

M.Sc. FORESTRY CURRICULUM



**DIRECTORATE OF EDUCATION
INDIAN COUNCIL OF FORESTRY RESEARCH AND
EDUCATION, DEHRADUN**

AN AUTONOMOUS BODY OF MINISTRY OF ENVIRONMENT AND FORESTS, GOVT. OF
INDIA

PREFACE

Forestry Education in the State Agricultural Universities, commenced following the recommendations of the National Commission on Agriculture way back in 1976 to give boost to agro-forestry as also the afforestation of waste lands through social forestry programmes. As of today, twenty-six State/Central Agricultural Universities are running forestry courses either at Under Graduate or Post Graduate level or both. Indian Council of Forestry Research & Education (ICFRE) was established in the year 1987 with the mandate to spear-head and oversee forestry research, education and extension in the country. Since then, ICFRE has been supporting forestry education in the states Agricultural Universities by providing financial assistance to help develop and upgrade their infrastructure. So far, these Universities have been recipient of grant-in-aid to the tune of about Rs. 40 Crore, which has led to considerable improvement in infrastructure facilities for effective delivery of forestry education therein.

In order to give full effect to the mandate of ICFRE with regard to forestry education, it was decided during October 2006 in the meeting of Vice Chancellors, Deans and Head of Forestry Departments of States Agricultural Universities running forestry courses, that ICFRE should take the lead role in giving direction and setting trends for quality forestry education in the country. With this decision in mind, the ICFRE set out to unify, improve and standardize the forestry syllabus at Under Graduate/Post Graduate levels. B.Sc. (Forestry) syllabus prepared by Fourth Deans' Committee of ICAR under the Chairmanship of Dr. S. L. Mehta, Vice Chancellor, Maharana Pratap University of Agriculture and Technology, Udaipur, has been endorsed by ICFRE with minor modifications / additions. The same has now been introduced by ICAR for implementation in these Universities. Further to this, ICFRE took initiative to prepare a model syllabus for Post Graduate courses by a Committee comprising the undersigned and the Deans/Head of various Forestry Colleges of these Universities. The present syllabus is outcome of the efforts made by the Committee. While deliberating upon the subject areas and the course contents of the curriculum, the Committee have endeavored to make it a professional programme with ample scope for specialization in the upcoming subject areas relevant for the sector, industries and other stake holders, thus broadening the scope and potential for employment for the Post Graduate students of forestry.

It is hoped that the ICAR and the State Agricultural Universities functioning under them, shall find the course curriculum very meaningful and useful towards meeting the complex challenges of forestry sector in times to come. This course curriculum has also been made flexible so as to incorporate regional variations as per the requirements of the Universities concerned. I hope the syllabus shall prove beneficial to the forestry faculty as well as the student community in these Universities.

(A. K. Wahal)
Dy. Director General(Education)
and
Chairman - Syllabus Committee.
ICFRE, Dehra Dun.

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1. Forestry Education at Post Graduation level in India

Forestry Education in States Agricultural Universities commenced from the year 1985 with the inception of under graduate forestry course at Dr. Y.S. Parmar University of Horticulture and Forestry, Solan and PDKV, Akola. Later on between the year 1991 and 2005, the country witnessed a rapid expansion of forestry education at University level. At present twenty-six State Agricultural Universities are imparting forestry education. Of these 14 Universities are running Post Graduation courses as under :-

Sl	Name of University	Course	Degree Awarded
01	FRI University,	P.G.	M.Sc. (Forestry), M.Sc (Wood Science & Technology) and M.Sc (Environment Management)
02	KAU, Trissur, Kerala	-- do --	M.Sc. (Forestry)
03	AAI-DU, Allahabad, U.P.	-- do --	M.Sc. (Forestry)
04	NAU, Navsari, Gujarat	-- do --	M.Sc. (Forestry)
05	UBKV, Cooch Behar, WB	-- do --	M.Sc. (Forestry)
06	BAU, Ranchi, Jharkhand	-- do --	M.Sc. (Forestry)
07	UAS Dharward, Karnataka	-- do --	M.Sc. (Forestry)
08	TNAU, Coimbatore, TN	-- do --	M.Sc. (Forestry)
09	CCS HAU, Hissar, Haryana	-- do --	M.Sc. (Forestry)
10	PAU, Ludhiana (Punjab)	-- do --	M.Sc. (Forestry)
11	GGU, Bilaspur, Chattisgarh	-- do --	M.Sc. (Forestry, Wildlife and Environment)
12	HNBGU, Srinagar (UK)	-- do --	M.Sc. (Forestry and Environmental Sciences)
13	SKUAST Srinagar (J&K)	-- do --	M.Sc. (Forestry and Environmental Sciences)
14	Dr. YSPUHF, Solan, H.P.	-- do --	M.Sc. (Forestry), M.Sc (Silviculture), M.Sc (Tree Improvement and Forest Products)

2. Change in Forestry Education scenario

The fast emerging emphasis on land use management, multiple and optimum natural resource management leading to sustainable development and awareness about land use interaction with social conditions, has necessitated that Forestry Education should become highly professionalized, specialized and oriented towards meeting the requirement of management of highly complex forestry resources on the one hand and satisfy the competing demands of goods and services from the same in a sustainable manner on the other hand. Further it is greatly realized that higher education system in the country has to accommodate the fast paced changes

and be tailored to meet the demands of the job markets so as to provide the right kind of human resources for the new production processes and systems in the globalized economic order. Forestry, has traditionally been realized both as a scientific discipline as well as profession. Post graduate forestry courses have, therefore, imperative to be fully geared to meet the challenges of market demands of specialized nature, as also contribute to the furtherance of forestry science by developing & promoting interest towards academics & research among the aspiring student community.

3. Post Graduate Forestry Curriculum.

At present forestry curriculum being followed in the Universities at Post Graduation level are of varied nature. The universities offering these course have designed the syllabus based on the expertise & resources available with them. There is wide variation in the course contents, their credit system & grades awarded. Close scrutiny of these courses revealed that many a subjects being taught have not only become out dated but are dealt at levels which are not upto the mark. No serious attempt has been made to modernize the syllabus and update them in keeping with the current demands from the sector. Secondly, the course curriculum also does not provide adequate scope for specialization which has become a key buzzword in market-driven economy. When compared with course programme followed at Masters' level in the top Universities elsewhere, the existing course curriculum does not stand any comparison.

Recently, an exercise was done by ICAR to update and modernize the syllabus at Graduation level which is now prescribed for being followed in the States Agricultural Universities. Having updated B.Sc. Forestry curriculum, the need to update and standardize M.Sc. Forestry, curriculum has become a pressing necessity. While attempting the job of drafting a new syllabus for M.Sc. Forestry programme ICFRE Committee has been of the view that the Forestry curriculum at Post Graduation level should be drafted on professional lines if it were to be intended to meet the emerging requirements of the sector. Secondly, it should also provide post graduate students ample scope and opportunity for specialization in upcoming areas in the field forestry and environment so that it may improve their chances for securing appropriate jobs in a fast expanding market economy. It has also been contended that specialization would not only enhance the employability for the students pursuing post graduate degree programme but shall also orient them towards pursuing serious research in the forestry arena. This, in turn, would generate a favourable environment in the Universities for conduct of forestry research thus facilitating furtherance of forestry science in the country.

4. New Curriculum

4.1 Objective

“ To Formulate a meaningful curriculum for the Post graduate (M.Sc) level forestry education at the universities to ensure development of core professional competence and research orientation in the students pursuing these courses to cater to the market requirement in the sector as well as to promote excellence in academics/ research arena in forestry”.

4.2 Salient Features of the Proposed Post Graduate Forestry Programme

4.2.1 Uniformity in Minimum educational qualifications for admission

The committee has recommended that there should not be lateral entry in the PG Course. It is also proposed that ICFRE should start conducting an admission test for open seats at national level. 30% seats may be reserved for the candidates qualifying entrance test in each course of all the Universities. Minimum eligibility for the course should be with B.Sc. Forestry (four year programme) having 50% marks in aggregate for general category and 45% marks for SC / ST candidates.

4.2.2 Degree awarded

It is proposed that the Post graduate Degree awarded at the end of the course should be M.Sc Forestry. The name of the specialized course shall be written after the name of the degree e.g. M.Sc. Forestry (Wood Science and Technology) in order to emphasize the specialization pursued by the student.

4.2.3 The Curriculum :

The Committee in this Report has recommended that this syllabus should be adopted in all universities, with some mechanism to ensure that uniformity of curriculum standards is maintained throughout India.

4.2.4 Academic Autonomy to Accommodate Regional Capabilities/requirements

Standardization of curricula should however, not mean that one uniform curriculum should rigidly be imposed on all universities/institutes. They should be given the autonomy to develop their own potentialities in accordance with the special requirements of their regions. In this way, national goals can be achieved without sacrificing local needs. Keeping this in view, the committee has provided flexibility in the core as well as in the supportive courses. While upto 20% deviation is permitted in the core, the students have been given a wide range of choices in the supporting specialized courses to select from.

4.2.5 The Syllabus :

Although the total duration of two years remains as such, a new pattern of time frame is proposed where the Core subjects will be studied by all the students in the first year followed by one selected subject for specialization for the first half of the second year. The final semester of six months will be for dissertation (3 months) and industrial/institutional attachment (3 months). It will ensure developing link with Industry and the institutes as the students after obtaining post graduate degree flood to job market annually. The committee has noted that to prepare the students for befitting jobs, the syllabus should be fully tuned.

4.2.6 Examination Reforms

It is recommended that all universities/institutes should uniformly adopt the semester pattern.

4.2.7 Credit System :

A credit based semester system was accepted as it offers maximum flexibility in terms of course offering, course duration, faculty and students schedules and optimum use of exiting faculties, continuous internal assessment of students through a mix of written examinations, assignments, term papers, oral presentations etc.

4.2.8 Duration of Course and System of Education :

It was unanimously decided that the Post Graduate Degree Programmes in this discipline should be of 2 years duration. To make it more applied and professional in nature, in the first year, core/compulsory subjects will be taken up along with the supporting course and in the 2nd year, courses pertaining to specialization will be taught in first six months and followed by 3 months dissertation and 3 months attachment with suitable industry/organization/institute.

4.2.9 Degree awarded:

It was unanimously agreed that the Post graduate Degree awarded at the end of the course should be M.Sc Forestry. The name of the specialized course shall be written after the name of the degree e.g. M.Sc. Forestry (Wood Science and Technology).

4.3.0 Mode of Admission:

The committee recommended that there should not be lateral entry in the PG Course. It was also suggested that ICFRE should start conducting an admission test for open seats at national level. 30% seats will be reserved for the candidate qualifying entrance test in each course of all the Universities.

4.3.1 Eligibility:

Minimum eligibility with B.Sc. Forestry (four year programme) having 50% marks in aggregate for general category and 45% marks for SC / ST candidates.

4.4 Course workload:

Ist year		= 33 credits
2nd year		
Ist Semester		=15-20 credits
2 nd Semester	i) Dissertation	= 08 credits
	ii) Industrial/institute attachment etc.	= 07 credits
Total Credits		= 63-65 credits

4.5 Course Curriculum:

The Committee after detailed discussion has arrived at a decision that the course curriculum in M.Sc Forestry should be as follows:

A. Core/ Courses:

Sl. No.	Subject	Credits
1.	Advanced Silviculture	2+0
2.	Forest Bio-metric	2+0
3.	Advanced Forest Management	2+0
4.	Remote Sensing & GIS	1+1
5.	Forest Resource Management and economics	2+1
6.	Wood based Industries	2+0
7.	Chemistry of Forest Products	2+0
8.	Forest Policy & Utilization	2+0
9.	Advanced Forest Ecology	1+1
10.	Forest Biodiversity Conservation	1+1
11.	Forest Protection	2+1
12.	Seminar	0+1
	a- Total Credits:	25 (19+6)

B. Supporting Courses:

(i)	Computer Application and Information Technology	0+2
(ii)	Research Methodology and implementation	1+1
(iii)	General Statistical methods	3+1

b- Total Credits: 8 (4+4)

C. 1. Specialisation: To be opted one, amongst the following subjects depending upon the course offerings at the University concerned.

- i. Wood Science and Technology
- ii. Medicinal Plants and Aromatic Plants
- iii. Plantation Technology

- iv. Watershed Management
- v. Eco-tourism
- vi. Agro-forestry
- vii. Bio-energy
- viii. Forest Bio-technology
- ix. Environment management
- x. Forest Business Management

c- Total Credits = 15- 20

2. Dissertations Credits = 0+08

3. Attachment with industry/institute etc. Credits = 0+07

d- Total Credits = 0+15

Grand Total of Credits (a+b+c+d) = 63-65

4.6 Examination and Evaluation System:

There shall be one mid-term test examination of 20% marks (Internal) and final theory examination of 80% marks (External). The syllabus of the concerned course shall be sent to the external examiners who shall set the question papers and also evaluate the answer books.

The practical examination will be conducted internally by the course instructors and one teacher nominated by the HOD.

4.7 Grade points:

10 points grading system shall be adopted with minimum average grade point (AGP) of 5.00 for passing a course and overall grade point average of (OGPA) of 5.50 for obtaining a degree. The University may award Ist class at and above 6.0 (OGPA).

4.8 Faculty specific recommendations:

The Committee made the following suggestions.

- a. Inter-institutional exchange of forestry faculty
- b. Training of faculty members in new emerging fields of forestry and related disciplines
- c. Remunerations to teachers for delivering specialized lectures if invited from outside the parent University/Institute.

- d. Provision for guest faculty from industry, SFDs, Financial Management Institutions.

4.9 Maximum permissible course workload:

16-18 Credits per semester

4.10 Departments in Forestry College:

The Committee have deliberated on this issue and decided that a Forestry college/ Faculty should have minimum of following 5 departments.

S. No.	Name of Departments
1.	Silviculture and Agroforestry
2.	Forest Biology & Tree Improvement
3.	Forest Products and Utilization
4.	Natural Resources Management
5.	Basic Science and Humanities

4.11 Proposed Academic Regulations for M.Sc. (Forestry):

S.No	Particulars	Masters Degree
1.	System of curricula delivery	Semester system
2.	Semester duration	110 working days including examination days
3.	Duration of the programme:	4 semesters (2 Academic Years)
4.	Eligibility for admission to the programme	B.Sc.Forestry (four year programme) with 50% marks (Gen. Category)/45% marks (SC/ST)
5.	Mode of Admission	30% seats reserved for candidates qualifying national CET (to be conducted by ICFRE). For other seats (domicile): a. Merit at UG level and b. Any other mode (to be decided by the concerned university)
6.	Degree nomenclature	M.Sc. Forestry (specialization) eg. M.Sc. Forestry (Medicinal & Aromatic Plants.)
7.	Minimum credit load <u>Course Work:</u> Core courses Supplementary courses Specialization courses Dissertation Institutional attachment	 25 (19+6) 08 (4+4) 15 - 20 08 07

8.	Minimum credits (total in all semesters)	63 - 65
9.	Permissible load/semester	16-18
10.	Minimum attendance	80%
11.	Advisory Committee	3 members (minimum) (2 from major area of specialization including Chairman and one from supporting fields)
12.	<u>Mode of Evaluation:</u> A Theory Mid term test (20%) Final End term (80%) Practical, End term (100%) B. Dissertation Evaluation Viva-voce C. Industrial attachment (Satisfactory/ Unsatisfactory) ii) Report	Internal External Internal External-1 examiner Internal-Advisory Committee and Deans' nominee (Satisfactory/Unsatisfactory) From industry/organization/institute To be evaluated by Chairman Advisory Committee (Satisfactory/Unsatisfactory)
13.	<u>Grading System</u> Scale Minimum Pass in a course Minimum OGPA to obtain degree First class	10 points scale 5.00 5.50 >6.0 (optional)

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COURSE CONTENTS

A. CORE COURSES

I. ADVANCED SILVICULTURE (2+0)

Forest ecosystem concept, stand dynamics-forest succession, competition and tolerance, classification of World's forest vegetation. Productivity and vegetation forms of India, forest composition and structure. Ecophysiology of tree growth, effect of radiation, water relationship, mineral nutrients and temperature. Natural regeneration of species and types including unevenaged silviculture. Intermediate treatments. Intensive studies pertaining to important commercial species. Advanced and modern nursery tools & techniques.

II. FOREST BIOMETRY (2+0)

Measurement of trees and stand, diameter (crop), girth, height, volume, form, bark thickness, crown width and crown length, determination of age and volume of felled as well as standing trees. Volume, yield and stand tables. Increment, forest inventory and sampling procedures. Growth and yield of standard density measures. Canopy density and its importance. Simulation techniques, growth and yield models and their applications. Modern tools of GPS etc. for measurements.

III ADVANCED FOREST MANAGEMENT (2+0)

Principles of forest management; scope and object of forest management, ecosystem management, development of forest management in India. Site quality evaluation and importance. Stand density, classical approaches to yield regulation in forest management, salient features and strategies, forest valuation and appraisal in regulated forests. Maximising present net value and benefits.

IV WOOD BASED INDUSTRIES (2+0)

Introduction, scope and importance of wood based industries in relation to Indian economy; brief description of types of wood based industries in India; pulp and paper industry – types of paper and raw material; pulp-mechanical, chemical and semi-chemical; beating, bleaching, sizing and sheet formation; description about rayon and other cellulose derived products; composite wood-plywood, laminated wood, core board, sand witch board, particle board and their manufacturing processes, properties and uses; principles of destructive distillation of hardwood and softwood; preparation of wood alcohol, acetic acid, acetone, charcoal and allied chemicals; scarification of wood-chemistry and processes; production of wood molasses, alcohol yeast and other by products from wood hydrolysis, wood substitution. Manufacture of Katha and cutch, visit to nearby wood based industries.

V REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM (1+1)

The use of aerial photography, satellite imagery and geographic information system for the collection, storage and spatial analysis for geo-referenced forest resources data and information. Acquisition and interpretation of satellite data for forestry purpose. The integration of spatial data analysis systems with knowledge-based systems and/or simulation systems for the development of information/decision support systems for forest management; satellite systems; satellite imageries – techniques, uses and limitation; future prospects of remote sensing in India; softwares used in remote sensing ; GIS versus remote sensing.

Practical: Uses of various photogrammetry instruments; recognition and identification of objects on photography; compilation of maps and their interpretation. Hands on practice on remote sensing and GIS, software. Digital and visual interpretation of satellite image.

VI ADVANCED FOREST ECOLOGY (1+1)

Advanced topics in forest ecology; including; forest population, forest community dynamics, forest community structure and analysis, forest productivity on a global scale, ecology of forest landscapes spatial heterogeneity; and hierarchy issues in ecology.

Practical: Study of forest community structure and its successional status; estimation of productivity of forest ecosystem; trip to different regions of the state to study forest vegetation; collection and preservation of specimen.

VII FOREST RESOURCE MANAGEMENT AND ECONOMICS (2+1)

Application of microeconomics in solving forest resource problems. Emphasis on forest products demand and supply analysis, forest products marketing, forest capital theory, and inter-regional and international trade in forest products. Impact of economics and physical variables upon forest appraisal and management decision. Valuation of non-market goods and economics of multiple-use, Ecosystem Analysis and Modelling. Forest certification, eco-development planning, Sustainability Analysis, SWOT Analysis. Application of operations research tools in evaluating forest management alternatives in public and private forest planning.

Practical: Exercises on estimation of demand and supply functions; biodiversity valuation, valuation of non-marketed forestry products. Exercises on financial and economic appraisal of forestry projects. Numerical exercises on marketing of forest products and international trade competitiveness. Computer applications for using programming techniques in evaluating forest management alternatives. EIA study of a project.

VIII FOREST POLICY AND LEGISLATION

(2+0)

Forest policy – Relevance and scope; National Forest Policy – 1894, 1952 and 1988; General principles of criminal law; Indian Penal Code, criminal procedure code; Indian evidence act applied to forestry matters; Forest laws; Indian Forest Act – 1927, general provision and detailed study; Forest Conservation Act 1980, Wildlife Protection Act 1972 Important Forest Rules and Guidelines, Important case studies and landmark judgments.

IX FOREST BIODIVERSITY CONSERVATION

(1+1)

Concept of biodiversity, Biodiversity zones species richness and endemism, state of biodiversity in India. Conservation of natural resources (hotspot areas, wildlife sanctuaries, national parks, biosphere reserves). Global warming and forests. Green House Effect and its consequences. Ozone depletion. Conservation laws and acts. Forest genetics resources of India: timber and non timber species. Survey-exploration and sampling strategies. Documentation and evaluation of forests genetical resources (FGR), Conservation, *in situ* and *ex situ* of gene resources. Biological diversity and its significance to sustainable use. Handling and storage of FGR. Intellectual property rights. Quarantine laws and FGR exchange.

Practical: Methods of vegetation analysis. Measurement of biomass and productivity. Quantification of litter production and decomposition. Visit to national parks, wildlife sanctuaries, botanical gardens and arboreta.

X CHEMISTRY OF FOREST PRODUCTS

(2+0)

Different chemical constituents of wood. Cell wall constituents. Chemistry of cellulose and its comparison with starch. Chemistry of hemicellulose and lignin. Extraneous components of wood-organic solvent soluble and water soluble. Volatile oils, Resin and its components. Gums. Tannins and phenolic substances. Chemistry of catechin. Bark and its components. Important natural pigments.

XI FOREST PROTECTION

(2+1)

Important diseases and insect pests of nurseries, farm forestry, plantations, avenue trees and their management. Assessment of losses due to diseases, insect pests, vertebrate pests, adverse weather, forest fires and weeds. Insect pests and mycoflora of seeds of forest trees and their management. Biodegradation of wood – microscopic and chemical effects of white rot, brown rot, soft rot and wood discoloration Heart rots – factors affecting heart rots, damage caused, compartmentalization of decay in trees and management of heart rots. Role of mycorrhiza in tree health. Theories of natural regulation of insect populations. Wildlife damage in nurseries, plantations and their management. Weed problems in nurseries, plantations and their control. Adverse climatic factors, acid rains and air

pollutants in relation to forest tree health. Biological control of insect pests and diseases of forest trees. Molecular tools for developing disease resistance in trees.

Practical:Collection, identification and preservation of important insect pests and disease specimens of forest plants Detection of insect infestation and seed borne mycoflora. Assessment of losses due to diseases, insect pests etc.Habitat management of vertebrate pests. Laboratory tests for estimating decay resistance in wood. Fire control methods and devices. Familiarization with the meteorological and plant protection equipment. Application of pesticides and bio-control agents in the management of insect pests,weeds, diseases in nurseries and plantations.Extraction of spores of arguscular mycorrhizal (AM) fungi from soil and assessment of mycorrhizal root infection.

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B. SUPPORTING COURSES

I. COMPUTER APPLICATION AND INFORMATION TECHNOLOGY

(0+2)

Working with MS-DOS. Database design. Data entry operation. Word processing: MS Office. Database management programme. Use of electronic spread sheet and graphics. Use of SPSS statistical application packages.

Features of Information Technology: Introduction to Information Technology - Basis of computer networking - LAN, WAN - BUS- Tokening- star-internet, intranet - Basics of E-mail - Exposure to web browsing(structure of URL), Types of web sites - internet service provider - using internet news - scope of IT in forestry.

II. RESEARCH METHODOLOGY

(1+1)

Selection of research problems considering National Forestry Policy - Writing project proposal, Generation of research questions, Stating objectives of research study, Proposing hypotheses, Planning for literature survey, Use of computer based literature, Planning for field work, Sampling and Enumeration exercises in the field and recording of the data and use of statistical tools. Interpretation of data and deriving inference and conclusions, Preparation of thesis/dissertation/research project report, Writing of scientific articles and technical bulletin, Monitoring and evaluation methods.

Practical: Laying out of designs in the field (i) Fan design, (ii) Latin Square, (iii) Randomized block design, (iv) Split plot design, (v) Row-Column designs and (vi) Scattered block. Data analysis of the above designs.

III. GENERAL STATISTICAL METHODS

(3+1)

(Prerequisite: Basic course at Statistics at UG Level)

Introductory : Statistics Scales of measurement, concept of graphical, exploratory and inferential data analysis, important variables of forestry sector

Probability and probability distributions: Review of probability theory, concept of random variable and expectation, probability distributions (Binomial, Poisson, Normal, Weibull) **Correlation and regression:** Simple, Rank, Partial, Multiple, Intra-class correlations, Furnival Index and coefficient of determination. Linear and non-linear regressions, parabolic, exponential, power and logarithmic functions

Estimation and Testing of Hypotheses Concept of point and interval estimation, estimators and estimates, properties of good estimators - unbiasedness and minimum variance, tests of significance - t, F, z, and χ^2 , testing significance of correlation and regression coefficients, analysis of variance (ANOVA) - one way and two way classification with single and more than one cell frequency.

Design of Experiments Principles of experimental designs, Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD), Row-Column (alpha) designs, Split Plot and Strip Plot Designs.

Sampling - Theory and applications Why sample? Simple Random Sampling (with and without replacement), Stratified Random Sampling, Double sampling, Multistage sampling, Cluster sampling

Multivariate statistical techniques Multivariate Analysis of Variance, Principal Component Analysis, Factor Analysis, Cluster Analysis

Practicals: Fitting of probability distributions, Computation of correlations and regressions, Tests of significance - t, F, z and χ^2 , Exposure to statistical packages SPSS and GENSTAT for ANOVA, multivariate analysis

C. SPECIALIZATON COURSES

1. WOOD SCIENCE AND TECHNOLOGY

I. Wood identification (0+2)

Planes of wood, physical characteristics of important woods. Identification of different types of cells and tissues. Anatomical studies of reaction wood. Classification of timber using dichotomous and perforated card keys. Modern timber identification techniques.

II. Wood Chemistry (1+1)

Chemical composition of wood : cell wall constituents-cellulose, lignin, hemicelluloses, pectic substance etc., cell contents-volatile and extractives. Cellulose derivatives and their applications, Hydrolysis and fermentation of lignocellulosic material. Pyrolysis and gasification of wood.

Practical: Extraction of cellulose, hemicellulose, lignin, extractives and ash content of wood.

III. General Properties of Wood (1+1)

Wood density, thermal, electrical and acoustic of wood. Mechanics and Rheology of wood: elasticity, plasticity and creep (tensile, compression and bending strengths) Toughness, torsion, shear, hardness and abrasion strengths. Acoustic and acousto-ultrasonics based non-destructive evaluation techniques. Factors affecting strength properties of wood .

Practical: Determination of wood density. Study of thermal, electrical and acoustic properties of wood. Determination of strength properties of wood (compression, tensile and bending).

IV. Wood Working and Log Grading (1+1)

Grading of logs and sawn timber, sawing techniques, technology of timber joinery: joints, metal fasteners, screw and nail holding. Planning moulding, shaping, turning, tenoning, mortising, boring and sanding of wood. Bending of solid wood. Wood finishing.

Practical: Sawing of wood, making of joints, use of fasteners. Planning, moulding shaping , turning, tenoning, mortising, boring and bending of wood specimens. Fabrication of wooden articles. Sanding and wood polishing.

V. Seasoning and Preservation

(2+1)

Wood water relationship, sorption behavior and wood drying. Wood seasoning; different types of seasoning methods- air drying, kiln seasoning and special seasoning methods like steaming, chemical seasoning , high temperature drying, solvent seasoning vacuum drying, water conditioning. Types of defects, Natural, Seasoning defects, defects due to external agencies, machining defects, effects of defects on utilization and other factors e.g. strength. Draw backs of unseasoned wood . Detection and diagnosis of wood stain and decay. Effect of discolouration and decay on wood characters. Evaluation of decay resistance to microbes and insects. Important fungi, beetles weevils, wood boring wasps, marine wood borers and termites in wood decay. Chemistry of wood decay. Decay wood in service and storage. Decay of improved and composite woods. Wood preservation: preservatives and treatment processes. Advantages and safety concerns of wood preservatives. Refractory and non-refractory behaviour of wood.

Practical: Moisture content determination of wood samples. Comparative studies on kiln and air dried wood, swelling coefficients of different wood. Collection and preservation of important fungal species and insects pests attacking wood. Analysis of decaying wood for physical and chemical parameters. Treatment of woods with different types of preservatives.

VI. Composite Wood

(1+1)

Modern trends in composite wood industry. Wood adhesives-types, characteristics and application. Plywood, laminated and inorganic wood composites-their manufacture, characteristics and application.

Practical: Preparation of different adhesives and their application. Manufacturing of plywood, wood cement panels and other composite boards.

VII. Pulp and paper technology

(2+1)

Raw material used in pulp and paper industries and its characteristics and handling. Pulping processes -mechanical, chemical, semi-chemical and biopulping. Pulp bleaching; pulp treatment-de-fibering, de-knotting, brown-stock washing, screening cleaning, thickening, etc.; recycled fibers; supplementary pulp treatment and additives. Paper making, paper machining (drying, calendaring, reel, external sizing, coating etc.). Structure of paper, its characterization and measuring method, strength, optional and structural properties of paper. Types of paper, coated paper, corrugated containers. Printing quality of paper, ageing of paper. Rayon industry. Environmental issues-water and air pollution.

Practical: Study of raw materials, techniques and pulp yield. Making of paper and its quality determination. Visit to nearby paper industry.

VIII. Wood Modification

(1+1)

Introduction to wood modification, its need and scope. Chemical modification of wood (acetylation phthalylation; reaction with isocyanates, acetals, ethers, epoxides, etc.) Wood impregnation and compregnation, heat stabilization, wood densification and wood plasticization.

Practical: Study of antishrink efficiency of wood treated with different chemicals. Impregnation of wood with monomers and subsequent polymerization. Compregnation of wood samples.

IX. Wood Based Small Scale Industries

(1+2)

Classification of small -scale wood based industries and their status. Processes involved in match, pencil, furniture, sports goods, charcoal, katha and cutch, rosin and turpentine industries. Bamboo and cane based industries. Economics of setting of small scale industries.

Practical : Preparation of wood for making match boxes, match sticks, pencils, sports goods, etc. Extraction of Katha and cutch form Khair wood samples. Oleoresin tapping and separation of rosin and turpentine. Basket making studies. Visit to nearby industries.

X. Marketing of Wood and Wood Products

(2+1)

Nature and scope of marketing. Approaches to marketing functions. Study of market structure and conduct of wood and wood product markets, marketing channels, costs, margins and price spread for selected wood and wood products. Locations and features of specialized markets, Review of domestic and international trade in timber and non-timber forestry outputs. Demands forecasts -concepts and methods. General introduction to WTO; its functions and decision making prices. IPRs and their implications for forestry and allied sectors in the country.

Practical: Library review of study in marketing and trade of wood and products. Analysis of price and quantity data of wood and wood products for examining trends, seasonal, cyclical, secular variations. Exercise on analysis of demand and supply of wood and wood products. Marketing efficiency. Exercises on marketing channels, cost margins and price spread of important forest products like katha, resin, paper, plywood ,medicinal plants etc. Visit to marketing institutions and forest industries.

XI Management of Timber log yard

Layout comprising space of logs unloading, log stacks, movement of mechanical log loader/ stacker and transport of logs to saw mill. Choice of suitable loader/ stacker. Alternative material loading/ unloading arrangements under Indian conditions.

Measures of yards hygiene, Spraying of Prophylactic preservatives and end coating of logs for protection of logs against bio-degradation and end splitting.

Hoppus and true volume measurement of logs.

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2. MEDICINAL AND AROMATIC PLANT

I. Basics of plant production (2+0)

Modes and methods of plant propagation. Factors influencing growth, nutrient uptake and assimilation, role of climatic and edaphic factors, micro and macro nutrients. Nursery technology, field layout and preparation, plant protection measures. Harvesting and post harvest handling.

II. Principles of breeding of medicinal herbs (2+0)

Role of genetics and related sciences in breeding of medicinal herbs. Breeding methods in relation to mode of reproduction, Methods of breeding self & cross pollinating and asexually propagating medicinal herbs. Heterosis, sterility and self incompatibility in herbs. Mutation and polyploidy breeding. Wide hybridization. Production and maintenance of pure seed. Systems followed in the release of plant varieties.

III. Medicinal Chemistry (2+0)

Organic compounds and their classification –aliphatic, aromatic and heterocyclic compounds; alkaloids; steroids; terpenoids, phenolic compounds; glycosides; carbohydrates. Primary and secondary plant metabolites. Plant sources and therapeutical uses of important phytoconstituents belonging to the categories of gums, anthraquinone glycosides, steroidal and triterpenoidal glycosides, tannins and phenolic compounds, lipids, alkaloids, terpenoids, etc. Basic principles of extracting different phytoconstituents.

IV. Improvement of medicinal and aromatic plants (1+2)

Plant genetic resources- general perspective. Ecology and biology of plant resources of medicinal value. Medicinal and aromatic plant diversity in the Indian gene center. Plant exploration , introduction & exchange. Conservation of medicinal and aromatic plants; its techniques, in-situ, ex-situ & biotechnological. Evaluation and breeding techniques of important medicinal and aromatic plants-*Picrorhiza kurrooa*, *Swertia chirayita*, *Valeriana jatamansi*, *Viola spp.*, *Gloriosa superba*, *Rauwolfia serpentina*, *Plantago ovata*, *Cassia angustifolia*, *Ocimum sanctum*, *Withania somnifera*. DUS (Distinctiveness, uniformity, stability) testing . Drug Descriptors for medicinal and aromatic plants.

Practical: Identification based on morphological features, pollen viability and germination, stigma receptivity. Field practice in emasculation, crossing and selfing in *Hypericum perforatum*, *Valeriana jatamansi*, *Matricaria chamomilla*, *Solanum spp.*, *Ocimum spp.*, *Gloriosa superba* ,*Mucuna spp.*, *Gentiana kurroo* and other species relevant to the region. Germplasm collection techniques. Determination of mode of reproduction. Breeding for meeting DUC criteria.

V. Cultivation of commercially important medicinal and aromatic plants (1+2)

Importance and need of cultivation of medicinal and aromatic plants. Origin, distribution, morphological features, climatic and soil requirements, propagation and nursery techniques, transplanting and after care, nutritional and water requirements, plant protection, harvesting and post harvest processing, active constituents and uses of important medicinal and aromatic plants : *Picrorhiza kurrooa*, *Saussurea costus*, *Aconitum heterophyllum*, *Podophyllum hexandurum*, *Swertia chirayita*, *Valeriana jatamansi*, *Viola serpens*, *Asparagus racemosus*, *Chlorophytum borivillianum*, *Stevia rebaudiana*, *Aloe vera*, *Echinacea spp.*, *Withania somnifera*, *Solanum nigrum*, *Cassia angustifolia*, *Andrographis paniculata*, *Pelargonium graveolens*, *Rosa damacena*, *Tagetes minuta*, *Matricaria chamomilla* or any other species specific to the region. crop geometry and crop management (seasonal, biennial and perennial crops), Organic cultivation of medicinal and aromatic herbs. Good agricultural practices (GAP) in medicinal plants. Precision farming.

Practical: Preparation and layout of nursery and field beds/plots. Methods of seed sowing. Preparation of shoot and root cuttings. Transplantation of seedling and rooted cuttings irrigation techniques. Hoeing and weeding, weed identification and their control. Harvesting, cleaning, drying and grading of crop produce. Demonstration of different storage methods. Essential oil distillation. Raising and harvesting of at least one crop grown in the area.

VI. Basic laboratory techniques (0+1)

Precautions commonly followed in the laboratory. Commonly used laboratory solvents, equipments and processes-distillation, filtration, crystallization, soxhlet extraction, etc. Different types of chromatographic techniques and their applications. Microscopy, microtomy and microphotography. Familiarization with spectroscopical tools.

VII. Processing of medicinal and aromatic plants (1+2)

Harvesting, drying, grading and storage of medicinal plants. Post harvest handling of aromatic plants. Different methods of essential oil extraction and their drying and storage. Active content dynamics vis-à-vis plant growth and post harvest processing for evaluation of chemical constituents.

Practical: Use of thin layer chromatography during extraction and purification of phyto-pharmaceuticals. Preparation of active constituent enriched extracts. Separation and purification of phytopharmaceuticals through conventional and column chromatographic techniques. Extraction of essential oils and their evaluation for quality parameters. Preparation of concretes and absolutes from plants containing essentials oils.

VIII. Plant classification and identification

(0+1)

Concept of taxonomy, keys and classification based on botanical features and official parts. Study of plant parts (microscopic and macroscopic) based on morphological features. Botanical description of selected types (Macroscopic and microscopic characteristics). Economic classification of medicinal & Aromatic plants. Preparation of herbaria and useful herbarium notes concerning individual plant species.

Practical: Field surveys for familiarization with local plants. Collection of specimens, description based on field characters, identification and classification, preparation of herbarium specimens and visit to local herbarium and museum.

IX. Pharmacognosy of Medicinal and Aromatic plants

(1+1)

History and scope of pharmacognosy. Pharmaceutical products. Classification of natural drugs. Chemical nature of drugs. Pharmacognostic analysis of drug plants based on botanical, chemical and histological features. Evaluation based on pharmacopoeial standards for both single drugs and compound formulations most commonly used in different systems of medicines. Pharmacognostic features of Sarpagandha, Jatamansi, Ashwagandha, Turmeric, Punarnava, Ephedra, Gymnema, Senna, Amla, Gokhru, Isabgol, Black pepper, Banafsha, Arjun or any other commercially species specific to the region.

Practical: Identification of drugs by morphological characters. Physical and chemical tests for evaluation of drugs. Gross anatomical studies of Ginger, Ashwagandha, Senna, Gentiana, Kalmegh, Sarpagandha, Mulhathi, Aconitum species or any other important species relevant to the region.

X. Biotechnological approaches in Medicinal & Aromatic Plants (1+1)

Historical backgrounds and scope of biotechnology in Medicinal and Aromatic Plants. Tissue culture techniques and its use. In -vitro propagation of *Atropa belladonna*, *Bergenia ciliata*, *Carum carvi*, *Catharanthus roseus*, *Glycyrrhiza glabra*, *Hyocyanus niger*, *Rauwolfia serpentina*, *Santalum album*, *Stevia rebaudiana* and *Swertia chirayita*, Molecular characterization by RAPD, RFLP etc. Biotransformation. Transgenic plants. Application of tissue culture in plant improvement.

Practical: Equipments used in tissue culture. Exercises on micropropagation of important medicinal plants. Preparation of stock -solutions, culture mediums, etc.

XI. Role of Medicinal and Aromatic Plants in Health Care systems

(1+0)

Concept of Health Care systems. Brief introduction to Ayurveda, Unani, Sidha, Homeopathy, allopathy, naturopathy, electrohomoeopathy, etc. Important medicinal plants used in treating various diseases in modern and complementary

systems. Biological activity of selected medicinal plants. Methods of preparing poultices, decoctions, powders, tinctures, active content rich extracts, etc.

XII. Trade and IPR in Medicinal & Aromatic plants (1+0)

Domestic and international trade in herbs and herbal products. Trade restrictions-regional, national and international. The concept of WTO, CITES etc., Concept of intellectual property rights(IPR). Plant varieties, Breeders and Farmers Rights Act. National Biodiversity Act. Indian patent laws and their implications. Functioning of the National and International Patent officer. Patents granted-nationally and Internationally to herbal products/formulations.

XIII Integrated disease and pest management in medicinal and aromatic crops (1+1)

Introduction to principles of integrated plant disease management in medicinal and aromatic crops. Economic threshold. Relationship of meteorological factors with disease development. Plant quarantine, eradication, protection and disease resistant strategies against important diseases. Biological and biotechnological approaches in disease management.

Scope and importance of integrated pest management (IPM). Tools of pest management, their description and usage in IPM programmes. Concepts of pest populations and population monitoring. Insects pests of important medicinal and aromatic crops, their biology, nature, extent of damage and their management.

Practical: Laboratory evaluation of botanicals, fungicides and biocontrol agents against plant pathogens. Hot water treatment and soil solarization. Fungicide and biocontrol application methods against seed, soil and foliar diseases. Collection, preservation and identification of development stages of insects pests of important medicinal and aromatic crops. Sampling of pest population and assessment of damage. Acquaintance with natural enemies of insects. Implementation of pest management programmes against pests of economic importance.

XIV. Study tour (Visit to Pharmaceutical and processing Units) (0+1)

Visit to government and private Pharmaceutical Units/Institutes in adjoining areas. Visit to large scale herb growing and processing units engaged in commercial cultivation and preparation of purified photochemical/standardized extracts. Visit to nearby marketing/trade centers.

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3. PLANTATION TECHNOLOGY

I. Seed Collection, Storage and Testing

(2+1)

Introduction, trends and development in tropical, sub-tropical and temperate forestry and their influence on seed demand. Seed problems –limiting factors in tree propagation and afforestation. Flowering and seed production in gymnosperms and angiosperms. Development and maturation of seed/fruit. Modes of seed dispersal. Determining optimal harvest maturity indices. Factors influencing choice of collection methods. Methods of seed collection and processing, Stage methods and seed testing techniques. Seed certification.

Eco-physiological role of seed storage. Classification of seed storage potential. Factors affecting seed longevity. Pre-storage treatment. Physiological change during ageing. Viability and vigor. Storage of orthodox, recalcitrant and pre-storage intermediate seeds. Fumigation and seed treatment.

Practical: Identification of forest seeds. Seed sampling, different storage methods. Seed quality testing –purity, viability and germination, collection and processing of seeds/fruits. Tests of viability viz., cutting, hydrogen peroxide, excised tetrozolium, embryo, seed health testing primarily to the presence or absence of disease-caused organisms such as fungi, bacteria, virus and animal pests, Recording, calculation and use of results.

II. Modern Nursery Production

(1+1)

Introduction and importance of nursery. Types of nurseries. Bare root, containerized and vegetatively produced nursery. Bare root nursery –nursery soil and water management, bed preparation, pre sowing seed treatments, seed sowing and intermediate operations viz., pricking, watering, fertilization, weeding and hoeing. Physiology and nursery environment interaction affecting seedling growth. Root culturing techniques. Lifting windows, grading, packaging and storing and out –planting. Containerized nursery –type and size of container including root trainers, selection of growing medium. Types of green house and mist propagation. Vegetative propagation –selection of superior phenotype, methods of propagation viz. cutting, budding, grafting and layering. Factors affecting rooting of cuttings.

Practical: Introduction and identification of modern equipments and tools used in nursery. Pre-sowing seed treatments. Preparation of nursery beds and growing media for containerized nursery. Sowing of seed and other intermediate nursery management operations. Preparation and planting of cuttings. Use of vegetative propagation methods such as budding, grafting and layering. Maintenance of nursery records. Identification of nursery insects and diseases and their control measures. Visit to nurseries.

III. Vegetative propagation technique (1+1)

Introduction and importance of propagation. Structures, media fertilizers, sanitation and containers, source selection and management in vegetative propagation, Techniques of propagation by cutting, grafting, budding and layering and its natural modification. Propagation of selected plants and rootstock for the important wild fruit species. Bud orchards.

Practical: Techniques of propagation by cutting, grafting, budding and layering. Precautions required in vegetative propagation. Use of plant bio-regulators for rooting. Handling of field propagated cuttings.

IV Nutrient Management (1+1)

History of nutrient management in forest nurseries and plantation. Essential nutrient elements and their deficiency. Mechanism of nutrient uptake by plants, functions and translocation/Interactions. Concept of nutrient availability. Climatic and soil conditions promoting micronutrient deficiencies in plants. Occurrence and treatment of micronutrient disorders. Evaluation of soil for the supply of micronutrient. Rare and non-essential elements. Technology and use of complex liquid and suspension fertilizers. Fertilizer use efficiency factors. Biological nitrogen fixation and bio-fertilizers. Farm yard manure and other organic fertilizers. Mycorrhizal associations and their significance. Economic implications of nutrient management. Importance of renewable waste and their recycling.

Practical: Principles and methods of soil and plant analysis. Preparation of nutrient solutions. Practical application of fertilizers. Study of fertilizer response and diagnosis of deficiency symptoms. Fertilizer testing and pot experiments. Nursery inoculation techniques of bio-fertilizers. Methods of application of formulated products-seed treatment, root dip, suckers treatment, soil application, foliar application and combination of different methods.

V. Weed management in Nursery & Plantations (1+1)

Problems and losses caused by weed flora (summer and winter) of India. Principles of weed control. Methods of weed control-cultural, biological, mechanical and chemical. Herbicide/weedicide classification, properties and their application. Mode of action of herbicides/weedicides. Equipments used in applying herbicides/weedicides.

Practical: Survey for identification of weeds in forest nurseries and plantations. Economic evaluation of weed control methods in nursery and plantations. Calculation of spray volume and herbicide concentration. Preparation of weed herbarium.

VI. Management of Insect-Pests and Diseases

(2+1)

Insect pests responsible for damaging nursery stock and forest plantation . Principles and methods of integrated pests management –physical, cultural, chemical and biological methods. Use of attractants and repellants. Male sterility techniques. Diseases of forest nurseries and plantations. Abiotic and biotic agents of tree diseases and their relationship with hosts. Methods of diseases control – exclusion, cultural, biological and chemical. Rodents, birds, squirrels, herbivores. Forest plant quarantine.

Practical: Collection and identification of insects and non-insects. Inspection and collection of damaged material showing insect damage. Identification and use of plant protection equipments. Preparation of different concentrations of pesticides and their use. Identification of important diseases in forest nurseries and plantations. Preparation of fungicidal concentrations and their use in controlling nursery and plantation diseases.

VII. Energy plantations and bio-fuels

(2+1)

Introduction and advantages of energy plantations Energy and biomass consumption patterns in India. Environment impacts of biomass energy. Assessment of bio-energy programmes in India. Power generation from energy plantation. Producer gas. High Density Energy plantations (HDEP). Land and biomass availability for sustainable bio energy. Impact of energy efficiency in power sector. Need for research and development on environment friendly and socio-economically relevant technologies. Energy from plants –problems and prospects. Petro-crops. Criteria for evaluation of different species for energy plantation. Network of NGOs in renewable energy use. Recent energy technologies in the production of bio-fuels.

Practical: Identification of important fuel woods and petro-crops. Study on different bio-fuels used in India. Determination of calorific value, moisture and ash content in biomass. Study of energy consumption pattern in rural and urban areas through survey. Visit to nearby units.

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4. WATERSHED MANAGEMENT

I. Watershed Concepts, project formulation and Planning (2+1)

Historical background, Multiple use concept, Watershed characteristics, Employment and Income generation, Sustainability and Equity Issues. Formulation of watershed projects (micro and macro watershed). Components of natural resources for watershed management. Preparation techniques for micro plan of watershed. Impact assessment techniques for upliftment of socio-economic status and environment. Valuing Inputs and Outputs Introduction – Approach, Using Market Prices in the Financial Analysis, Estimating Future Prices – Treatment of Inflation, Estimating Relative Price Changes. The big project effect, appropriate economic value measure for different types of inputs and outputs. Identifying and valuing remedial measures to maximize benefits of investment. Comparing costs and benefits- introduction, constructing value flow tables, discounting benefits and costs. Net present value (NPV), internal rate return (IRR), relationships between NPV and IRR. Sensitivity analysis – introduction, purpose, guidelines, sources and techniques of sensitivity analysis.

Practical: Survey of watershed, preparation of micro-plan and planning of watershed for effective implementation. Exercises on economic profitability of various land-based enterprises bases in cost and revenue concepts.

II. Applications of Remote Sensing and GIS in watershed management (1+1)

Basic concepts of Remote sensing and geographic information systems (GIS), Determination of geo-morphological, physiological, vegetation, soil, land use, parameters of a watershed. Spatial and non-spatial data analysis. Preparation of thematic layers and their digitization.

Practical: Thematic layers build up, overlaying and their integration using ERDAS and ARC/INFO software package. Interpretation of satellite data and digital image processing. Preparation of thematic maps.

III. Watershed survey, mapping and structural engineering designs (1+1)

Compass, Surveying, plane table surveying, leveling, preparation of contour maps of watershed. Terraces and bunds- types, design. Soil and water conservation and water harvesting structures – types, design. Sedimentation- sources, estimation of sediment bank treatment techniques.

Practical: Preparation of contour maps, estimation of earth work, design of check dams, acquaintance with water lifting devices, use of measurement, conveyance and control structures.

IV. Watershed hydrology and resources conservation (2+1)

Hydrological cycle and characteristics of small and medium watersheds-precipitation, infiltration, run-off (run-off hydrographs) total and peak, soil moisture, hydrograph, ground water and evapo-transpiration. Resources inventory-soil, land, water and Niota. Soil survey and land use planning –soil types, fertility, productivity, erosion and conservation practices. Water resource development, water availability, pressurized irrigation crop water requirements and water use efficiency. Biota- vegetation types, distribution and utilization. Wildlife –role and conservation.

Practical: Rain water budgeting – run off and soil loss , infiltration, soil moisture, deep percolation and ground water change, rainfall measurements hydrograph.

V. Watershed production system-I (Fruit & Other Crops) (1+1)

Importance of commercial fruits grown in watershed areas. Export of important fruits of Pome (apple, pear), stone fruits (peach, plum, apricot, almond and cherry), nuts (walnut, pecan) tropical and sub-tropical fruits (mango, citrus litchi, guava, ber, sapota, banana, grapes, dates, pineapple). Study of pomological charioteers of important commercial species varieties and rootstocks. Detailed cultural practices, orchards soil management, manuring, irrigation, weed control, training and pruning. Harvesting, grading and packaging . Special production problems. Methods of plant protection. Principles of multiple cropping, concept, definitions and essentials of crop rotation . cultivation practices for important crops rotation. Cultivation practices for important crops – wheat, maize, rice, cotton, sugarcane, pulses, oil seeds and fodder.

Practical: Identification of important varieties , species and rootstock, Physico-chemical analysis of fruits. Important cultural practices relation to commercial fruits. Visit to orchards. Identification of crop plants, seeds weeds. Acquaintance with crop production practices, herbicides, their application and equipment.

VI. Watershed Production System -II (Vegetables and medicinal Plants) (1+1)

Area, production, economic importance and export potentials of tropical and subtropical vegetable and tuber crops, description of varieties and hybrids, climate and soil requirements, seasons, seed rate, preparation of field, nursery practices and transplanting for transplanted vegetable corps, planting for directly sown/planted vegetable crops, spacing, planting system, water and weed management, nutrient deficiencies, use of chemicals and growth regulators, cropping systems, harvest, yield and seed production, organic farming.

Importance of cultivation of medicinal and aromatic plants. Choice of medicinal and aromatic species for different watershed areas, their utility and cultural practices. Agro technology of *Valeriana jatamansi*, *Podophyllum hexandrum*, *Dioscorea*

deltoidea, Asparagus species, Cymbopogon sp., Viola, Acorus calamus, Centella asiatica, Bacopa monnieri, Mentha soecies, Rauwolfia serpentina, vetiver and suitable local species of medicine importance.

Practical: Identification and description of tropical and subtropical vegetable and tuber crops, nursery practices and transplanting for transplanted vegetable crops, preparation of field and sowing/planting for direct sown/planted vegetable crops, herbicide use in vegetable culture, top dressing of fertilizers and inter-culture, use of growth regulators, identification of nutrient deficiencies, physiological disorders, harvest indices and maturity standards, post harvest handling and storage, seed extraction, working out cost of cultivation for vegetable and tuber crops, project preparation for commercial cultivation.

Visit to nearby watershed areas; collection and identification of medicinal and aromatic plants in that area. Selection of nursery site, preparation of nursery beds and nursery raising. Field planting techniques. Cultivation, harvesting and processing of at least one medicinal or aromatic crop.

VII. Afforestation and Agroforestry in watershed areas (1+1)

Afforestation, Reforestation: - constraints, scope and basic principles. Techniques of afforestation; soil working techniques, selection of species, stock quality, weeding, pruning, lopping, manures and fertilizers. Growth measurements and harvesting. Multipurpose trees, Their characteristics and management practices for fuel, fodder, fibre, fruits and timber production. Agroforestry- Definition, its role in water development. Diagnosis and design, Agroforestry models for different land types- arable, pastures and wastelands. Alley cropping, silvi-pastoral system, high density short rotation plantations/ energy plantation. Agri-horticulture and horti-silvi-medicinal systems. Environmental benefits of afforestation, reforestation and agroforestry.

Practical: Preparation of site for planting, planting layout pattern. Layout of different soil working techniques for hill slopes. Preparation of suitable plantation models for farmlands and catchments areas, Visit to different watershed and prepare watershed plans for plantation.

VIII. People's participants in watershed management. (1+1)

Participation -meaning scope, objectives, principles and historical perspective. People's participants- case studies on successes and failures. Participatory research approaches- AR, PAR, PR, PLA. Participatory planning, implementation, monitoring and evaluation.

Practical: Case studies and their analysis. Visit to selected watersheds for understanding concepts of people's participation . Application of participatory research approaches - review and analysis of selected cases. Application of

participatory techniques in programme cycle, viz., resources inventory, analysis of production problems, need assessment, prioritization of need, planning, implementation, monitoring and evaluation.

IX. Social organization/institutions and Impact analysis (1+1)

Social organizations – definition, principles advantages, types and formation processes. Community mobilization. Psychodynamics of group processes – social values, trust, and confidence, cohesiveness, self disclosure, openness and honesty, decision making, leadership, conflict management and group strategies. People’s movements for social change. Women’s empowerment and mobilization for watershed management. Gender analysis framework. Concept, documentation and application of ITK. Adoption process.

Practical: Study of social organization and their formation processes. Community mobilization for watershed management. Application of Gender Analysis in watershed management. Documentation and use of ITK. Identification of adaptors categories and factors influencing adoption process.

X. Watershed bio-diversity and livestock management (1+1)

Concepts of biodiversity in watershed, threat biodiversity. Biodiversity conservation –In-situ conservation and Ex-situ conservation. In-situ conservation ; Natural preservation, standard stand. Ex-situ conservation – clone banks/ seedling bank, breeding seed orchard, botanical garden, seed banks, pollen banks in vitro conservation. Tree spp. For watershed. Identification of tree, shrub and grass for watershed areas. Production and management of important fodder spp. Importance of livestock in improving the economy of farmers. Management of livestock-breeding feeding , weeding. Fodder and feed requirement, calendar to produce green fodder round the year and its preservation. Optimization of animal production. Animal product technology and marketing. Prevention and control common disease of animals/livestocks.

Practical: Visit to different watershed area. Identification of tree spp. grasses, shrub. Establishment of vegetative barrier in watershed area. Management of tree, shrubs and grasses in watershed areas. Identification of important breed of cattle. Identification of various tools used in livestock management. Preparation and marketing of milk products.

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5. ECO-TOURISM

I. Ecotourism- concepts and approaches (2+1)

Eco tourism - study history of tourism- identify various forms of tourism and evolution of ecotourism. Understand dimensions of tourism and essential conditions for tourism to occur. Differences between tourism components. Mass tourism versus ecotourism. Organized tours and Free Independent Travelers. World Tourism Organization. Problems with definition of ecotourism and criticisms. Understand dimensions of ecotourism and the criteria to qualify for ecotourism. Quebec declaration. Different forms of ecotourism like hard and soft ecotourism. Ecotourism indicators and conceptual differences between developing and developed countries. International organizations and NGOs promoting ecotourism. Sociological implications of eco-tourism.

Practicals: Students should make detailed reference on the various forms of Ecotourism in the World- Visit to various ecotourism areas and identify the tourism components- suggest modifications. Students should also undertake some exercises on the blending of local cultural and sociological heritage with the various forms of eco-tourism.

II . Eco systems of the world (2+0)

Major ecosystems of the world-definitions of a typical ecosystems-concepts and approaches of Odum -Arctic tundra eco system, northern and southern hemisphere ecosystems, coniferous forests, temperate ecosystems-savanna -grass land, tropical rain forests, deciduous forest eco systems-coastal systems mangroves etc, important features ,faunal and floral populations Adaptations and modifications-threat to ecosystems-conservation and preservation-new approaches. Influence of anthropogenic factors on the adaptation of different eco-systems. Studies on localized niches of potential tourist spots.

III. Ecotourism in protected areas (2+1)

Protected areas in India - Ecotourism- a worldwide view. Ecotourism in Indian context. Planning ecotourism in protected areas. - Visitor management in ecotourism areas - zoning, carrying capacity. Participation of local people in ecotourism. Conflicts in PA's. Ecotourism for sustainable development of PA's. New directions in ecotourism industry. Ecotourism in practice in important PA's of India - case studies of Periyar Tiger Reserve, Keoladeo National Park, Kanha National Park and Jim Corbet National Park and Sunderbans Tiger Reserve. Limitations and problems of ecotourism. Ecotourism as a way for sustainable management of natural resources. Local livelihoods and eco-tourism like nomadic grazing, agro-pasturatism).

Practical: Visits to surrounding ecotourism destinations- prepare ecotourism activity maps- Preparation of route maps to important National parks and sanctuaries of India- Preparation of information procedure about forest tourist spots in India. Exercises on the preparation of location-specific model eco-tourism plans.

IV. Ecotourism Landscaping (2+1)

Introduction - definition and historical background - Components and elements in landscaping - Principles of landscaping - landscape architecture for ecotourism- Landscape ecology with special reference to ecotourism - walkways-ropeways- turfs, topiaries, live hedges-pergolas, carpets, lawn etc -Urban ecotourism -importance -history of urban planting in India - Planning and planting programmes for institution and industrial complexes - Importance of arboriculture in ecotourism landscaping- Management of trees - planning of roads, bridges, parking area - Planting methods - balanced lines - unbalanced line and sporadic system - formal and informal planting methods.

Practicals: Preparation, planning and designing of recreation parks, thematic parks, practice on topiary, arboriculture, preparation of planting pattern for avenue planting, national highways and village roads.

V. Economics of Ecotourism (2+1)

Ecotourism as a business opportunity- market demand for ecotourism - analysis of ecosystem market demand in India- marketing issues-Investment of international agencies like World Bank in ecotourism projects. Ecotourism economics at macro and micro economic level in developing countries. Ecotourism as a green business and role of green consumerism. Business plans. Identifying unique selling points for marketing. Potential of internet in marketing ecotourism. Economic valuation of ecotourism sites (based on methods like travel cost method). Environmental Impact Assessment. Payments for Environmental services and role of ecotourism. Multiplier effects, opportunity costs and leakage in ecotourism industry. Sharing ecotourism revenues among stakeholders. Training in ecotourism to deliver quality service- Practical exercise on the economic inflow-out flow in the selection ecotourism area- impact on the economic well being of the local population. Potential of eco-tourism in the sustainable management of local livelihood. Impact of eco-tourism on the income of local inhabitants. Feasibility plans for effective eco-tourism. Eco-tourism based capacity building.

Practical: Economic analysis of tourism components- case study of some important ecotourism destinations- analysis of primary and secondary beneficiaries-report preparation. Exercises on feasibility studies, environmental impact assessment and economic valuation of natural resources need to be included.

VI. Design and management of Ecotourism

(2+1)

Ecotourism plans and management of visitors and other resources including human and natural resources. Types of eco-tourists - commercial eco-tourist - nature tour operators - Quality control, codes of conduct etc. Use of GIS and ICT for effectively managing and planning ecotourism. Criteria and indicators for sustainable management and monitoring. Charter for Sustainable Tourism. Sustainability issues in ecotourism management and ecotourism certification- Role of socio-economic factors in decision making. Designing ecotourism products using local technologies. Carrying capacity considerations. Use of GIS in ecotourism design- Existing ecotourism markets and ecotourism market segmentation. Paradigm shifts possible due to climate change and its potential influence of carbon economy on existing ecotourism markets. Role of local institutes and other grass-root agencies in the design and managerial of specific eco-tourism plans. The genders dimensions of designing and management of eco-tourism and management of eco-tourism.

Practical: Mapping of major ecotourism destinations with GIS intervention- Identify one area of ecotourism potential - assess the carrying capacity- design suitable ecotourism activities-

VII. Modern Research approaches on Eco-tourism

(0+2)

The students have to work in groups to reach to a conclusion as to which definition and concept they find most viable. Once they agree on a concept, let them present it and have a debate. Give the students a list of problems that common property resources face and facilitate group discussion such that they can come up with recommendations. Discuss the merits and demerits of the recommendations. Evaluation and monitoring of the various ecotourism activities of the region, such as, Nature Walk - The guided day trek, The Tiger Trail, Border Hiking, Bamboo Rafting, Jungle Patrol, Tribal Heritage, Jungle Inn, The Bamboo Grove, Green Mansions, the backwater cruise. Identify an area where ecotourism in vogue- Identify the various ecosystem activities in the selected area, evaluate in terms of economic feasibility, ecological adaptability and social acceptance. Climate change and its influence on carbon economy. Study the carrying capacity and impact of ecotourism activity on the ecosystem, suggest recommendation to overcome the ill effects of ecotourism. Student should conduct a detailed survey including tourists, ecotourism managers/operators, and submit the final report.

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6. AGRO-FORESTRY

I. Agroforestry Systems (2+1)

Agroforestry objectives, importance, potential and impediments in implementation. Land capability classification and land use. Overview of global agro-forestry systems, shifting cultivation, taungya system, multiple and mixed cropping, alley cropping, shelter-belts and windbreaks, energy plantations and homestead gardens. Concepts of community forestry and social forestry, linear strip plantations. Diagnosis and Design – Trends in Agroforestry systems research and development.

Practical: Survey and analysis of land use systems in the adjoining areas. Design and plan of suitable models for improvement.

II. Soil and water management in Agroforestry (2+1)

Soil and water management –objectives and scope in relation to agro-forestry systems. Soil and water conservation , land classification and carrying capacity. Irrigation potential and methods. Optimization of waters use in agroforestry systems and dry land farming . Interpretation of agro-meteorological data for water management. Problem soils and their management, soil organisms and nitrogen fixation. Biogeochemical cycling of nutrients including organic matter decomposition. Nutrients budgeting and soil productivity under different agro-forestry systems.

Practical: Calculation of water storage and fluxes in the soil. Determination of “in-situ infiltration rate of soils. Measurement and estimation of run-off . Mineral nutrient analysis of soil plants. Study of biogeochemical cycles in agro-forestry systems.

III. Principles of crop Production in Agroforestry (2+1)

Choice of inter-crops for different tree species sowing and planting technique. Planting patterns, crop geometry, nutrient requirements, irrigation scheduling and weed management of field crops cereals, pulses, oilseed, fodders, vegetables, medicinal plants and ornamentals, seed production. Production potentials in multiple cropping in relation to agro climatic conditions. Crop combination, crop combination interactions in crop mixtures. Allelo-pathy. Canopy management & plant protection.

Practical: Management of crop growth rates. Study of crop –weed association and fertilizer response in different crops. Quantitative evaluation of multiple and intercropping systems. Preparation and application of herbicides. Field visits.

IV. Trees and Shrubs for Agroforestry (2+0)

Introduction, importance of woody elements in agro-forestry systems, their role in biomass production. Suitability of species for different purposes. Multipurpose trees in agro-forestry systems. Role of nitrogen fixing trees/ shrubs. Choice of species for various agro climatic zones for the production of timber, fodder, fuel wood, fibre, forage, medicinal and aromatic plants, live hedge, alley cropping, wind breaks and green manuring. Generic and specific characters of trees and shrubs for agro-forestry

V. Management and productivity in Agroforestry systems (2+0)

Classification of agro-forestry systems. Eco-zones and choice of system. System components and their integration. Management of tree plantation thinning, lopping, pruning, etc. Ecological and socioeconomic interactions. Criteria for selection of agro-forestry design. Role of tree architecture and its management on system's productivity. Ecological sustainability. Recent trends in agro-forestry development – technologies and research with special emphasis on space and time considerations and introduction to on –farm trials.

VI. Economics of Agroforestry systems (2+1)

Basic principles of economics applied to agro-forestry. Optimization techniques- Planting , budgeting and functional analysis. Role of time, risk and uncertainty in decision making. Financial and socio-economic analysis of agro-forestry projects. Principles of financial management and harvesting, post harvest handling marketing of agro-forestry products including benefit sharing.

Practical: Exercises on agro-forestry production relationships. Preparation of enterprise, partial and complete budgets. Application of various methods in formulation and appraisal of agro-forestry projects. Case studies on harvesting, post harvest management and marketing of agro-forestry products.

VII. Watershed Management (2+0)

Concept of watershed management. Ideo-types of watershed development plans and activities for the watershed. Criterion for watershed size determination. Characteristics of a watershed and their role in watershed management. Quantification of the benefits and effectiveness of the package of practices adopted for management of watershed. Biological and engineering approach in the management of degraded and denuded habitats as an integrated and multiple approach.

VIII. Range Management

(2+0)

Principles and practices of range land management. Improvement of range productivity by vegetation manipulation through control of undesirable vegetation, burning, fertilization, soil and water conservation and protection. Range improvement and livestock management. Feeding habits and grazing behavior of range livestock. Optimal livestock and range utilization, fodder from trees/shrubs and their nutritive values, propagation techniques, Micro climatic studies, root behavior, crown architecture including methods for minimizing unfavorable interactions. Production potential of different silvi-pasture systems. Species testing. Provenance trials. Seed certification and storage. Elite trees selection.

IX. Fruit crops in Agroforestry

(1+1)

Fruits crops-their need and relevance in agro-forestry. General features of multipurpose fruits species. Fruits trees suitable for timber, fuel, fodder, ornamental, wind breaks, soil and water conservation. Choice of trees as wind breaks for orchard protection and their interaction with fruit productions. Fruits trees suitable for various assemblages and their planting plans in different agro-climatic situations and agro-forestry systems. Modifications in training and pruning, floor and fertility management, yield and quality improvement.

Practical: Field survey and acquaintance with specialized features of fruit species and varieties for agro-forestry. Planting plans including wind breaks. Training and pruning and methods of floor and fertility management of fruits crops in agro-forestry systems.

X. Animal production in Agroforestry

(2+1)

Importance of cattle –sheep and goat vis-à-vis agro-forestry systems. Feed and fodder resources in agro-forestry systems. Nutrient analysis of forages derived from fodder trees/shrubs. Nutrient requirement for various livestock and their ration computation with agro-forestry forages and tree leaves. Forage and tree leaves preservation. Calendars for forage crop production in agro-forestry systems including lopping schedules. Optimization of animal production. Animal products technology and marketing.

Practical: Analysis of calcium, phosphorus and other minerals in forages and tree leaves. Digestibility of some agro-forestry forages. Preparation of leaf meal and forage conservation. Familiarity with common veterinary instruments, AI equipments and common feeds and fodders.

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7. BIO ENERGY

I. Introductory Bio-energy (2+0)

Energy Sources and overall energy demand and availability, Energy Consumption in various sectors and its changing pattern, Energy Resources Depletion of energy sources and impact on environmental climatic change, United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol Sustainable Development, Renewable sources in India, their utilization pattern in the past, present and future projections of consumption pattern, Energy and Environmental policies, Depletion of ozone layer, Global warming, Biological damage due to environmental degradation.

II. Heat and Thermodynamics (1+0)

Units conversions for Energy, Concepts of Energy, Heat and Work, Ideal gas law, 1st and 2nd law of thermodynamics, Thermodynamic power cycles, Reversible heat Engine cycle, Carnot Cycle, heat transfer, Conversion of various forms of energy (heat, electricity, mechanical etc.), Specific heat.

III. Biomass chemistry (1+0)

Major chemical constituents of biomass, Chemistry of lignin, Cellulose, Starch and hemicelluloses. Oils, gums and resins. Tannins and phenolic substances.

IV. Renewable energy technologies 2+0)

Basic principles, Systems used in practice and applications, Agriculture Crop & Forestry residues used as fuels, Bio-fuels, Biomass gasifiers etc., Biogas technology, Briquetting of forest wastes as a fuel, Types of wood burning cookstoves, smoke emission analysis of wood burning cookstove, Energy storage Devices and systems. Thermal insulation, Heat loss and Heat gain and its evaluation, Techniques for energy conservation in various devices.

V. Energy and chemical from biomass (2+0)

Concept of Bioenergy, Biomass resources including industrial, domestic and solid waste as a source of energy. Biomass feed stocks, Production of chemicals by combustion, pyrolysis, gasification, liquification, conversion of substrates into methanol and ethanol, amino acids, aerobic and anaerobic conversion, fermentation etc., Bio-diesel etc.

VI. Bio fuels (0+2)

Biomass, its classification, characteristics and utilization, Techniques for biomass assessment, biomass estimation, Properties of biomass. Types of bio fuels (Liquid,

solid and gas), Importance, production processes and technology, bio-fuels applications, bio-fuels for transportation.

VII. Biomass gasifier and biogas (0+2)

Importance of biogas, different types of biogas plant, various substrates used to produce biogas, individual and community biogas operated engines and their uses, biomass gasifier and types, application of gasifiers to thermal power and engines, technology.

VIII. Briquetting and cookstove technology (0+2)

Procedure for setting up a briquetting plant, economic analyses of briquetting, appliances for biomass briquettes, Types of wood burning cookstoves for cooking, space heating and water heating, Environmental analysis of wood burning cookstoves, Determination of thermal efficiency of cookstove. Determination of calorific value of wood species and ash content.

IX. Practical / industrial training (0+1)

Students shall have to submit a report based on his training at the end of the semester and present the work which he has carried out.

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8. FOREST BIOTECHNOLOGY

I. Introductory Forest Biotechnology (2+0)

Historical development of biotechnology; scope of biotechnology in forestry; different methods of biotechnology related to forestry; plant tissue culture and response pattern; application of plant tissue culture in tree improvement; *in vitro* selection and micro propagation in forestry for conservation; gene regulation, genetic engineering techniques; basis of operation in DNA manipulation; transgenic plants; molecular markers and its application in forestry; modification of plant species to practically desired products; bio-degradation of forestry wastes through genetically engineered microbes.

II. Plant Tissue Culture- I (2+1)

Plant tissue culture-principles, history, development, fields of application, progress and prospects with special reference to tree crops. Culture conditions. Stages of micro propagation. *In vitro* propagation via enhanced release of auxiliary buds, somatic organogenesis and somatic embryo genesis. Problems and Progress in *in vitro* propagation of tree crops. *In vitro* pollination and fertilization for distant hybridization. Somaclonal variation - factors influencing - exploitation for crop improvement. Haploid culture and production of homodiploids, Protoplast isolation, culture and regeneration; Protoplast fusion for somatic hybridization and its application. Techniques for direct gene transfer to protoplasts.

Practical: Preparation and storage of stock solutions, preparation of culture media. Collection, handling and pre-treatment of explants. Micro-propagation of crops via different routes. *Ex vitro* establishment of plantlets. Production of somatic embryos. *In vitro* pollination and fertilization. Protoplast isolation and culture. Haploid culture. Components and preparation of culture medium. Collection, handling and surface sterilization of explants. Inoculation and incubation. Essential features of tissue culture laboratories.

III. Plant Tissue Culture- II (2+1)

Need of *in vitro* conservation. Short and medium term conservation. Long term storage, cryo-preservation, freeze preservation, significance of liquid nitrogen, pre-freezing treatments - use of cryo-protectants, dry freezing, incubation. Alteration/modifications in cell components during cryo-preservation. Recalcitrant species. Thawing and reculture. Survival of freeze preserved cells/tissues. Clonal fidelity and karyotype stability of cryopreserved cultures and regenerates. Use of biochemical and molecular markers for testing the stability, Protocol development.

Practical: Preparation of *in vitro* cultures for short, medium and long term preservation. Practicing different protocols for conservation. Thawing and reculture. Assessing the stability of regenerates. RFLP, RAPD and other techniques. Manipulation of culture media and conditions for prolonging the culture period.

IV. Molecular Biology

(2+1)

History and development of Molecular Biology. Nucleic acids – DNA and RNA as genetic materials. Nucleosides and nucleotides, DNA double helix –properties of DNA – absorbance, ionic interaction, denaturation and renaturation, sedimentation. Secondary structure of single stranded DNA – inverted repeat sequences, alternative structures of duplex DNA C value and concept of selfish DNA, cell organelle DNA Chloroplast and genes and mitochondrial DNA and genes. DNA replication – semi-conservative replication. Organization in prokaryotes and eukaryotes. DNA polymerases, replicon, eyes, rolling circle and D-loops, nick translation, okazaki viruses. Reverse transcriptase, primase, helicase, topoisomerases, gyrases, methylases and nucleases. DNA sequencing.

Practical: Estimation of DNA and RNA. Isolation of total nucleic acids from bacteria. Large-scale preparation of total plant DNA. Isolation of total RNA. Agarose gel electrophoresis. Denaturation of DNA. Ethidium fluorescent assay of nucleic acids. Estimation of C value. Binding of polyamines to DNA. Assay of DNA polymerase. DNA sequencing.

V. Principles of Genetic Engineering

(2+1)

Recombinant DNA Technology : Major events, Genomic and DNA clones, Different methodologies and rationale of cloning gene.

The Tools of Genetic Engineering: Concept of restriction and modification, Restriction endo-nucleases, Modifying enzymes, Ligases, Host-vector system,- E-coli as a host.

Different Kinds of vectors: Plasmids, phage vectors, M 13, cosmids, phagemids, YACS, BACS, PACS and expression vectors.

The Means of Genetic Engineering: Different strategies of cloning, Ligation strategies, Genomic libraries, cDNA libraries, Gene tagging, Introduction to molecular market technology.

The product: Sub cloning, Nested deletions, Sequencing and sequence analysis, Site-directed mutagenesis, Expression of cloned genes, Isolation and purification of the expressed product.

PCR Technology: Different types of PCR, Applications of PCR in cloning genes, promoters and flanking sequences. Utilizing PCR in the lab for preparation of probes, PCR on molecular marker technology.

Practical: Isolation of nucleic acids and their sequencing, Experiment with cloning vectors: pUC 18, pUC 19, pBR 322, phage etc. Extraction and purification of plasmid DNA restriction methylation and ligation reactions, preparation and transformation of competent E.coli. Identification of recombinants.

VI. Techniques in Genetic Engineering

(2+1)

Cloning and Transformation in Prokaryotes, Vector preparations, Insert preparations, Ligation.

Transformation:

Methods of direct transformation: PEG mediated, microinjection, particle bombardment, electroporation.

Method of indirect transformation: *Agrobacterium tumefaciens* and *A. rhizogenes* Screening for recombinant clones, analysis of the recombinant DNA, Isolation of the recombinant plasmid, Restriction analysis, Excision of the insert, Restriction analysis of the excised insert, Sequence analysis of the insert, construction of Genomic and cDNA library, Gene isolation, Promoter analysis, Gene expression.

Genetic engineering for insect/disease resistance, Genetic engineering for wood quality improvement, high biomass, adoption to harsh sites and for incorporating male sterility and rooting of tree cutting.

Practical: *Agro-bacterium* mediated genetic transformation, Antibiotic resistance, insertional inactivation. Estimation of proteins and enzymes involved in the defense mechanism-glucanase and chitinase activity, mRNA isolation after exposing the plant to stress conditions. Evaluation of gene expression.

VII Forest Genomics

(2+1)

Molecular breeding of Forest trees, Constructing molecular maps, Molecular tagging of genes/traits, Marker-assisted selection of qualitative and quantitative traits, Physical maps of chromosomes, The concept of gene synteny, The concept of map-based cloning. Basic structure of DNA, overview of genomics technology, concept of maps: Genetic maps, properties of marker used for creating genetic maps, Physical maps: STSs, ESTs Chromosome separation method, high resolution physical mapping approach, Automated sequencing, sequence annotation. Recent advances in molecular marker technique and genomics with special reference to tree.

Micro arrays Application: gene expression, SNP detection, detection of environmental agents. **Micro array design:** cDNA micro array, oligonucleotide arrays. Micro array fabrication. Detection technology. Computational analysis of micro array data.

Practical: Isolation and quantification of plant DNA, PCR operation and gel electrophoresis, RAPD and ISSR, gene sequencing, sequence annotation.

VIII Environmental Pollutants and Biotechnology

(2+0)

Environment: Basic concepts and issues. Environmental Pollution: Types of pollution, Methods for the measurement of pollution; Methodology of environmental management - the problem solving approach, its limitations Air pollution and its control through Biotechnology.

Water Pollution and its control: Water as a scarce natural resource, Need for water management, Measurement of water pollution, sources of water pollution, Waste water collection, Waste water treatment-physical, chemical and biological treatment

processes Microbiology of Waste Water Treatments, Aerobic Process: Activated sludge, Oxidation ditches, trickling filter, towers, rotating discs, rotating drums, oxidation ponds. Anaerobic Processes: Anaerobic digestion, anaerobic filters. Up flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar, antibiotic industries.

Microbiology of degradation of Xenobiotics in Environment - Ecological consideration, - decay behavior & degradative plasmids; Hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides. Bioremediation of contaminated soils and waste lands. Biopesticides in integrated pest management.

Solid waste: sources and management (composting, wormy culture and methane production). Global Environmental Problems: Ozone depletion, UV-6, green-house effect and acid rain, their impact and biotechnological approaches for management. Bioleaching, Bio-fertilizer for sustainable agriculture & environment (AMF, ECM, PGPRs, PSBs, with special reference to low input agriculture).

9. ENVIRONMENT MANAGEMENT

I. Environmental Pollution (3+0)

Definition of pollution, Causes of Pollution of the biosphere, classification of pollutants, National and International Environmental Standards of important Pollutants.

Air Pollution: Types and major sources of air pollutants, dispersal and deposition, response of biotic and abiotic ecosystem components to pollutants. Ionizing radiation, acid rain- causes and consequences. Monitoring of gaseous pollutants and particulate matter. Air pollution mitigation and control. Vehicular Pollution monitoring and abatement technologies. Biological abatement of air pollution, Development of green belt.

Water Pollution: Important pollutants, sources and transformation in nature, eutrophication effects of organic pollutants on organisms and communities. Impact of heavy metals, halogens, and radio-nuclides on aquatic flora and fauna treatment technologies for industrial effluents/ wastewater. Monitoring water pollution and water quality studies. The pollution problem-pollution categorization, sewage, infectious agents, nutrients, chemicals, organic and inorganic sediments, radioactive materials, heat. Causes, consequences and control of eutrophication. Biomanipulation and eco-restoration of lakes: Top-down and Bottom-up approaches. Environmental Health and sanitation

Soil Pollution: Types and sources of soil pollution. Solid waste generation, soil pollutants. Heavy metal toxicity in soil. Hazardous wastes and their Management. Impact of pesticides, industrial waste and fertilizers on soil physico-chemical properties monitoring soil pollution.

Noise Pollution: Causes and consequences of noise pollution. Monitoring and abatement techniques.

II. Environmental statistics (2+0)

Numerical analysis, Statistical methods for environmental systems, Significance of statistical data analysis. Probability theory it's applications, correlation and regressions, analysis of variance, sampling of environmental systems and data analysis. Ecological economics, ecological integration with economy: Cost benefit analysis.

III. Global climatic changes (2+0)

Earth's climate systems, major green house gases, future climatic predictions, adaptability and vulnerability of predictions, adaptability and vulnerability of forest and aquatic ecosystems, responses of biotic communities and changes in reproductive biology of flora and fauna.

Ozone depletion and UV radiation hazards, El Niño effect

IV. Environmental law (2+0)

Government policies for environmental conservation. Government agencies responsible for environment. Environmental legislation for protection of species and natural resources such as EPA 1986, Air and Water Act and Rules. International Environmental Legislation: Protocols, Treaties, Conventions such as CBD, UNFCCC, CITES, WCS, Kyoto, IUCN. Basal, Ramsar etc. Important International organizations and institutions. Environmental standards in India. Public Interest Litigation's (PILs) and their role in control of environmental pollution in India. Important case studies.

V. ENVIRONMENTAL POLICY AND LAW (3+0)

Environment and Development Policies:

Land and agricultural Policies: Land Use Policy, Industrial Policy, Policy on resettlement and rehabilitation. Forest Policies in India; National Forest Policy 1952 and 1988.

National Environment Policy 2006, Policy on abatement of Pollution, National Eco tourism Policy, National Tourism Policy, National Trade Policy, National Water Policy.

Bio-Diversity Related Laws:

The Indian Forest Act 1927 and subsequent amendments; Forest Conservation Act, 1980 and Rules; Wild Life Protection Act 1972 and Rules, Wild Life Protection Amendment Act 2002, Biodiversity Act 2002, Biodiversity Rules 2004, National Biodiversity Strategic Action Plan, Plant Varieties Protection and Farmer's Rights Act, 2001, Geographical Indications of Goods Act, 1999. The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, Case Law

Pollution Control Laws

Public Nuisance – S.133 Cr.P.C; Law of Strict Liability, Public Liability Insurance Act, 1991. Water (Preventing and Control of Pollution) Act, 1974; Water Cess Act 1977; Air (Prevention and Control of Pollution) Act, 1981; Environment (Protection) Act 1986 and Rules 1987; Subsequent allied Rules Environment Impact Assessment, Quality Control and auto regulation and Environment Audit, Energy and Environment, Mining and Environment

VI. International Environmental Law (3+0)

Evolution of International Environmental Law, Sources and bases of International Environment Law. Principles of Permanent Sovereignty over Natural Resources (PSNR) Polluter pays principle, Common but differentiated responsibility, Sustainable Development, Inter-generational and Intra-generational Equity, Precautionary Principle, Public Trust

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Ramsar Convention on Wet Lands, The Basel Convention on the Control of Trans-boundary Movement of Hazardous Wastes and their Disposal , The Montreal Protocol ,International Tropical Timber Agreement , Convention on Biological Diversity, 1992 (CBD) Cartagena Protocol on Bio-Safety, 2000 (CPB) , United Nation Framework Convention on Climate Change, Kyoto Protocol , WTO and Environment, TRIP and Patenting Issues.

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10. FOREST BUSINESS MANAGEMENT

I. Fundamentals of Farm Management (2+0)

Farm management -scope and approaches, Cost-concepts, principles and functions. Basic laws of production. Principles involved in farm management decision making decisions as to what, how, when where and how much to produce. Factor-factor, factor-product and product-product relationships. Cost of cultivation and production. Break-even analysis. Decision making under risk and uncertainty. Farm business efficiency measures. Fundamentals of inventory control. Economic order quantity and ABC analysis. Management of resources - land, labour, capital and machinery.

II. Organizational Behavior and Human Resource Management (2+0)

Concept of organization, human relations and management -scope, characteristics and key elements in organization behavior -scientific & human relation approaches in organizational behavior. Role of behavioral sciences in organizational behavior. Principles of management. Motivation - meaning, nature, types and importance of motivation , theories of motivation with special reference to need theory and theory X,Y of motivation. Tools and techniques of motivation. Organizational stress & its management techniques. Attitudes and job related issues - job design, job satisfaction and organizational effectiveness. Group - meaning and types of groups. Leadership theories - trait & styles approach to leadership. Personality, definitions, determinants, approaches & theories of personality. Organizational communication. Transactional analysis. Managing change & organizational development.

III. Principles of financial management (2+1)

Finance - definition, aims and objectives. Goals of financial management, organization of finance functions in business firms. Investment appraisal criteria - discounted and non-discounted cash flow criteria and their merits and limitations. Introduction to EBIT-EPS analysis under different financing alternatives and dividend policy. Working capital management; need, concepts and sources of working capital. Gross and net working capital; factors influencing working capital requirements. Importance and preparation of Financial Statements, Balance Sheet and Profit and Loss accounts. Ratio analysis. Sources of long term finance. Purpose and essentials of budgeting, important components of master budget, preparation of operating, responsibility, financial and capital budgets. Capital and credit management, 3 Rs and 3 Cs of credit. Farm credit policy. Role of banks and cooperatives in the field of rural finance.

Practical: Exercises on return to investment, repayment capacity, internal rate of return, estimation of credit requirements, risk bearing ability, repayment plans and financial ratios. Case studies on working of credit societies, cooperative banks, Land Development Banks, etc.

IV. Marketing and International Trade

(2+1)

Market - concept, components and classification. Discussion on demand and supply and factors affecting the same. Simple market model and price determination. Market structure, conduct and performance. Marketing - definition and scope. Concept of marketing functions and approaches to marketing. Peculiarities of marketing of raw and manufactured agricultural and forestry goods. Market integration - meaning, types, degree, measurement and effects of market integration. Marketing cost, margin and price spread - concepts and applications. Marketing efficiency - definition, approaches to the assessment of marketing efficiency and empirical assessment of marketing efficiency. Fundamentals of theories of international trade, features of export-import policies. WTO - its structure, functions and decision making process. IPRs and their implications for forestry and allied sectors in the country.

Practical: Library review of studies in marketing and trade of international timber and non timber forest products. Analysis of price and market arrival data of forestry products for examining trends, seasonal, cyclical, secular variations. Exercises on analysis of demand and supply of important forest products. Marketing efficiency. Exercises on marketing channels, costs, margins and price - spread of important forest products. Case studies based on visits to selected markets, marketing institutions and forest based industries.

V. Fundamentals of Projects Planning, Monitoring and Evaluation (2+1)

Project - importance and steps in project formulation. Ex-ante, concurrent and ex-post project appraisal. Choice of discount rate. Financial feasibility of project, various techniques used. Advantage and disadvantages of discounting and non-discounting feasibility criteria. Sensitivity analysis. Introduction of network scheduling techniques. Critical path methods, characteristics, use and preparation of critical path. Monitoring and evaluation -definition, objectives and types. Project review meeting and preparation of project status reports. Fundamentals of environment impact assessment.

Practical: Project preparation. Application of various methods like Net Present Value, Internal Rate of Returns, Benefit Cost Ratio, annuity, payback period, CPM, PERT approach in the formulation and appraisal of various Agroforestry and forestry projects. Exercises on sensitivity analysis.

VI. Cultivation of Commercial Medicinal and Aromatic Plants

(1+1)

Importance and need of cultivation of medicinal and aromatic plants. Origin, distribution, morphological features, climatic and soil requirements, propagation and nursery techniques, transplanting and after care, nutritional and water requirements, plant protection, harvesting and post harvest processing, active constituents and uses of important medicinal and aromatic plants. *Picrorhiza kurroa*,

Saussurea costus, Aconitum heterophyllum, Valeriana jatamansi, Podophyllum hexandrum, Swertia chirayita, Viola serpens, Asparagus racemosa, Chlorophyllum borivilianum, Stevia rebaudiana, Aloae vera, Echinacea spp. Withania somnifera, Solanum nigrum, Cassia angustifolia, Andrographis paniculata, Pelargonium graveolens, Rosa damascena, Tagetes minuta, Matricaria chamomilla

Practical : Preparation and layout of nursery and field area. Methods of seed sowing. Preparation of shoot and root cuttings. Transplanting of seedlings and rooted cuttings. Irrigation techniques. Hoeing and weeding, weed identification and their control. Harvesting, cleaning, drying and grading of farm produce. Demonstration of different stage methods. Essential oil distillation. Raising and harvesting of at least one crop grown in the area.

VII. Commercial Utilization of Renewable Energy (0+2)

Application of solar drier in post harvest processing of horticulture & forestry crops. Utilization of solar green house technology for nursery raising, in floriculture and medicinal and aromatic plants etc. Solar passive house technology. Solar photovoltaic) for electricity, water lifting and batteries. Fuel saving devices (improved cook stoves, solar cooker and kerosene stove). Solar water heating systems. Solar still for potable water. Gasification of biomass and Briquetting of biomass. Visits to the industries manufacturing renewable energy devices.

VIII. Soil and Water Management (2+1)

Characterization of orchard and forest soils and their management in relation to different tree species. Suitability of fruit/forest crops to particular soil and climate. Soil erosion, its nature and extent, mechanisms and causes, soil loss equation, physico-chemical properties in relation to erodibility. Soil conservation methods for shallow, deep, sloppy and degraded lands. Soil and water conservation techniques. Watershed management, concepts, principles and practices. Water resource potential –surface and sub-surface, utilization and harnessing, aquifers, storage, discharge and recharge. Planning for optimum use of soil and water resources.

Practical: Determination of runoff rate, rain drop impact, suspension ratio, silting rates of dams and ponds in a catchments area. Preparation of watershed (soil, water, plant, and livestock) management plants.

IX. Production M management in Plantation Forestry (1+1)

Object and scope. Site selection, site preparation –cleaning, weeding, digging, fencing, roads, choice of species, time of planting, planting pattern, spacing, plantation methods, intercultural operations. Nutrition of plantation crops. Introduction, nutrient deficiencies, diagnosis and corrective measures. Plant protection measures, rotation, thinning, energy and industrial plantation. Harvesting, conservation, transport and Marketing. Plantation economics.

Practical: Study the equipments and materials for establishment of plantations. Site preparation. Visit to industrial plantations. Exercise on cost of production of plantation. Exercises on intercultural operations.

X. Modern Nursery Production (1+1)

Introduction and importance of nursery. Types of nurseries –bare root, Containerized and vegetatively produced nursery. Bare root nursery –nursery soil and water management, bed preparation, pre sowing seed treatments, seed sowing and intermediate operations viz., pricking, watering, fertilization, weeding and hoeing. Plant physiology and nursery environment interaction affecting seedling growth. Root culturing techniques. Lifting windows, grading, packing and storing for out planting . Containerized nursery - type and size of container including root trainers, selection of growing medium. Types of green houses and mist propagation. Vegetative propagation-selection of superior phenotype. Method of propagation viz. cutting, budding, grafting and layering. Factors affecting rooting of cuttings.

Practical: Introduction and identification of modern equipments and tools used in nursery. Seed quality testing-viability and germination. Pre-sowing seed treatments. Preparation of nursery beds and growing media for containerized nursery. Sowing of seed and other intermediate nursery management operations. Preparation and planting of cuttings. Use of vegetative propagation methods such as budding, grafting and layering. Maintenance of nursery records. Identification of nursery insects and diseases and their control measures. Visit to nurseries.

XI. Application of Remote Sensing and GIS in Watershed Management (1+1)

Basis concepts of Remote and Geographic Information System (GIS) , Determination of geomorphological, physiological, vegetation, soil, land use parameters of a watershed. Spatial and non-spatial data analysis. Preparation of thematic layers and their digitization.

Practical: Thematic layers build up, overlaying and their integration using ERDAS and ARC/INFO software package. Interpretation of satellite data and digital image processing. Preparation of thematic maps.

XII. People's Participation in Watershed Management (2+1)

Concept of participation-meaning, types and conditions for participation. Participatory process- philosophy and phases. Concept of participatory Development (PD), participatory watershed management and key elements of its processes for planning, implementation, monitoring and evaluation. Motivations – Definition, theories and techniques of motivation for enhancing people's participation in watershed management. Training programme in watershed management – planning designing, organization and evaluation . Developing

communication skills for participatory watershed planning, monitoring and evaluation. Key communication/key informants and local leader-their role in watershed management. Concept of RRA & PRA, techniques of conducting PRA and their application in watershed management.

Practical: To study the methods of identifying local leaders/key communicators.

Practical exercises on the application of participatory Rural Appraisal (PRA)

Techniques in watershed management.

Exercises on designing and organizing farmers training programme for watershed management.

Writing news items, success stories, leaflets and folders for the farmers.

How to organize meeting, group discussion demonstration/ on -farm trials of watershed management.

Visit to selected watershed projects