Protection, Agroforestry	6
6	PUNJAB AGRICULTURAL UNIVERSITY, DEPARTMENT OF FORESTRY AND NATURAL RESOURCES, COLLEGE OF AGRICULTURE Ludiana 14100, Punjab Tel: +91-161-51960 Fax: +91-161-51794	1962	Silviculrure, Tree Improvement, Forest Management, Agroforestry	10
7	TAMIL NADU AGRICULTURE UNIVERSITY, FOREST COLLEGE AND RESEARCH INSTITUTE Mettupalayam-641301 Tel: +91-425-42010 Fax: +91-422-41672	1985	All aspects of forestry, Wood Science, Agroforestry, Project Formulation, Research Methodology	22

8	UNIVERSITY OF AGRICULTURAL SCIENCE, DEPARTMENT OF FORESTRY Bangalore 560 065, Karnataka Tel: +91-80-330153 Fax: +91-80-320840	1973	Silviculrure, Forest Management,. Farm Forestry, Social Forestry, Biotechnology, etc.	11

Appendix III

List of forest research institutions offering training/educational courses in India

Sl. No.	Organization/Address	Year of Establi-shment	Areas of Teaching/ Training	Teaching Staff Strength
1	ARID FOREST RESEARCH INSTITUTE 12/10 Nandanvan, Jodhpur 342008	1988	Aspects of arid zone forestry	
2	FOREST RESEARCH INSTITUTE (ICFRE-Deemed University) P.O. New Forest 248 006, Dehra Dun (UP) Fax: +91- 0135-23258 E-Mail: icfre@envfor.delhi.nic.in	1906	All aspects of forestry, Wood Science	
3	INDIAN PLYWOOD INDUSTRIES RESEARCH AND TRAINING INSTITUTE PB No. 2273, Tumkur Road Bangalore 560 022			
4	INSTITUTE OF RAIN AND MOIST DECIDOUS FOREST RESEARCH P.O. Jorhat 785 001, Assam	1988		
5	INSTITUTE OF FOREST GENETICS & TREE BREEDING P.B. No. 1031, R.S. Puram, Coimbatore	1988	Tree improvement of dry deciduous & plantation species	
6	INSTITUTE OF WOOD SCIENCE AND TECHNOLOGY P.O. Malleswaram 18th Cross Bangalore 560 003 Tel: +91-80-3341731 Fax: +91-80-3340529	1988	Main research areas: All aspects of Wood Science	
7	KERALA FOREST RESEARCH INSTITUTE P.O. Peechi 680 653, Thrissur Dist. Kerala Tel: +91-487-282037 Fax: +91-487-282037 Website: http:// www.kfri.org	1975	Main research areas: All aspects of tropical forestry and Wood Science	
8	RESEARCH AND TRAINING DIVISION PINJORE, DIVISIONAL FOREST OFFICE, Pinjore, Ambala, Haryana Tel: 2469 (Kalak)	1966	Silvicultrure, Forest Management, Wood Technology, Social Conservation, Forest Industries	5

Appendix IV

Curricula of different courses/universities in India

(1) G.B. Pant University of Agriculture and Technology, Pant Nagar

Four-year B.Sc. (Forestry) Programme (as on 1990)

I.	Remedial Courses		
A.	Inter Agric. Group:		Semester Credits
1.	BPC-131	General Chemistry	2 (1-0-3)
2.	BPM-209	Elementary Mathematics	4 (4-2-0)
3.	BPP-123	Introduction to Physical Measurements	2 (1-0-3)
			8
B.	Inter Biology Croup:		
1.	APA-100	Elementary Agriculture	2 (1-0-3)
2.	BPM-209	Elementary Mathematics	4 (4-2-0)
			6
C.	Inter-Maths Group:		
1.	APA-100	Elementary Agriculture	2 (1-0-3)
2.	BBB-100	Elementary Botany	3 (2-0-3)
3.	BBZ-110	Elementary Zoology	3 (2-0-3)
			8
D.	10+2 Science Group (Biol./Maths)		6/8
E.	10+2 Science Group Biol.+ Maths :		
1.	APA-100	Elementary Agriculture	2 (1-0-3)
F.	Hindi courses for those students who have not studied Hindi at High School or euivalent		
1.	BHS-105	Elementary Hindi	2 (1-0-2)
			2
II.	Basic Supporting Courses:		
1.	BHS-215	General English	3 (2-0-2)
2.	BHS-210	Tech. Writing	2 (1-0-2)
3.	BHS-271	Pub. Org. & Rural Soc. Problems	4 (3-0-3)
4.	AFC-110	General Economics	2 (2-0-0)
5.	BPS-210	Elements of Statistics	3 (2-0-2)
6.	APH-206	Elements of Horticulture	4 (3-0-3)
7.	AAS-202	Principles of Animal Husbandry	3 (2-0-3)
8.	APA-200	Princ. & Prac. of Agronomy	3 (2-0-3)
9.	APS-215	Introductory Soils	2 (2-0-0)
10.	APB-220	Elements of Genetics	3 (2-0-3)

11.	ACE-200	Introd. Communication & Extn.	3 (2-0-3)
12.	APP-204	Introd. Plant Pathology	2 (1-0-3)

III. Core Courses:

1.	BBB-210	Systematic Botany of Forest Species	3 (2-0-3)
2.	BBB-220	Physiology of Forest Species	3 (2-0-3)
3.	APB-221	Princ. of Breed of Forest Trees	3 (2-0-3)
4.	AAS-213	Utilization of Forest Products as livestock feed	3 (2-0-3)
5.	AFS-232	Human Food and Nutrition	3 (2-0-3)
6.	APE-208	Forest Entomology	3 (2-0-3)
7.	APP-252	Forest Pathology	3 (2-0-3)
8.	BBB-221	Forest Ecology	4 (3-0-3)
9.	AEC-248	Introductory Forest Economics	3 (3-0-0)
10.	APA-APS231	Forest Soils and Their Management	2 (2-0-0)
11.	APA-APS 240	Erosion and Conservation of Forest Lands	3 (3-0-0)
12.	AAS-251	Introduction to Wild Life	3 (2-0-3)
13.	TMP-201	Forest Engineering-I	3 (2-0-3)
14.	TSW-205	Forest Engineering-II	3 (2-0-3)
15.	APF-240	Principles of Silviculture	3 (2-0-3)
16.	APF-242	Silviculture Regeneration Methods	3 (2-0-3)
17.	APF-244	Silviculture Systems	3 (2-0-3)
18.	APF-247	Silviculture of Indian Trees	3 (2-0-3)
19.	APF-255	Forest Mensuration-I	3 (2-0-3)
20.	APF-256	Forest Mensuration-II	3 (2-0-3)
21.	APF-260	Forest Management & Working Plans	3 (2-0-3)
22.	APF-265	Forest Logging & Harvesting	4 (3-0-3)
23.	APF-251	Fundamentals of Forest Protection	2 (1-0-3)
24.	APF-271	Forest Policy, Law and Planning	3 (3-0-0)
25.	APF-280	Forest Surveying & Mapping	3 (2-0-3)
26.	APA/APF-	285 Silvipasture	3 (2-0-3)
27.	APF-290	Social Forestry	3 (2-0-3)
28.	APF-291	Wood Science	3 (2-0-3)
29.	APF-292	Wood Processing & Utilization	3 (2-0-3)
30.	APF-293	Minor Forest Products	2 (1-0-3)
31.	APF-294	Special Field Practices in Forestry	2 (0-0-2)
	(1 credit - each in two semesters)		91
	N.S.S.		2
	Elective		18
	Work Program		1
			112

Optional Courses:

APE-305	Introductory Apiculture & Sericulture	2 (1-0-3)
APE-232	Plant Protection Equipment	1 (0-0-3)
APF-252	Advances in Forest Protection	3 (2-0-3)
APF-261	Forest Plantation Management & Yield Regulations	3 (2-0-3)
APH-340	Medicinal & Aromatic Plants	3 (2-0-3)
APH-341	Cultivation of Condiments & Spices	2 (1-0-3)
APH-301	Ornamental Gardening	3 (2-0-3)
APP-301	Principles of Plant Diseases Control	3 (2-0-3)
APE-302	Insecticides	2 (1-0-3)
AEC-348	Forest Economics	3 (2-0-3)

Note: Semester credits 2 (1-0-3) denotes the following; one lecture period of one duration, none tutorial, and one practical of 3 hours duration per week in semester of about 18 weeks.

(2) Kerala Agricultural University, College of Forestry, Vellanikkara

This College of Forestry started from 1986 under the Kerala Agricultural University offers both graduate (B.Sc.) and postgraduate (M.Sc.) courses with intake of 15 and 9 students respectively. The 4-year graduate course imparts theoretical and practical knowledge in forest ecosystem, dynamics/production and protection forestry, wildlife, social- and agro-forestry, forest management, tree physiology and genetics, environmental management, wood science and allied aspects. Field experience by frequent visits to various forests in the country and a 3-month long field training in forest ranges expose the students to practical problems of the forestry. The M.Sc. course includes specialised areas of silviculture and agroforestry, tree physiology and breeding, forest management and utilization and wildlife sciences.

The Department of Wood Science offers courses in introduction on forestry (2+0), wood anatomy (2+1), wood science and technology (2+1), forest products (1+1), forest research methods (1+0), wood-based industries (2+0) and global forestry (1+0), etc.

MSc - Fundamentals of Wood Science (1 + 1)
BSc - Wood Anatomy (2 + 1)
Wood Science and Technology (2 + 1)
Forest Products (1 + 1)
Wood based industries (2 + 0)

Note: (2 + 1) means 2 credit hours a week for theory and 1 credit hours for practicals equivalent to 2 lab. hours

(3) Panjabrao, Krishi Vidyapeeth, Akola

Layout for B.Sc. (Forestry) Degree Programme

S.No.	Course No.	Title of Course	Credits
		FIRST SEMESTER	
1.	LANG-111	Language-II (English)	1 + 1 = 2

2.	BIOC-111	Biochemistry	1 + 1 = 2
3.	PLPHY-111	Fundamentals of PI. Physiology	2 + 1 = 3
4.	AHDS-111	Livestock Management in Forest	1 + 1 = 2
5.	AGRO-111	Introduction to Indian Agriculture	1 + 0 = 1
6.	HORT-111	Fundamentals of Horticulture	2 + 0 = 2
7.	ENT-111	Introduction to Entomology	1 + 1 = 2
8.	RUSO-111	Rural Sociology	1 + 1 = 2
9.	MATH-111	Mathematics-I	1 + 1 = 2
			11 + 7 =18

SECOND SEMESTER

1.	LANG-122	Language-II (Marathi/Hindi S English)	0 + 1 = 1
2.	MET-121	Meteorology	1 + 1 = 2
3.	GNPS-121	General Psychology	1 + 0 = 1
4.	ENGG-121	Surveying & Mapping	1 + 2 = 3
5.	AGRO-122	Principles of Crop Prod.	1 + 1 = 2
6.	ACSS-121	Soil Science - Farm, Comp & Prop.	2 + 1 = 3
7.	ECON-121	Elements of Economics	1 + 0 = 1
8.	ANTH- 121	Anthropology	1 + 0 = 1
9.	MATH-122	Mathematics-III	1 + 1 = 2
			9 + 7 =16

THIRD SEMESTER

1.	BOT-231	Genetics & Cytogenetics	1 + 2 = 3
2.	ENGG-232	Soil Water Conservation & Drainage	1 + 1 = 2
3.	AGRO-233	Weeds & Weed Control	1 + 1 = 2
4.	PATH-231	Introduction to Plant Pathology	1 + 1 = 2
5.	FOR-232	History & Geography of Indian Forests	1 + 0 = 1
6.	FOR-232	Plant Propagation - Seed and Vegetable	1 + 1 = 2
7.	FOR-233	Silviculture I - Nursery Management	1 + 1 = 2
8.	FOR-234	Farm & Social Forestry	1 + 1 = 2
9.	FOR-235	Forest Seed Technology	1 + 1 = 2
10.	MATH-233	Mathematics-III	1 + 1 = 2
			10 +10=20

FOURTH SEMESTER

1.	STAT-241	Elements of Statistics	2 + 1 = 3
2.	BOT-242	Plant Breeding	1 + 1 = 2
3.	AGRO-244	Crop production in Dry Farming Areas	2 + 1 = 3
4.	ACSS-242	Forest Soils	2 + 1 = 3
5.	FOR-246	Tree Improvement	2 + 1 = 3
6.	FOR-247	Forest Ecology Tour	0 + 2 = 2
7.	EXTN-241	Forest Tree biology	1 + 1 = 2
8.	ENGG-243	Forest Eng. Road & Structure	1 + 1 = 2

			11 + 9 =20
		FIFTH SEMESTER	
1.	STAT-352	Introduction to Computer Programming	1 + 1 = 2
2.	EXTN-352	Communication & Diffusion of Innovation	1 + 1 = 2
3.	FOR-358	Dendrology	2 + 1 = 3
4.	FOR-3510	Silviculture-II Regeneration Methods	1 + 1 = 2
5.	FOR-3511	Silviculture-III Systems	1 + 1 = 2
6.	FOR-3512	Minor Forest Products	1 + 1 = 2
7.	FOR-359	Forest Ecology	2 + 1 = 3
8.	MATH-354	Mensuration	2 + 1 = 3
			11 + 8 =19
		SIXTH SEMESTER	
1.	ENGG-364	Forest Engineering - Equip. & Machinery	1 + 1 = 2
2.	ENT-362	Forest Entomology	2 + 1 = 3
3.	PATH-362	Forest Plant Pathology	2 + 1 = 3
4.	FOR-3613	Forest mensu. - Inventory	1 + 1 = 2
5.	FOR-3614	Integrated Pest Management	2 + 1 = 3
6.	FOR-3615	Forest Management - Planning & Evaluation	1 + 1 = 2
7.	FOR-3616	Fire Ecology & Management	1 + 1 = 2
8.	FOR-3617	Forest Management Tour	0 + 2 = 2
			10 + 9 =19
		SEVENTH SEMESTER	
1.	VET-471	Introduction to Wild-life	1 + 1 = 2
2.	AGRO-475	Grassland Management	1 + 1 = 2
3.	ACSS-473	Soil Survey & Land Use	1 + 1 = 2
4.	FOR-4718	Forest Mens. - Modelling & Analysis	1 + 1 = 2
5.	FOR-4719	Agro-forestry	1 + 1 = 2
6.	FOR-4720	Forest Management - Reg. & Harvesting Sched.	2 + 1 = 3
7.	ELE-471	Elective - I	1 + 1 = 2
8.	ELE-472	Elective - II	1 + 1 = 2
9.	ENGG-475	Forest Hydrology & Watershed Management	1 + 1 = 2
			10 + 9 =19
		EIGHTH SEMESTER,	
1.	VET-482	Wild Life Management	1 + 0 = 1
2.	ACSS-484	Aerial Photos & Remote Sensing	1 + 1 = 2
3.	FOR-4821	Forest Management Resource Analysis	1 + 2 = 3
4.	FOR-4822	Forest Economics	1 + 1 = 2
5.	FOR-4823	Forest Policy & Legislation	2 + 0 = 2
6.	FOR-4824	Forest Products Utilization	1 + 1 = 2
7.	ELE-483	Elective - III	1 + 1 = 2
8.	ELE-484	Elective - IV	1 + 1 = 2

9.	EXTN-483	Extension Administration & Programme Planning	1 + 1 = 2
			10 + 8 =18

(4) University of Agriculture Sciences, Bangalore (as on 1990)

FIRST YEAR

Trimester I

Eng.	104	A course in Scientific & Technical Language	1 + 1
Soc.	102	Sociology	2 + 1
Mic.	101	Microbiology	2 + 1
Zool.	105	General Zoology	2 + 1
Econ.	102	Principles of Economics	2 + 1
NCC/Ph.Edn.	101	National Cadet Corps (NCC)/Physical Education	0 + 1
			15

Trimester II

Eng.	105	Language Laboratory	0 + 1
Psy.	102	Psychology	2 + 1
Ph.	103	Physics and Meteorology	2 + 1
Chem.	104	Organic Chemistry	2 + 1
Star.	101	Elements of Statistics	2 + 1
Bot.	104	Morphology and Anatomy	2 + 1
NCC/Ph.Edn.	102	NCC/Physical Education	0 + 1
			17

Trimester III

Math.	108	Mathematical Methods	1 + 1
Phy.Chem.	105	Physical Chemistry	2 + 0
Bot.	106	Systematic Botany	2 + 1
Agron.	101	Principles of Crop Production	2 + 0
Ag.Econ.	101	Introductory Agricultural Economics	2 + 1
Ag.Engg.	201	Surveying	2 + 1
NCC/Ph.Edn.	103	NCC/Physical Education	0 + 1
			16

SECOND YEAR

Trimester I

Hort.	101	Fundamentals of Horticulture	2 + 1
Ag.Chem.	103	Introduction to Soil Science	2 + 1
Pl.Path.	101	Introduction to Plant Pathology	2 + 1
Agron.	105	Forage Crop and Production	2 + 1
Ag. Mic.	303	Soil Microbiology	2 + 1
Ag.Ent.	101	Introductory Entomology	2 + 1
			18

Trimester II

Hort.	201	Plant Propagation	2 + 1
Ag.Extn.	201	Fundamentals of Extension Education & Rural Development	2 + 0
Ag.Bot.	302	Genetics	2 + 1
Ag.Chem.	303	Soil Fertility & Fertilizer Use	2 + 1
PN.	105	Principles of Nutrition	3 + 0
			14

Trimester III

For.	101	Introduction to Forestry	2 + 1
Crop Phy.	201	Crop Physiology	2 + 1
Agron.	103	Water Management	2 + 1
Seed Tech.	201	Seed Technology	2 + 1
D.Sc.	202	Dairy Science	1 + 1
Ag Engg.	301	Soil & Water Conservation Engineering	2 + 1
			17

THIRD YEAR

Trimester I

For.	109	Tree Physiology	2 + 1
For.	121	Forest Engineering	2 + 1
For.	123	Wood Anatomy, Properties and Uses	2 + 1
For.	125	Minor Forest Products	1 + 1
Ag.Maco.	341	Principles of Marketing, Finance and Cooperation	2 + 1
For.	102	Fundamentals of Silviculture & Silviculture System	2 + 1
			17

Trimester II

For.	103	Silviculture of Indian Trees	2 + 1
For.	105	Forest Soils	1 + 1
For.	106	Forest Microbiology	1 + 1
For.	108	Dendrology	2 + 1
For.	111	Forest Pathology	2 + 1
For.	112	Forest Entomology	2 + 1
			16

Trimester III

Seric.	101	Introduction to Sericulture	1 + 1
For.	104	Forest Inventory, Photo interpretation and Remote Sensing	1 + 1
For.	110	Forest Cytogenetics & Tree Breeding	2 + 1
For.	113	Elementary Forest Management	2 + 0
For.	114	Forest Mensuration	2 + 1
For.	119	Forest Protection	2 + 0
For.	131	Waste Land Management	1 + 1

AG.Extn.	301	Communication and Diffusion of Agricultural Innovation	1 + 1
			18

FINAL YEAR

Trimester I

For.	107	Forest Ecology and Conservation of Natural Resources	2 + 0
For.	116	Forest Hydrology & Watershed Management	2 + 1
For.	127	Social Forestry	2 + 1
For.	129	Farm Forestry & Agro-forestry	2 + 1
For.	130	Forestry Extension	0 + 1
For.	132	Energy Plantations and Alternate Energy Sources	1 + 0
For.	122	Forest Economics	2 + 1
		Educational Tour	0 + 1
			17

Trimester II

For.	115	Forest Policy and Law	2 + 0
For.	117	Wild Life & Range Land Management	2 + 1
For.	118	Industrial Forestry	1 + 0
For.	128	Environmental Forestry	1 + 1
		Major	2 + 1
		Elective	2 + 1
			14

Trimester III

For.	120	Forest Stay and Preparation of Working Plans (Placement Training)	0 + 4
For.	124	Wood Science and Technology	2 + 1
For.	126	Harvesting and Post-harvest Technology of Forest Produce	2 + 1
		Major	2 + 1
			13

(5) Dr. Y.S. Parmar University of Horticulture and Forestry

B.Sc. Forestry (4 years degree program - as on 1990)

		Course Title	Credit Hours
BASIC SCIENCES			
BOT	122	General Botany	2 + 1
EAP	011	Introductory Zoology	2 + 1 NC
ORI	011	Orientation	1 + 0 NC
BOT	011	Fundamentals of Biology	2 + 1 NC
MTH	011	Algebra and Trignometry	3 + 0 NC
MTH	012	Matric Algebra and Calculus	3 + 0 NC
ENG	011	Grammar and Composition	1 + 1 NC

HND	011	Elementary Hindi	2 + 0 NC
MTH	121	Analytical Solid Geometry and Differential Equations	3 + 0
BCH	121	Introductory Biochemistry	3 + 1
MBG	211	Basic Microbiology	2 + 1
GEN	211	Fundamentals of Genetics	2 + 1
STA	311	Elements of Applied Statistics	2 + 1
OEN	311	Introductory Plant Breeding	2 + 1
COM	411	Introduction to Computers	1 + 1
BTC	411	Introductory Biotechnology	1 + 1
			27

AGRICULTURAL SCIENCES

ESC	111	Elements of Economics	2 + 0
SWM	111	Fundamentals of Soil Sciences	2 + 1
ESC	113	Forest Typology and Anthropology	2 + 0
ESE	122	Elements of Rural Sociology and Behaviour of Psychology	2 + 0
SWM	221	Principles of Hydrology and Soil Conservation	2 + 1
SWM	222	Surveying and Mapping	2 + 1
SWM	311	Chemistry and Fertility of Forest Soils	2 + 1
FCM	221	Principles of Horticulture	2 + 1
VGC	121	Fundamentals of Crop Production	3 + 1
FLS	321	Introduction to Floriculture and Land Scape	2 + 1
SLV/ASC	122	Livestock Management in Forestry	2 + 1
MPP	222	Introductory Forest Pathology	3 + 1
MPP/EAP/VGC	323	Integrated Pest Management	2 + 1
SWM	421	Soil Survey, Remote Sensing and Land Use	2 + 1
			41

FOREST SCIENCES

FBI	111	Meteorology and Climatology	2 + 1
SLV	111	Introduction of Indian Forest and Wildlife	2 + 0
SLV	112	Fundamentals of Silviculture	2 + 0
SLV/ASC	122	Livestock Management in Forests	2 + 0
SLV	211	Forest Mensuration	2 + 1
FBI	211	Dendrology	2 + 1
FBI	212	Forest Ecology	2 + 1
SLV	212	Grassland Management	2 + 1
SLV	213	Practical Field Forestry	0 + 2
SLV	221	Practices of Silviculture	2 + 1
FPU	222	Forest Utilization (non-timber products)	1 + 1
FPU	223	Practical Field Forestry	0 + 2
EAP	312	Forest Entomology	3 + 1
ESE	312	Forest Economics	2 + 1

SLV	312	Silviculture Systems	2 + 0
FHI	311	Practical Field Forestry	0 + 2
FPU	325	Forest Utilization	2 + 0
FBI	321	Tree Physiology	2 + 1
FPU	322	Wood Anatomy	1 + 1
SLV	321	Silviculture of Indian Trees	2 + 0
FBI	324	Tree Improvement and Seed Technology	3 + 1
SLV	323	Practical Field Forestry	0 + 2
ESE	411	Forest Resource Analysis	1 + 1
SLV	413	Wildlife Management	2 + 0
SWM	422	Forest Engineering	2 + 1
SLV	421	Forest Policy and Legislation	1 + 0
SLV	422	Agroforestry	2 + 0
SLV	412	Ergonomics	2 + 0
		Total	71

Electives	10
1. Social Forestry and Environmental Conservation	
2. Tree Improvement and Production Forestry	
3. Forest Protection	
4. Medicinal and Aromatic Plants and Forest Products Professional Training	0 + 5
Total	86
GRAND TOTAL	153

(6) A.I.F.C. Diploma, Indira Gandhi National Forest Academy, Dehra Dun

FIRST YEAR

Sl.No.	Subject	No. of Lecture.hours	
		Theory	Practical
1.	Silviculture I (Foundations of Silviculture)	50	1
2.	Silviculture II (Practice of Silviculture)	50	-
3.	Mensuration I (Measurement of Characteristics of Individual Trees and Forest Inventories)	55	10
4.	Mensuration II (Volume and Growth Estimations of Crops and Use of Aerial Photographs)	45	20
5.	Forest Soils	30	30
6.	Geology	25	16
7.	Utilization (Logging)	35	25
8.	Utilization II (Forest Products other than timber)	35	-
9.	Forest Surveying	40	50
10.	Land Management and Soil Conservation	42	-

11.	Optional Elementary Mathematics or Optional Botany	25	10
12.	Botany I (Histology, Physiology, etc.)	38	40
13.	Forest Engineering I (Building Materials, Building Construction, etc.)	40	30
14.	Wildlife Management and Recreation	35	-
15.	General Forest Protection	25	-

SECOND YEAR

Sl. No.	Subject	No. of Lecture hours	
		Theory	Practical
1.	Silviculture IV (Silviculture of Indian Trees and Silviculture System)	20	-
2.	Forest Management	22	-
3.	Working Plan	50	-
4.	Forest Economics	20	-
5.	Forest Valuation	48	10
6.	Utilization III (Wood Technology)	28	-
7.	Forest Botany II (Systematics)	57	31
8.	Forest Engineering II (Road, Bridges, Water Supply, Timber Structures)	50	30
9.	Forest Policy and Law	40	30
10.	Forest Entomology (including Zoology)	25	-
11.	Mycology and Forest Pathology	30	30
12.	World Forestry	23	10
13.	Environmental Conservation	20	-
14.	Utilization IV (Wood Based Industries)	10	-
15.	Electives	15	-
	Elective I (Genetics and Tree Improvement) or	30	20
	Elective II (Forest Ecology) or	30	20
	Elective III (Forest Statistics)	30	20

(7) Proposed course curriculum for B.Sc. (Forestry) degree programme for Indian Agriculture Universities (Patil and Burley 1985)

The course curriculum for B.Sc. (Forestry) degree programme has been standardized based on the basic framework of other professional degrees offered at the University of Agricultural Sciences, Bangalore, and at other Agricultural Universities in India. The course curriculum and course outlines would particularly suit to the Agricultural Universities where the Trimester System of education is followed.

The proposed degree programme in Forestry is of four years' duration, with a total of 192 credit hours. In each year, there are three trimesters each of 14 weeks' duration. A course with (2+1) credit hours will have two theory classes, each of one hour duration and one practical class of three hours' duration (in the field or in the laboratory) per week. The list of courses suggested and broad course outlines are given in the following paragraphs.

In the fourth year there are opportunities to specialise in different disciplines. Initially, the following major fields of specialization may be offered and the students should be given an opportunity to specialise in the discipline of their choice.

1. Silviculture
2. Forest Soils
3. Forest Mensuration
4. Forest Botany and Taxonomy
5. Forest Genetics and Tree Breeding
6. Tree Physiology
7. Forest Ecology
8. Forest Entomology
9. Forest Pathology
10. Wood Science
11. Wildlife Management
12. Forest Economics
13. Social Forestry
14. Agroforestry

I year		II year	
I Trimester	Credit hours	I Trimester	Credit hours
Botany	2 + 1	Forest Economics	2 + 1
Zoology	2 + 1	Silviculture - I: Ecological	2 + 1
Organic Chemistry	2 + 1	Forest Engineering	2 + 1
Mathematics	2 + 1	Forest SoiIs	2 + 1
Psychology	1 + 1	Horticulture - II	2 + 1
Economics	2 + 0	Crop Production	0 + 1
National Cadet Corps (NCC) / Physical education	0 + 1		
TOTAL	17	TOTAL	16
II Trimester		II Trimester	
Biochemistry	2 + 1	Silviculture - II: Practices	2 + 1
Geology and Soils	2 + 1	Forest Ecology	2 + 1
Sociology	2 + 0	Forest Surveying	2 + 1
Tree Physiology	2 + 1	Agronomy	2 + 1
Forest Botany	2 + 2	Microbiology of Forest Soils	1 + 1
English: Language laboratory	0 + 1	Soil and Water Management	2 + 1
N.C.C./Physical education	0 + 1		
TOTAL	17	TOTAL	17

III Trimester		III Trimester	
Meteorology & Hydrology	2 + 1	Silviculture - III:	2 + 1
Microbiology	2 + 1	Important Species/Systems	
Horticulture - I	2 + 1	Forest Entomology	2 + 1
Soil Science	2 + 1	Harvesting	2 + 1
Principles of Crop Production	2 + 0	Forest Utilisation	2 + 1
English: Scientific &	1 + 1	Anatomy, Wood Properties	2 + 1
technical language		Wood Science and Technology	2 + 1
N.C.C./Physical education	0 + 1		
TOTAL	17	TOTAL	18

III year		IV year	
I Trimester	Credit hours	I Trimester	Credit hours
Forest Genetics	2 + 1	Landscaping, National Parks &	2 + 1
Economic Entomology	1 + 1	Forest Recreation	
Forest Mensuration	2 + 1	Environmental Forestry	2 + 0
Statistical methods	2 + 1	Forest Planning	2 + 0
Watershed Management	2 + 1	Forest Management	2 + 0
Forest Production - I	0 + 1	Management Plan	1 + 2
Study tour - I	0 + 1	Work study	1 + 0
		Study tour - II	0 + 1
TOTAL	16	TOTAL	14

II Trimester		II Trimester	
Tree Breeding	2 + 1	Agroforestry	2 + 1
Forest Pathology	2 + 1	Computers in Forestry	2 + 1
Photo Interpretation &	2 + 1	Forest Policy and Law	2 + 0
Remote Sensing		Forest research methods - I	1 + 1
Forest Inventory &	1 + 2	Major field of specialization	2 + 1
Yield Prediction		Forest stay	0 + 1
Livestock Husbandry	2 + 1		
Forest Production - II	0 + 1		
TOTAL	16	TOTAL	14

III Trimester		III Trimester	
Forest Seed Technology	2 + 1	Forest Extension	2 + 1
Forest Protection	2 + 1	Social Forestry	2 + 1
Forest Industries	2 + 1	Forest research methods- II	0 + 1
Wildlife & Range Management	2 + 1	Major field of specialization	2 + 1
Ergonomics	1 + 0	Philosophy and Professional Ethics	1 + 0
Arboriculture	1 + 0	Global Forestry	2 + 0

Cropping scheme & crop planning	1 + 1	Tribal Ethnology	1 + 0
TOTAL	16	TOTAL	14
		GRAND TOTAL	192

Syllabuses of the proposed course curriculum for B.Sc. (Forestry) degree programme for Indian Agriculture Universities

I YEAR I TRIMESTER

Botany (Credit hours 2+1)

Morphology, anatomy, and development of plants. The relations of structure with vegetative and reproductive function. Principles and methods of taxonomy. Physiology: photosynthesis, respiration, nutrition, water relations, and growth. Stimulus and response.

Zoology (Credit hours 2+1)

Elementary principles of zoology. Animal biology, animal groups, animal behaviour, comparative physiology, comparative neurobiology, structural molecular biology, cell and developmental biology, animal ecology.

Organic chemistry (Credit hours 2+1)

A study of the general characteristics of the following classes of compounds: Alkanes, alkenes, alkyl halides, hydroxy compounds, amino compounds, oxo-compounds. Fatty acids and their derivatives, arenes and derivatives, heterocyclic compounds; poly functional compounds: Bifunctional and trifunctional compounds, carbohydrates, peptides and proteins, Configuration, confirmation and optical activity.

Mathematics (Credit hours 2+1)

Algebra, trigonometry and geometry, elementary theory of differentials, integrals, derivatives, power series, complex numbers, differential equations, limits, and some of their applications.

Psychology (Credit hours 1+1)

Behaviour, motive and emotions, perception, learning and memory, thinking, human abilities, personality, social behaviour.

Economics (Credit hours 2+1)

Basic economic theory, contemporary economic institutions and problems; the theory of production, demand, supply, and employment; the role of money and the banking system; monetary and fiscal policy; price determination; the role of competition; international trade and finance. Investment and development. Cooperatives.

National cadet corps (N.C.C.) - I (Credit hour 0+1)

Organisation. Drill without and with arms, cane drill, rifle, bayonet, map-reading, section leading, field craft,

smartness and turnout. One annual training camp is compulsory for the year. OR (Operations Research).

Physical education - I (Credit hour 0+1)

Foundation of physical education, physiological, sociological and psychological; Tournaments and competitions, construction and laying out of the track and field and playground events. Rules of various games. General conditioning compulsory on all days. Games: Football, Basketball, Kabaddi, Badminton (shuttle and ball).

I YEAR II TRIMESTER

Biochemistry (Credit hours 2+1)

Biochemistry in relation to the structure, metabolism, growth and heredity of plants and animals. Enzymology; the chemistry and biogenesis of wood cellulose, hemicelluloses, lignin, exudates, extractives etc., including species differences. Energy feedstock.

Geology and soils (Credit hours 2+1)

Physical geology, mineralogy, petrology, palaeontology, stratigraphy and structural geology with some aspects of geophysics. Soil fomation, constitution and classification.

Sociology (Credit hours 2+0)

Sociological theory; Modern social institutions; Rural, industrial and political sociology; Social group, social control, social change and development.

Tree physiology (Credit hours 2+1)

Form and life of forest trees; growth and development, movement, structure, physiological functions and processes in trees, reproduction of trees. Water, light and food relations, ageing and abscission. Chemical composition of the plant, absorption and conduction of water and mineral salts, root pressure; transpiration; ascent of sap; photosynthesis, translocation, storage and assimilation; respiration, fermentation: Responses of woody plants to environmental stress: Role of plant growth substances, growth analysis.

Forest botany (Credit hours 2+2)

Developmental morphology and anatomy of trees; Taxonomy; A systematic study of tree and shrub families, genera and species with emphasis on identification of species. Students need to make a labelled collection of woody plants. Ecology of flowering plants: vegetation types and experimental methods; physiology and genetics of habitat and distribution.

English - language laboratory (Credit hour 0+1)

Spoken English, group discussion and public speaking.

National cadet corps (N.C.C.) - II (Credit hour 0+1)

Drill without and with arms, cane drill, rifle, bayonet, map-reading, section leading, patrolling, platoon tactics. OR (Operations Research).

Physical education - II (Credit hour 0+1)

Rules of sports events, recreation and agencies promoting recreation. Various types of recreational activities. General conditioning compulsory on all days. Games: cricket, volleyball; gymnastics.

I YEAR III TRIMESTER

Meteorology and hydrology (Credit Hours 2+1)

Weather and climate, composition and structure of atmosphere, insolation, air temperature, variation and measurement and energy transformation. Atmospheric pressure and winds - cyclones, depressions and anticyclones. Atmospheric moisture, relative humidity, evaporation, condensation, precipitation and seasonal changes in them. Water resources, hydrologic cycle. Monsoon phenomenon; clouds and their classification. Cyclic and quasi-periodic phenomena. Meteorological instruments and measurement of weather parameters. Weather data analysis and interpretations - weather forecasting and interpretations of synoptic charts. Agro-climatic classification.

Microbiology (Credit hours 2+1)

Mycology, bacteriology and virology: Structure, life cycles, mating systems and physiology of fungi, bacteria and viruses, their interactions with other organisms: disease and symbiosis.

Horticulture - I (Credit hours 2+1)

Phases of growth, growth and fruiting habits. Principles and methods of training and pruning horticultural plants. Fruitfulness, picking, grading, packing and transport of flowers, fruits and vegetables. Plant propagation: sexual propagation, apomixis, polyembryony, fruit and seed development; Asexual propagation by cutting, budding, grafting, layering of specialized, structures; micro-propagation, embryo and tissue culture, commercial propagation methods for important crops. Establishing the orchard and management practices.

Soil science (Credit hours 2+1)

Soil properties, chemical and physical processes in soil as they affect root development and function, and the availability of water and nutrients. The rhizosphere. Soil organic matter. Plant nutrients and their effect on plant growth. Source, classification and effects of organic manures and fertilizers on soil and crop growth.

Principles of crop production (Credit hours 2+0)

History and development of agriculture. Factors of plant growth. Soil and water management, and weed control in relation to crop production. Economic of crop production.

English: scientific and technical language (Credit hours 1+1)

Scientific and technical writing and the technique of indirect narration. Passive form, use of articles and punctuation in technical literature. Tense forms, sequence of items of the nominal group in english, distinct characteristics of qualitative and quantitative adjectives. Skill in composition.

National cadet corps (N.C.C.) - III (Credit hour 0+1)

Drill without and with arms. Rifle, patrolling, platoon tactics, outdoor exercise. OR (Operations Research).

Physical education - III (Credit hour 0+1)

Recreation facilities, personnel and supervision, schedule, camp activities, organisation of rural recreation, constructive activities and productive reaction. General conditioning compulsory on all days. Games: Hockey, kho-kho; Track and field events.

II YEAR I TRIMESTER

Forest economics (Credit hours 2+0)

Application of economic prtinciples to forestry and land-use. Renewable and non-renewable resources; economics of forestry enterprise; marketing, trade, investment; conservation economics, sustained yield; subsidies, loans and tax relief as instruments of policy. Financial and economic analysis: social costs and benefits. Linear programming.

Silviculture - I: Ecological basis (Credit hours 2+1)

Role of forests, general nature of vegetation of the world; forest environment: factors of site, site quality, climate and weather; physiographic conditions; edaphic and biotic factors; interactions of locality factors. Influence of forests on their environments. Factors of production, primary production, biomass production; classification of forest types, principal forest types of India and their distribution.

Forest engineering (Credit hours 2+1)

An elementary account of the machines used in forestry for silvicultural operations, harvesting and forest engineering. The technical and economic aspects of the spacing, alignment, construction and maintenance of forest roads, bridges and culverts, including the selection of appropriate materials and equipment. The design and construction of buildings required by forestry enterprises. The use of lumber, plywood, glued-laminated timber and composite materials in construction. Analysis and design of timber architectural components and their connections and their use in building construction.

Forest soils (Credit hours 2+1)

Major soil groups, study of forest soils; soil - vegetation relationships; soil chemistry, tree nutrition and nutrient cycling, deficiency symptoms; interaction of forest production, soil fertility and management. Water relations, maintaining and improving forest productivity. Acid, saline and alkaline soils. Soil Survey and Soil Mapping. Attributes and limitations imposed on tree growth by various soil types.

Horticulture - II (Credit hours 2+1)

Study of important fruit crops: Mango, banana, citrus fruits, grape, guava, papaya, sapota, pineapple, pomegranate and fig. Study of important spice and plantation crops: Betel-vine, pepper, cardamom, clove, cinnamon, nutmeg, coconut, cashew nut, arecanut, coffee, tea, cocoa and rubber. Olericulture: Study of important vegetable crops - solanaceous vegetables, cucurbits, cole crops, greens, salad vegetables, tuber crops, bulbous vegetables, leguminous vegetables, perennial vegetables and other miscellaneous vegetable crops; layout of vegetable and kitchen gardens. Floriculture: Ornamental gardening. Garden types and designs. Preparation, layout and maintenance of lawns, flower beds and hedges.

Crop production (Credit hour 0+1)

Cultivation of crops in a plot of at least one tenth of a hectare by individual students. Students should carry out all the operations and maintain regular cultivation sheet and record observations on season, crop growth, yield, etc. They should prepare a note at the end of the trimester on the crop condition as influenced by various agronomic, climatic and soil factors. The net profit will be retained by the students.

II YEAR II TRIMESTER

Silviculture - II: practices (Credit hours 2+1)

Biological factors underlying stand manipulation; regeneration, tending and harvesting of forest stands; pure, mixed, even and unevenaged stands; selection of species, nursery management, plantation establishment, weed control, drainage, competition and protection; relationships of soil fertility and moisture availability to the growth of forest stands. Analysis of stand responses such as growth rate, stem form, tree quality, product quality and value; energy plantations; afforestation and management of problematic sites like acid, saline and alkaline soils, eroded soils, swamps, sand dunes, windy climates etc.

Forest ecology (Credit hours 2+1)

The ecosystem concept; basic ecological principles and concepts of forest ecology. Forest environments, forest community, vegetation - environment relations. Ecological adaptation and evolution. Succession, production and radiation ecology. Concepts of ecosystem analysis. Pioneer and competitive life cycle strategies; adaptive leaf and crown morphology. Inter and Intra-specific competition, reciprocal yield and self-thinning laws. Aut-ecology of important tree species.

Forest surveying (Credit hours 1+2)

The basic principles of plane table surveying, measurement of horizontal and vertical distances and angles together with an analysis of their source of error; survey calculations and adjustments; chain and compass surveying; topographical surveying; computation of areas; maps, scale and reading; copying, enlargements and reduction of maps.

Agronomy (Credit hours 2+1)

Study of important cereals, millets, pulses, oilseeds, forage crops, fibre crops, and commercial crops, with reference to: their importance, origin, history and distribution; the soil and climatic requirements for their cultivation; cultivation practices covering preparation of land, varieties, planting, irrigation, manure and fertilizer application, after care, harvesting, processing, storage and marketing. Seed production.

Microbiology of forest soils (Credit hours 2+1)

Microbial population of forest soils with emphasis on rhizosphere interaction and mycorrhizae. Nitrogen fixation. Decomposition of organic matter.

Soil and water management (Credit hours 2+1)

Causes and types of soil erosion. Universal soil loss equation; techniques of monitoring soil erosion and water,

flow. Soil and water conservation methods. Role of perennial vegetation in soil and water conservation. History, problems, programmes and achievements of soil and water conservation in India.

II YEAR III TRIMESTER

Silviculture - III: important species and systems (Credit hours 2+1)

Productivity of important tree species as function of silvicultural manipulation. Silviculture of important tree species including N-fixing and multi-purpose trees both indigenous and exotics. Study of Silvicultural Systems and their application. Choice of System, methods of conversion and evaluation of Silvicultural Systems.

Forest entomology (Credit hours 2+1)

Fundamentals of entomology; the impact, biology and management of insect pests of trees and other economic plants and wood products. Nature of damage and the stages of the insects responsible. Estimation of the damage and the economics of control. Diagnosis and ecological interpretation of pest succession in forest stand development. Pest population - forest stand dynamics. Long-range pest management and decision making.

Harvesting (Credit hours 2+1)

The technical.and economic aspects of harvesting wood; factors to be taken into account in harvesting - the choice of appropriate machinery (operational capacity and output), and the design of harvesting systems. Felling, conversion, extraction and transportation. Pit sawing, mobile saw mills, chipping.

Forest utilisation (Credit hours 2+1)

Products and services available from forests. Primary conversion (sawing, veneering and chipping). Seasoning, including kiln design and operation. Wood preservation (equipment, Chemicals and processes). Wood panels (manufacture and uses). Pulp and paper (processes and uses). Wood working (equipment, wood structures, joinery, cabinet making). Chemicals and energy from wood, including charcoal, minor forest products. Utilisation of waste, wood and residues.

Anatomy and properties of wood (Credit hours 2+1)

Developmental anatomy of wood; processes of wood formation, differentiation and maturation; cell and tissue types and functions. Variation in structural properties within and between trees and taxa. Manipulation of structural features through breeding, silviculture and environmental modification. Relation between anatomy and taxonomy; wood use and processing.

Wood science and technology (Credit hours 2+1)

Wood anatomy, chemical, physical and mechanical properties of wood and factors determining them. Defects and abnormalities Drying characteristics of wood (effects on properties). Agencies of deterioration, durability and amenability to preservative treatment, wood preservation materials and processes; glueing, finishing and improvement of wood. Grading and standardization.

III YEAR I TRIMESTER

Forest genetics (Credit hours 2+1)

Nucleus and cytoplasm in heredity and differentiation; chromosome chemistry and mechanics; natural and experimental mutation; quantitative variation; the physiology of gene action. Evolution: ecological, geographical and population genetics; natural and artificial selection; origin of species and evolution of genetic systems.

Economic entomology (Credit hours 1+1)

Sericulture: morphology and anatomy of the mulberry silk worm. Rearing techniques of mulberry and non-mulberry silk worms. Apiculture, Lac-culture; study of other beneficial insects - parasites, predators, pollinators, weed killers and scavengers.

Forest mensuration (Credit hours 2+1)

Methods of measuring trees and stands. Measurement and computation of volumes and weights of felled trees and logs. Form factors. Construction of volume and weight tables; determination of age of trees. Assessment of increment and yield.

Statistical methods (Credit hours 2+1)

Theory and methods of sampling, standard error; theory of probability and statistical inference. Experimental designs; analysis of variance, single and multiple comparisons; response curves; linear regression. Multiple regression analysis and curve fitting.

Watershed management (Credit hours 2+1)

Interaction of climate, vegetation and soils. The influence of various land-use practices/vegetation on the quantity and quality of water yield, emphasizing the importance of interception losses. Manipulation of vegetation for soil and water conservation - effects on river flow.

Forest production (Credit hour 0+1)

Students will work in the field or nursery, and manage the area assigned to them. They will keep a record of the work done and record observations on the crop managed by them.

Study tour - I (Credit hour 0+1)

The students of third year class will undertake study tour for about a fortnight during the trimester break. They will visit forest areas, plantations, industries and other institutions in the state and get acquainted with the work and developmental activities in which the student will maintain the record book on the information of the study tour and will submit it to the tour leader.

III YEAR II TRIMESTER

Tree breeding (Credit hours 2+1)

Methods of plant breeding; principles and practices of tree breeding; selection-practice, progeny testing, provenance

trials, vegetative and clonal propagation. Breeding trees or higher production and quality wood, resistant to pests, diseases and environmental stresses; special problems of design and analysis in tree breeding. Breeding strategy.

Forest pathology (Credit hours 2+1)

The basic principles of forest pathology; life histories, classification, prevention and control of bacteria, fungi and viruses that cause tree diseases and wood deterioration. Impact of air pollutants; climatic and environmental damage on trees; physiological disorders, quarantine measures. Disease epidemiology, genetics and physiology of disease resistance. Pathology of amenity trees.

Photo interpretation and Remote Sensing (Credit hours 2+1)

Photogrammetry: aerial photography, geometry of air photos and stereo models, applications in measurement and mapping; photo-interpretation, identification of tree species, stand delineation, interpretation of land forms and soils; Remote Sensing, large-scale photos in forest inventory; regeneration mapping; terrain analysis and site selection; imagery and image analysis - video, thermal satellite, computer and radar.

Forest inventory and yield prediction (Credit hours 1+2)

Scope and objectives; basic techniques of estimating growth and yield of trees and stands. Forest sampling methods. Planning inventory; recurrent inventory; permanent sample plots; sample size and allocation; double sampling; data processing; techniques for predicting the growth and yield of stands by various methods; use of growth models.

Livestock husbandry (Credit hour 2+1)

The biology, husbandry and management of domestic animals (cattle, goats and sheep, poultry, pigs, rabbits and fish).

Forest production - II (Credit hour 0+1)

Students will continue and complete the work started under Forest production - I, and write a brief report.

III YEAR III TRIMESTER

Forest seed technology (Credit hours 2+1)

Seed biology, seed production, processing, testing, certification and storage. Seed banks and seed orchards.

Forest protection (Credit hours 2+1)

Impacts of destructive agents upon forests. Prevention and protection against damage caused by shifting cultivation, mismanagement, domestic and wild animals, injurious plants. Climatic hazards and environmental stress. Predicting hazard. Basic principles and technology of forest fire management. Decision making and tile application of techniques in forest fire management.

Forest industries (Credit hours 2+1)

Wood as an industrial raw material. The resource base and its future. Present and projected future demand. The

role of forest industries in the economy, their interrelationships with each other and production forest enterprises. Organisation structure of the major forest industries including trade associations (sawmilling, panels, pulp and paper, wood working, particle, fibre and chip board, plywood and match, etc.); construction timber; marketing of wood products. Rural and Cottage industries using wood. Pollution control; recycling.

Wildlife and range management (Credit hours 2+1)

Wildlife ecology and management. Techniques of study and management; comparison of natural and plantation forests in terms of ecology and requirements of wildlife. Management strategies to integrate forestry and wildlife conservation. Wildlife parks. Range management. Importance of range management in soil and water conservation; The ecology and physiology of plants in relation to grazing; Animal nutrition in relation to range management; range surveying and management planning; range conservation and range development; range economics; Administration and management of range lands.

Ergonomics (Credit hour 1+0)

Physical work load, psychological problems (often connected with technical development and work organisation); work and the working environment, including medical and technical work hygiene; pertinent legislation; housing, nutrition, clothing, etc. Labour safety and work improvements.

Arboriculture (Credit hour 1+0)

Selection of landscape trees, shrubs and vines; plant growth and form; planting site- soil and climate; management: site preparation, planting, transplanting large plants, special planting situation, fertilization, irrigation, soil management, pruning, chemical control of plants, preventive maintenance and repair, diagnosing plant problems, pest management, non-infectious disorders; legal rights and responsibilities.

Cropping scheme and crop planning (Credit hours 1+1)

Cropping scheme, factors considered in preparation of cropping schemes suitable for different tracts, selection of crops, crop rotation and mixtures. Preparation of alternate cropping plans for use of individual farmer. Working out seed, manure, insecticide, fungicide, water and labour requirements, short-time and long-time crop planning in utilizing available farm resources fully.

IV YEAR I TRIMESTER

Landscaping, national parks and forest recreation (Credit hours 2+1)

Landscaping. landscape analysis; principles of landscaping; designing, planning and management of landscapes; techniques of landscaping. landscape of the multi-purpose forest - conservation and landscape; landscape and recreation. National parks; concepts, principles and policies, influencing the development and management of National Parks, nature reserves, wildlife management; parks and people.

Forest recreation, outdoor recreation; planning for recreation. Demand and supply of forest recreation resources to forest uses; recreational use of forested areas; recreation resource policy and implementation of plans.

Environmental forestry (Credit hours 2+0)

Nature of natural resources, the biotic regions land, its characteristics, uses and problems; management of soil and water resources, environmental pollution; conservation of environments and resources; problems of population and conservation. The environmental impact of forest practices; the study of environmental, law and policy related to forestry. Integrated resource or land-use planning.

Forest planning (Credit hours 2+0)

Competing demands for land - nature, evaluation and allocation; alternatives; planning for the use of land on sustained basis; fanning criteria and techniques; planning situations; project planning.

Forest management (Credit hours 2+0)

Principles of management and functions of managers; planning, organising, staffing, directing and controlling. Management in the forestry sector, public and private including social industrial and ecological aspects.

Management plan (Credit hours 1+2)

Preparation of management plan with defined objectives for a particular forest area.

Work study (Credit hour 1+0)

Method study, method training, work measurement; techniques and application to output and performance; project planning; critical path analysis and resource levelling. A study visit to a work situation to carry out method study and work measurement.

Study tour - II (Credit hour 0+1)

The students of final year class will undertake a study tour for about three weeks during the trimester break. They will visit a few important institutes, forest areas and plantations in the country and get acquainted with the agro-climatic and socio-economic conditions and the work and developmental activities in progress. Each student will maintain the record book on the information gathered on study tour and will submit it to the tour leader.

IV YEAR II TRIMESTER

Agroforestry (Credit hours 2+1)

Definition and scope, potentials and constraints; agroforestry practices; the systems perspective; ecological aspects of agroforestry; role of agroforestry in soil and water conservation; socio-economics of agroforestry; concepts and techniques of agroforestry research and planning. Diagnosis and design methodology.

Computers in forestry (Credit hours 2+1)

Introduction to computers; mainframe to micro; characteristics and use of computers especially in forestry; practical introduction to programming, business software, data bases, simulation models.

Forest policy and law (Credit hours 2+0)

Forest policy: Definition, scope, range and foundation of a stable forest policy; forest policy in relation to.land use policy. National forest policy, the history of forest policy and programme development; the policy making process.

Successful forest policies of the different countries in the world.

Forest law: Legal definitions, application of criminal procedure code and Indian Penal code; law of evidence; object of Social Forest law; legal organization of the forest service.

Forest research methods - I (Credit hours 1+1)

Elementary principles of the philosophy and methods of science; limitations of research techniques; structure of research organisations, research planning; students need to plan, lay-out and conduct a field experiment. Maintenance of experimental records, recording of observations, sampling technique, tabulation, analysis and interpretation of result. Preparation of data for a scientific paper. Essential features for success in field experiments.

Forest stay (Credit hour 0+1)

Students will stay in a forest area for about ten days and engage in the relevant professional work. They will keep the record of work done and submit a report after completing the stay.

Major field of specialisation (Credit hours 2+1)

IV YEAR III TRIMESTER

Forestry extension (Credit hours 2+1)

Extension education, information and behavioural change, communication, extension tools and methods, extension programme planning and evaluation.

Social forestry (Credit hours 2+1)

Socio-economics: Policies - land use, economic, energy policies, etc., land tenure and application, tax, incentives, rural sociology, project identification, preparation, appraisal, monitoring, farm and community forestry, planning for large areas, labour, seed and plant supplies.

Forest research methods - II (Credit hour 0+1)

Communication of research findings; preparation, oral presentation and submission of the research report based on the field experiment conducted during previous course (Forest Research Method - I). Practical application of experimental results.

Philosophy and professional ethics (Credit hour 1+0)

Religion, culture and the environment. General, moral and political philosophy; philosophy of the social sciences; philosophy of mind; logic; moral principles to guide foresters in the exercise of their profession.

Global forestry (Credit hours 2+0)

Forest geography of the world forest resources and practices in different regions of the world; regional development of wood based industries and trade patterns in forest raw materials and finished products.

Tribal ethnology (Credit hour 1+0)

Linkages of forestry and tribal development; constitutional provisions for development of scheduled tribes and forests; symbiotic relationship between tribals and forests; concept of tribal development; tribal co-operative societies; socio-economic aspects of shifting cultivation; tribal development programmes; tribal land and tenurial systems.

Major field of specialization (Credit hours 2+1)

Appendix V

Lead institutions and human resources in selected Asian countries in the field of wood science

BANGLADESH		
Institution	**Thrust Areas**	**Areas and Resource Persons**
Bangladesh Forest Research Institute P.O. Box 273, **Chittagong**-4000		**Wood Technology** Tel: +880-31-681577 Fax: +880-31-681566 Email: bfri@spnet.ctg.com
Chittagong University, Institute of Forestry Chittagong 4331		Gias Uddin Ahmed Tel: +880-31-210132-49
CHINA		
Bamboo Research and Development Center (BRDC), Chinese Academy of Forestry Hangzhou http://www.forestry.ac.cn/zzzx/bamboo	1. Scientific research and technical development on cultivation, utilization and development of bamboo 2. BRDC has technical and economic exchange programmes both domestically and abroad. 3. Conducts technical training on bamboo for China and other countries.	
International Network for Bamboo and Rattan (INBAR) Anyuan Building No.10, Anhui Beili, Asian Games Village, Chaoyang District, **Beijing** 100101-80 URL: http://www.inbar.org.	1. Through a growing Network of participating organizations and individuals from all continents of the world, INBAR develops and assists in the transfer of appropriate technologies and solutions to benefit the peoples of the world and their environment.	Tel: +86-10-64956961/82 Fax: +86-10-64956983 Email: info@inbar.int

Research Institute of Wood Industry **Chinese Academy of Forestry** **Beijing** Post No:100091	1. Wood property 2. Wood drying 3. Wood protection 4. Wood-based Panels 5. Wood Adhesives and Panel Surface finishing 6. Machinery and Automation, 7. Civil engineering designing	**Wan Shou Shan** Tel: 010-62889410 Fax: 010-62881937 Email: office.mg@wood.forestry.ac.cn Units: National Quality Monitoring and Testing Center for Wood-based Panels
Research Institute of Chemical Processing and Utilization of Forest Products No. 16, Suojin Wucun, **Nanjing**, 210042, P. R. China	1. Pulping and Paper-making from wood and non-wood fibers. 2. Chemical utilization of Oleoresin. 3. Chemical utilization of forest resources. 4. Activated carbon and wood-based energy 5. Adhesives. 6. Manufacture of Furfural and Furfuryl Alcohol by hydrolysis of plant cellulose materials, and Chemical modification of cellulose.	**Director- Shen Zhaobang** Tel: +86 25 5412131 Fax: +86 25 5413445 E-mail: ricpufp@public1.ptt.js.cn
Shanghai Wood Industry Research Institute 667 Zhongshan Road (West), **Shanghai** 200051		Director: Ma Xin Tel: 0086-21-2412200/2412266 Fax: 0086-21-2412266
INDIA		
Forest Research Institute (FRI), Dehra Dun, Deemed University http://envfor.nic.in/icfre.html	1. Ph.D. programmes for postgraduates students. 2. Specialized courses-Postgraduate Diploma courses in Pulp and Paper Technology, Wood Technology and Plantation Technology. 3. Networking with other training institutions involved in the field of forestry education.	

Indian Plywood Industries Research and Training Institute (IPIRTI), Bangalore (URL: http://envfor.nic.in/ipirti.html),	1. Finger-jointed and glulam structures from plantation grown timbers and bamboo mat boards from bamboos. 2. Training in mechanical wood industries and processing small diameter logs 3. Developed new products like bamboo mat boards and application in various uses for housing	DIRECTOR Tel: +91-80-8394231 Fax: +91-80-8396361
Institute of Forest Genetics and Tree Breeding (IFGTB) URL: http://envfor.nic.in/ifgtb.html	1. Provenance trials of Teak, Casuarina, Acacia nilotica, Albizia lebbek, Neem and Bamboos. 2. Socio-economic survey and studies on productivity in agroforestry systems. 3. In situ and ex situ conservation studies on biodiversity of forest genetic resources	**Wood properties of Acacia/Eucalypts -** **Dr. Mohan Varghese**
Institute of Wood Science and Technology (IWST), Bangalore-560 003 URL: http://envfor.nic.in/icfre.html	1. Processing / utilization of lesser known timber of plantation species. 2. Development of indigenous substitutes for imported raw material in perfumery industries. 3. Utilization of alternative timbers for catamarans, the traditional craft of poor coastal fishermen of A.P.	**Wood anatomy/ identification/ properties -** **Dr. R. V. Rao** Tel: +91-80-3341731 Fax: +91-80-3341731 **Wood Treatment for catamarans -** **Dr. K. S. Rao** Tel: +91-80-3341731 Fax: +91-80-3341731

Division of Wood Science **Kerala Forest Research Institute** **Peechi** 680 653, **kerala** URL: http://www.kfri.org	1. Wood and Non-wood (bamboo/rattan) anatomy, identify-cation, properties 2. Economic schedule for preservative treatment of rubber wood 3. Utilization of wood from wilt-diseased coconut palms 4. Pulpwood quality of Clonal eucalypts from short rotation plantation 5. Protection of pulpwood in storage 6. Rural technology for rattan (cane) curing 7. Grading rules for rattan (cane) 8. Harvesting tool for reed bamboo 9. Preservative treatment and storage of reed bamboo 10. Local tools, equipments and technologies for processing bamboo and rattan 11. Wood quality of fast grown teak, eucalypts, acacia,	**Wood/rattan anatomy and identification, wood quality of tropical woods -** **Dr. K. M. Bhat** Tel: +91-487-282037 Fax: +91-487-282249 Email: kmbhat@kfri.org or maksbhat@vsnl.com (home) **Wood/ bamboo anatomy, Bamboo-reed harvesting -** **Dr. K. V. Bhat** Tel: +91-487-282037 Fax: +91-487-282249 Email: kvbhat@kfri.org **Rubber wood, coconut stem, bamboo Preservation -** **Dr. R. Gnanaharan,** Tel: +91-487-282037 Fax: +91-487-282249 Email: gnana@kfri.org **Rubber wood, coconut stem, Preservation, Acacia -** **Dr. T. K. Dhamodaran** Tel: +91-487-282037 Fax: +91-487-282249 Email: tkd@kfri.org **Rubber wood bio-degradation -** **Dr. E. J. Maria Florence** Tel: +91-487-282037 Fax: +91-487-282249 Email: flory@kfri.org

INDONESIA		
Centre for Research and Development of Isotopes and Radiation Technology, National Nuclear Energy Agency (P3TIR-BATAN) Jl. Cienere Ps. Jumat, Kotak Post 7002 JKLS **Jakarta** 12070	1. Modification rubber latex for wood adhesives 2. Development of lingo-cellulosic plastic composites (wood, rattan, bamboo) by radiation polymerization technique	**Radiation polymerization technique for wood plastic and rattan/bamboo composites -** **Marga UTAMA** Tel: +62-21-7690709 Fax: +62-21-7691607 Email: marga@batan.go.id **Sugiarto DANU** Tel: +62-21-7690709 Fax: +62-21-7691607
Department of Forest Products Technology, Faculty of Forestry, Bogor Agricultural University Kampus IPB Darmaga P.O. Box 168, **Bogor** 16001	1. Wood extractives and pulping chemistry 2. Chemical modification, wood-polymer composites, 3. Bio-deterioration and preservation 4. Wood physics and mechanics 5. Wood machining 6. Growth stresses and wood quality 7. Wood anatomy/ proeprties	**Pulping and wood Chemistry -** **Prof. Wasrin SFAII** Tel: +62-251-621285 Fax: +62-251-621256 Email: wasrinsy@indo.net.id **Dadeb sarip NAWAWI** Tel: +62-251-621285 Fax: +62-251-621256 Email: jthh-ipb@indo.net.id **Chemical modification / composites -** **Prof. Yusuf Sudo HADI** Tel: +62-251-621677 Fax: +62-251-621256 Email: yshadi@indo.net.id **Wood physics/ Engineering -** **Sucahydo SADIYO** Tel: +62-251-621285 Fax: +62-251-621256 Email: jthh-jpb@indo.net.id **Naresworo NUGROHO** Tel: +62-251-621285 Fax: +62-251-621256 Email: jthh-jpb@indo.net.id

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Faculty of Forestry, **Gadjah Mada University** Bulaksumur, **Yogyakarta** 55281	1. Properties and utilization of tropical woods/biomass 2. Utilization wood from TOF 3. Bamboo utilization	**Wood formation, growth rate and properties -** **Sri Nugroho MARSOEM** Tel: +62-274-901420 Fax: +62-274-566171 Email: nugroho@idola.net.id **Utilization wood from TOF -** **KASMUDJO** Tel: +62-274-901428 Fax: +62-274-901420 **Bamboo utilization -** **Yustinujs SURANTO SETYOHARJONO** Tel: +62-274-901420 Fax: +62-274-561420 Email: fkt-ugm@indo.net.id

Faculty of Forestry, Mulawarman University Jl. Ki Hajar Dewantara, Kampus Gn., Kelua, P.O. Box 1013, **Samarinda** 75123	1. Utilization wood residues in pulp and paper 2. Wood adhesives and engineering	**Utilization wood residues in pulp -** **Sipon MULADI** Tel: +62-541-744602 Fax: +62-541-735379 Email: pulp-lab@smd.mega.net.id **Wood adhesives and engineering -** **Isna Yuniar WARDHANI** Tel: +62-541-744602 Fax: +62-541-735379 Email: pulp-lab@smd.mega.net.id
Faculty of Forestry, Winaya Mukti University Jl. Winaya Mukti No. 01, Jatinangor, Sumedang 45363, **West Java**	1. Properties and testing of wood based panels 2. Wood preservation & termite resistance 3. Utilization of forest-based residues	**Wood-based panels & residue utilization -** **SUTRISNO** Tel: +62-22-7798260 Fax: +62-22-75009361 Email: tisno62@usa.net **Eka Mulya ALAMSYAH** Tel: +62-22-7798260 Fax: +62-22-75009361 **Rudi DUNGANI** Tel: +62-22-7798260 Fax: +62-22-7798260 Email: cephot@usa.net **Noor RAHMAWATI** Tel: +62-22-7798260 Fax: +62-22-7798260 Email: rahmawati_noor@hotmail.com **Entang RASYID** Tel: +62-22-7798260 Fax: +62-22-7798260 Email: erasyid@bdg.centrin.net.id

Forest Products Research Centre Jl. Gunung Batu No.5, **Bogor** 16610	1. Wood anatomy, identification and wood properties 2. Wood preservation 3. Plywood and composite boards from Indonesian woody species	**Plywood, particleboard and composite boards -** **I.M. SULASTINGSIH** Tel: +62-251-326378 Fax: +62-251-313613 Email: titin@usim.or.id **Wood preservation , thermal treatment -** **Pipin PERMADI** Tel: +62-251-326378 Fax: +62-251-313613 Email: permadi@indo.net.id **Properties of wood/ lingo-cellulosic materials -** **Nurwati HADJIB** Tel: +62-251-326378 Fax: +62-251-313613 Email: usim@indo.net.id **Wood suitability for pulping and bio-pulping by enzymatic and fungal lignin degradation -** **Ridwan Achmad PASARIBU** Tel: +62-251-326378 Fax: +62-251-313613 Email: slitbang@bogor.indo.net **Rene M. SIAGIAN** Tel: +62-251-326378 Fax: +62-251-313613 Email: slitbang@bogor.indo.net **Wood, rattan, bamboo properties, drying and permeability -** **Efrida BASRI** Tel: +62-251-326378 Fax: +62-251-313613 Email: efrida@usim.or.id **Wood biodeteriration -** **Paimin SUKARTANA** Tel: +62-251-326378 Fax: +62-251-313613 Email: paimins@usim.or.id

Institute for Research and Development of Cellulose Industry Bandung Jl. Raya Dayeuhkolot No. 132, **Bandung** 40258	1. Cellulolse, lignin, pulp and paper, bleaching, etc 2. Utilisation of NWFPs as raw material for pulping	**Cellulose derivatives, lignin and waste-water treatment of pulp and paper mill -** **Nursyamsu Bahar TOBING** Tel: +62-22-5202980 Fax: +62-22-5202871 Email: bbsindag@melsa.net.id **Pulping and bleaching technology -** Tel: +62-22-5202980 Fax: +62-22-5202871 Email: bbsindag@melsa.net.id **Susi SUGESTY** Tel: +62-22-5202980 Fax: +62-22-5202871 Email: bbsindag@melsa.net.id
Perum Perhutani Teak Centre Pusat Pengembangan Sumberdaya Hutan, Jl. Wonosari Batokan, Tromol Pos 6		**Sadhardjo Sm** Tel: +62-296-425280 Email: sadhardjo@usa.net
Research and Development Centre for Biology (Botany division), Indonesian Institute of Sciences Jl.Ir. H. Juanda 22, **Bogor** 16002	1. Wood and bamboo anatomy 2. DNA moelcualr study and phylogenetic analysis	**Bamboo anatomy/ molecular marking and classification -** **Elisabeth A. WIDJAJA** Tel: +62-251-322035 Fax: +62-251-325854 Email: ewidjaja@indo.net.id **Wood anatomy/tree mutiplication -** **Ninik SETYOWATI** Tel: +62-251-322859 Fax: +62-251-370934 Email: prosea@indo.net.id

JAPAN		
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Division of International Environmental and Agricultural Science, Graduate School of Agriculture, Tokyo University of Agriculture and Technology Saiwai, Fuchu, **Tokyo** 183-8509 (URL: http://samia.ab.a.u-tokyo.ac.jp/aeb/) Tel: +81-42-367-5655 Fax: +81-42-360-8830	1. Mechanical wood processing, industrial safety, etc.	**Mechanical wood processing -** **Prof. Shigeru KITAYAMA** **Sawmilling and laser processing -** **Prof. Nobuaki HATTORI**
Faculty of Agriculture, Gifu University **Yanagido, Gifu** 501-1193 Tel: +81-58-293-2833 Fax: +81-58-293-2840	1. Biochemistry and effective use of plant constituents 2. Enzymatic ligninolysis and biologically active phenolics	**Biochemistry and use of plant constituents -** **Prof. Hideo OHASHI** **Enzymatic ligninolysis and biologically active phenolics -** **Prof. Shingo KAWAI**
Faculty of Agriculture, Iwate University **Morioka, Iwate** 020-8550 Tel: +81-19-621-6103 Fax: +81-19-621-6107	1. Wood-based panels	**Wood-based panels -** **Prof. Noboru SEKINO**

Faculty of Agriculture, **Kyoto University** Sakyo-ku, **Kyoto** 606-8224 URL: http://mirror.xanet.edu.cn/www.kyoto-u.ac.jp/index-e.html Tel: +81-75-753-7531 Fax: +81-75-753-6020	1. Wood and heartwood formation in fast growing tropical hardwoods 2. Anatomy of palms, bamboo, monocotyledons, etc. 3. Genetic engineering of bamboo 4. Anatomy, ultra-structure, quality of tropical woods and biomass utilization 5. Lignin, cellulose, enzyme studies	**Heartwood formation in tropical hardwoods -** **Prof. Tadashi NOBUCHI** **Genetic engineering of bamboo -** **Prof. Jun-ichi AZUMA** **Quantitative wood anatomy and X-ray diffraction -** **Prof. Minoru FUGITA** **Ultra-structure and lignifications -** **Prof. Keiji TAKABE** **Biodegradable plastics from cellulosic and other biomass -** **Prof. Mariko YOSHIOKA**
Wood Research Institute (WRI), **Kyoto University,** **Uji City, Kyoto** 612-0011 URL: http://mirror.xanet.edu.cn/www.kyoto-u.ac.jp/index-e.html Tel: +81-774-38-3601 Fax: +81-774-38-3600	6. Fundamental methodology, machines and systems for producing the high-performance of wood composites and their characteristic functions. 7. The development of wood carbon materials with new functions by thermal conversion and the technology for bio-energy. 8. The development for improving fire-resistant performance of wood composites. 9. studies on gene expression in woody plants to elucidate function of target genes.	

Faculty of Agriculture, **Kyoto Prefectural University** Sakyo-ku, **Kyoto** 606-8522 Tel: +81-75-703-5186 Fax: +81-75-703-5149	1. Wood extractives, chemical modification of wood and wood-based materials 2. Vibration properties of wood 3. Wood permeability and sap-flow	**Chemical modification of wood -** **Prof. Kazuya MINATO**
Faculty of Agriculture, **Kyushu University** Higashi-ku, **Fusuoka** 812-8581 URL: http://www.bcasj.or.jp/jb/3erarotx.html Tel: +81-92-642-2111 Fax: +81-92-642-2804	1. Phenolic resin adhesives & chemical modification 2. Biotechnology and gene mapping	**Adhesives and chemical modification of wood -** **Prof. Mitsuo HIGUCHI** **Bio-synthesis of wood components -** **Prof. Kokki SAKAI** **Prof. Koki FUGITA** **Prof. Ryuichiro KONDO** **Prof. Mitsuhiro MORITA** **DNA-Gene mapping -** **Prof. Susumu SHIRAISHI**
Faculty of Agriculture, **Shizuoka University** Suruga-ku, **Shizuoka** 422-8529 Tel: +81-54-237-1111 Fax: +81-54-237-3028	1. Wood adhesion, bond quality, wood composites 2. Utilization of Bamboo in panels and MDF. 3. Recycling of wood resources	**Wood adhesion, bond quality and composites -** **Prof. Kinji TAKI** **Utilization of Bamboo in panels and MDF -** **Prof. Hiroaki YOSHIDA** **Wood composites and recycling -** **Prof. Shigehiko SUZUKI**
Faculty of Agriculture, Tottori University **Koyama, Tottori** 680-8553 Tel: +81-857-31-5343 Fax: +81-857-31-5347	1. Wood gluing and durability of glued structures in exposed conditions 2. Board manufacture from agro-residues 3. Wood quality variation of tropical/arid zone trees	**Wood gluing and durability of glued structures -** **Prof. Tomoyasu SAKUNO** **Wood quality variation of tropical/arid zone trees -** **Prof. Ikuo FURUKAWA**
Faculty of Agriculture, Yamagata University **Tsuruoka, Yamagata** 997-8555 Tel: +81-235-28-2805 Fax: +81-235-28-2812	1. Chemical characterization of forest products	**Chemical characterization -** **Prof. Koichi OGIYAMA**

Faculty of Agriculture, Utsunomiya University **Utsunomiya, Tochigi** 321-8505 URL: http://www.utsunomiya-u.ac.jp/index.html/ Tel: +81-28-649-5398 Fax: +81-28-649-5401	1. Formation of reaction wood, tissue culture of woody plants, wood quality improvement by smoke heating 2. Lignin bio-degradation	**Tissue culture and, wood quality improvement -** **Prof. Nobuo YOSHIZAWA** **Lignin bio-degradation -** **Prof. Shinzo YOKOTA**
Faculty of Science and Engineering, Shimane University, Matsue, Shimane, 690-8504 URL: http://susc3002.riko.shimane-u.ac.jp/index-e.html Tel: +81-852-32-6492 Fax: +81-852-32-6499	1. Automation of wood processing machinery 2. Developing Reinforced wood - based panels 3. Anatomy and identification of tropical woods other wood-based materials 4. Chemical modification of low quality wood for higher performance	**Wood-working machinery -** **Prof. Chiaki TANAKA** **Wood anatomy/ identification and wood quality modification -** **Prof. Takeshi FURUNO**
Graduate School of Agricultural and life sciences, University of Tokyo Yayoi, Bunkyoku, **Tokyo** 113-8657 URL: http://www.a.u-tokyo.ac.jp/english/ Tel: +81-3-3812-2111 Fax: +81-3-5841-5023	1. Utilization of agricultural residues like rice straw, pulping, recycling of wood resources 2. Bio-polymer chemistry, bleaching and lignin chemistry	**Lignin derivatives, pulping -** **Prof. Gyosuke MESHITSUKA** **Wood physics, engineering and recycling -** **Prof. Takanori ARIMA** **Bio-polymers and cellulose chemistry -** **Prof. Shigenori KUGA**
School of Agriculture, Ehime University **Matsuyama** 790-8566 URL: http://ugas-eu.agr.ehime-u.ac.jp/index.htm Tel: +81-89-946-9803 Fax: +81-89-977-4364	1. Wood physics, drying, permeability, charcoal 2. Tissue culture and biotechnology, pulping 3. Non-destructive testing 4. Bio-mechanical pulping	**Wood physics, charcoal -** **Prof. Kazuo HAYASHI** **Biotechnology/tissue culture -** **Prof. Sanro TACHIBANA** **Non-destructive wood testing -** **Prof. Masatoshi SUGIMORI** **Prof. Sanro TACHIBANA** **Bio-mechanical pulping -** **Prof. Kazutaka ITOH**

School of Agriculture, Kochi University Nankoku, **Kochi** 783-8502 URL: http://www.kochi-u.ac.jp/EN/katudo/no.html Tel: +81-88-864-5114 Fax: +81-88-864-5200	1. Wood preservation, extractives 2. Pulp and paper 3. Silviculture and wood properties 4. Wood mechanics and permeability	**Pulp and paper, extractives -** **Prof. Kazuhiko SAMESHIMA** **Prof. Yoshito OHTANI** **Wood properties -** **Prof. Shinji FUJIWARA** **Wood mechanics and permeability -** **Prof. Yasushi KANAGAWA**
MALAYSIA		
Department of Forest Products, Faculty of Forestry, Universiti Putra Malaysia 43400, Serdang, **Selangor**	1. MDF and Glulams from Rubberwood / Malaysian timbers 2. Biodegradation of wood 3. Durability and treatment of bamboo, bamboo laminates and composite boards	**MDF and Glulams from Rubberwood/hardwoods -** **Wong Ee Ding** Tel: 603-894866101 Ext.2450 Fax: 603-89432514 Email: edingw@hotmail.com **Biodegradation of wood -** **Ahmad Said Sajap** Tel: 603-894866101 Ext.2450 Fax: 603-89432514 Email: ahsaid@forr.upm.edu.my **Bamboo utilization -** **Zaidon Ashaari** Tel: 603-894866101 Ext.2415 Fax: 603-89432514 Email: zaidon@forr.upm.edu.my
Forest Products Technology Division, Forest Research Instititute Malaysia (FRIM) Kepong URL: http://www.frim.gov.my	1. Utilization of plantation grown small timbers and Wood protection 2. Glulam structures and stress grading 3. Properties and utilization of NWFPs (Bamboo laminates, rattan furniture, etc) 4. Utilisation of palm/wood resisues	**Wood Technology -** **Dr. Mohd. Dahlan Janton** Tel: 603-6270 2350 Fax: 603-6275 2561 Email: dahlan@frim.gov.my **Wood anatomy & treatability -** **Dr. Ani Sulaiman** Tel: 603-6270 2350 Fax: 603-6275 2561 Email: anis@frim.gov.my

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		Furniture Testing - **Mohd.Arshad Saru** Tel: 603-6270 2350 Fax: 603-6275 2561 Email: arshad@frim.gov.my
Timber Research and Technical Training Centre **Department of Forestry,** 93660 **Kuching, Sarawak**	1. Research and training	**John S.K. Cheng** Tel: 0060-82-612211 Fax: 0060-82-612490
PHILIPPINES		
Forest Products Research and Development Institute (FPRDI) College, **Laguna** 4031		Tel: 0063-94-3630/2377 Fax: 0063-94-3630
University of the Philippines at Los Banos, College of Forestry College, **Laguna** 4031		Tel: 0063-94-3206 Fax: 0063-94-3206
THAILAND		
Forestry Research Support Programme for Asia and the Pacific (FORSPA) **FAO Regiojal Office for Asia and the Pacific** 39 Phra Atit Road, **Bangkok** 10200	1. Regional Networking and capacity building of forestry research institutions of Asia pacific Region	**Dr. S. Appanah** Senior Programme Adviser Tel: 66-2-2817844 Ext. 136, Fax: 66-2-280-4565 E-mail: Simmathiri.Appanah@fao.org **Mr. Taco Bosdijk** Associate Professional Officer Tel: 66-2-2817844 Ext. 136, Fax: 66-2-280-4565 E-mail: Taco.Bosdijk@fao.org
Royal Forest Department, Forest Products Research and Development Division 61 Phaholyothin Road, Chatuchak, **Bangkok** 10900		Tel: 0066-2-5791537 Fax: 0066-2-5794844