(V) M.Sc. (Forestry) Silviculture and Agroforestry

Major Courses

Course Code	Course Title	Credit hrs
	Semester I	
SAF-511*	Silviculture	2 + 1
SAF-512*	Interactions in Agroforestry Systems	1 + 1
SAF-513	Plantation Forestry	2 + 1
SAF-514	Climate Change and Conservation Silviculture	2 + 0
SAF-515	Nutrient and Weed Management in Production Forestry	1 + 1
	Semester II	
SAF-521*	Forest Biometry	1 + 1
SAF-522*	Agroforestry Systems	2 + 1
SAF-523	Modern Nursery Technologies	1 + 1
SAF-524	Industrial Agroforestry	1 + 1
SAF-525	Trees and Shrubs for Agroforestry	1 + 1
SAF-526	Forest Tree Seed Technology	2 + 1
SAF-527	Crops and Live Stock Management in Agroforestry	2+0
	Semester III	
SAF-531*	Silvicultural Practices	1 + 1
SAF-532	Economics of Agroforestry Systems	2 + 1
SAF-591	Master's Seminar	1 (0+1)
	Semester IV	
SAF-599	Master's Research	0+30

*** Core and compulsory courses.**

Note: A student has to opt total 20 credit hours.

Syllabus of Major courses of Silviculture and Agroforestry

SAF-511 SILVICULTURE 2 + 1

Theory

UNIT I

Forest ecosystems- Introduction to tropical/temperate silviculture. Role of silviculture in forest and wild land management, major forest formations-classification, distribution, composition and structure. Vegetation dynamics- species richness-diversity indices. Vegetation forms of India and their productivity.

Forest ecosystem- structure and functioning, community development, competitive interactions in forest communities, forest succession, concepts and models of succession-Connell-Slatyer models, climax theories, tolerance.

UNIT II

Ecophysiology of tree growth- effect of radiation and water relationship, mineral nutrients and temperature. Forest stand development - stand development, even-aged and uneven-aged stands, age and site quality. Tree architecture and its role in stand management.

UNIT III

Stand density determination-stand density indices-stand density management- density management diagram, silvicultural treatments involved- thinning as a stand management tool, objectives of thinning, effects on growth and yield, thinning effect on economic yield of stands.

Forest site quality evaluation-direct and indirect methods.

UNIT IV

Treatment analysis-silvicultural regimes- factors influencing choice of regimes, use of system analysis to determine regimes, models for evaluating silvicultural alternatives, development of silvicultural

regimes to suit management objectives, optimum management strategies, silvicultural prescriptions for maximum production regime.

Practical

Visit to forest areas to study forest composition, classification, factors of locality, site quality, form and growth of forest trees- study plant succession- study stand density, changes on productivity- thinning effects.

Suggested Readings

Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture.* McGraw-Hill Book Company.

Julius E. 1992. *Plantation Forestry in the Tropics*. Oxford University Press.

Khanna LS. 1996. *Principle and Practice of Silviculture*. International Book Distributors.

Khanna LS. 2015. *Theory and Practice of Indian Silviculture Systems*. Bio-Green Publisher.

Lamprecht. 1986. *Silviculture in the Tropics*.Verlag Paul Parey, Hamburg und Berlin.

Nyland RD, Laura S, Kenefic, Kimberly K, Bohn and Susan LS. 2016 *Silviculture: Concepts and Applications* (III edition), Kindle Edition, USA.

Pascal. 1988. *Wet Evergreen Forests of the Western Ghats.*

Shepherd KR. 1986. *Plantation Silviculture.* Springer.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture- Applied Forest Ecology*. John Wiley & Sons.

SAF 512 INTERACTIONS IN AGROFORESTRY SYSTEMS 1+1

Theory

UNIT I

Tree-crop interphase- biological factors affecting form and function in woody and non-woody plant mixtures. Nature and types of interactions- positive and negative, aboveground and belowground interactions- competition, complementarity in resource sharing.

UNIT II

Method for quantifying interactions, principles of resource capture and utilization of light and water, nutrition and space. Tree-soil-crop interactions- nitrogen fixing trees interactions in agroforestry. Allelopathy. Use of radioisotopes in tree-crop interaction studies. Root distribution of trees and crops-competition and/orcomplementarity. Animal-tree-crop interaction.

UNIT III

Management options to neutralize negative (competitive) interactions, tree husbandry practices for alleviating competition- tree density manipulation, pruning, mixture of trees and herbaceous crops.

Practical

Different methods for quantifying interactions. Studies on allelopathy. Effect, microclimate modifications, different plant mixtures, tree-soil-crop interactions. Estimation of Land Equivalent Ratio, Estimation of competition indices,Measurement and interpretation of light interception in agroforestry systems, Interpretation of yield responses to shelter, soil water and drainage measurement, transpiration measurement, quantifying root distribution.

Suggested Readings

Avery MA, Cannel MGR and Ong CK. 2005. *Biophysical Research for Asian Agroforestry*. Oxford and IBH Publishing Co. Pvt. Ltd.

Mac Dicken, KG and Vergara NT. 1989. *Agroforestry-classification and Management.*

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic Pub.

Ong CK and P Huxley. 2002. *Tree-Crop Interactions- A Physiological approach*, CAB International.

Patra AK. 2013. *Agroforestry-Principles and Practices*. New India Publishing AGENCY, New Delhi (India).

SAF 513 PLANTATION FORESTRY 2+1

Theory

UNIT I

Role of plantation forestry in meeting the wood demand – status of plantation forestry in India and world. Purpose of plantation, factors determining scale and rate of plantation. Land suitability and choice of species. Preliminary site preparation for establishing plantation. Plantation planning, project formulation and appraisal. Planting programme, time of planting, spacing, pattern and planting methods.

UNIT II

Nutritional dynamics and irrigation of plantation. Mechanization in plantation. Protection and after care of plantation. Pruning and thinning in plantations for quality wood production. Rotation in plantation. Failures of plantations. Impact of interaction and integration of plantation forestry.

UNIT III

Protective afforestation, afforestation of inhospitable sites. Plantation forestry for climate change mitigation- carbon forestry. Ecological factors and long term productivity. Sustainable yield from plantations. Case studies in plantations of Eucalyptus, Casuarina, Poplars, Acacias, Pine, Silver Oak, Gmelina, Teak, Sandal, Bamboo, etc. Production technology of energy plantations, industrial plantations. Emerging concepts in plantation forestry: mixed plantation, continuous cover forests.

Practical

Analysis of plantation problems in Asia and India. Preparation of plantation calendar –Preliminary arrangement for a plantation programme. Planting geometry and calculation of planting stock. Study of different cultural operations and site preparation for plantation. Studies on wood based industries – problems and prospects. Management of Eucalyptus, Casuarina, Teak, Sal, Poplar, Acacias and Bamboo plantations. Production technology for energy plantations. INM in plantations. Irrigation and plantations. Economics of pulpwood, timber and energy plantations. Study of mixed plantation model.

Suggested Readings

Dwivedi AP. 1993. *Forestry in Indi*a. Surya Publ.

Julius E. 1982. *Plantation Forestry in the Tropic*s. Clarendon Press, Oxford.

Kumar V. 1999. *Nursery and Plantation Practices in Forestr*y. Scientific Publ.

Luna RK. 1989. *Plantation Forestry in Indi*a. International Book Distributors.

Prakash R, Chaudhari DC and Negi SS. 1998. *Plantation and Nursery Techniques of Forest Tree*s. International Book Distributors.

SAF 514 CLIMATE CHANGE AND CONSERVATION SILVICULTURE 2+0

Theory

UNIT I

Global climate change-factors involved, green house gases, potential threats, global carbon cycle and C-budget, carbon sequestration. Forests and climate change: Forest responses and vulnerabilities to climate change mitigation.Status of forests in global climate change. Harnessing Forests for Climate Change Mitigation, International climate negotiation, UNFCCC, IPCC, CoP :LULUCF, REDD++ and CDM.

UNIT II

Silviculture and sustainability-criteria and indicators for sustainable plantation forestry in India-CIFOR guidelines. Silvicultural and stand management strategies for carbon sink maximization and source minimization. Adaptive silviculture for climate change.

UNIT III

Disturbance- natural and anthropogenic, short and long term impacts and their implications. Fire loss estimation in forests. Deforestation and degradation trends at global, national and regional levels. Mega development projects, Road widening projects and conservation of native and threatened species, management and rehabilitation plans.

UNIT IV: Impacts of 'No Green Felling' on stand productivity and health. Restoration forestry-silvicultural treatments for habitat restoration, catchment area treatments, enrichment planting, Analog forestry for site productivity and carbon value. Expanding forest and tree cover area- TOF sector in India.

UNIT V

Role of canopy in regulating functional inputs to stand: canopy and forest continuum, Continuous Cover Forestry. Silviculture of old growth stands and sacred grooves- their ecological significance and

biodiversity values. Carbon sequestration potential of Trees Outside forests (TOFs), homegardens and urban forests.

Suggested Readings

Anderson P and Palik B. 2011. *Silviculture for Climate Change.* U.S. Department of Agriculture, Forest Service, Climate Change Resource Center.

SAF-515 NUTRIENT AND WEED MANAGEMENT IN PRODUCTION FORESTRY 1+1

Theory

UNIT I

History o fnutrient management in forest nurseries and plantations. Essential nutrient elements and their deficiency. Mechanism of nutrient uptake by plants, functions and translocation/interactions. Concept of nutrient availability.

UNIT II

Climatic and soil conditions causing micronutrient deficiencies in plants. Occurrence and treatment of micronutrient disorders. Evaluation of soil for the supply of micronutrient. Rare and non-essential elements.

UNIT III

Technology and use of complex liquid and suspension fertilizers. Fertilizer use efficiency. 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 wastes and their recycling.

UNIT IV

Principles of weed control. Methods of weed control-cultural, biological, mechanical and chemical. Herbicide/weedicide classification, properties and their application.

Practical

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. Important weeds in forest nurseries and plantations. Control of weeds.

Suggested Readings

Allen V and Barker. 2007. *Handbook of Plant Nutrition*. Pilbeam London.

Dinesh Kumar, Sanjay Chowdhary and Rajvir Sharma. 2011. *Weed Management: Principles and Practices.* Narendra Publishing House.

Gupta OP. 2011. *Modern Weed Management*. Agrobios, New Delhi (India).

Rajaram C. 2012. *Hand book of Plant Nutrition.* NehaPublishers& Distributors.

Rammoorthy and Subbian P. 2012. *Weed Management*. Agrotech Publishing Academy, Udaipur (India).

SAF-521 FOREST BIOMETRY 1+1

Objective

To develop understanding of students about tree and stand measurements, forest inventory and yield concepts.

Theory

UNIT I

Measurement of tree parameters. Determination of tree age and dendrochronology for growth history and climate change studies.

UNIT II

Estimation of volume, growth and yield of individual tree and forest stands. Preparation of volume tables. Application of yield and stand tables.

UNIT III

Forest inventory, sampling methods adopted in forestry, Use of GIS in forest inventory. Quantification of regeneration and stand establishment. Measurement of crown density and crown ratios. Simulation techniques. Growth and yield prediction models – their preparation and applications.

Practical

Calculations of volume of felled as well as standing trees. Volume table preparation. Application of different sampling methods. Preparation of yield and stand table. Quantification of regeneration and stand establishment. Measurement of crown density and crown ratios. Crown profiling of trees and stand. Dendrochronological studies.

Suggested Readings

Chaturvedi AN and Khanna LS. 1994. *Forest Mensuratio*n. International Book Distributor.

Ram Parkash 1983. *Forest Surveyin*g. International Book Distributor.

Sharpe GW, Hendee CW and Sharpe WE. 1986. *Introduction to Forestr*y. McGraw-Hill.

Simmons CE. 1980. *A Manual of Forest Mensuratio*n. Bishen Singh Mahender Pal Singh, Dehradun.

SAF-522 AGROFORESTRY SYSTEMS 2+1

Theory

UNIT I

Agroforestry: objectives, importance, potentials and limitations for implementations. Land capability classification and land evaluation. Basis of classification of agroforestry systems and principles, indigenous *vs.* exotic, intraspecific variations, crown architecture of tropical/temperate trees. Ideotype concept for selection of multipurpose trees. Nitrogen fixing trees. Overview and case studies of different agroforestry systems.

UNIT II

Structural and functional attributes of agroforestry systems, shifting cultivation, taungya system, multiple and mixed cropping, alley cropping, silvopastoral systems, shelter-belts and windbreaks, energy plantations and home gardens.

UNIT III

Role of trees in soil productivity and conservation– micro-site enrichment- litter and fine root dynamics, Nitrogen fixation and nutrient pumping. Soil productivity and management in agroforestry.

UNIT IV

Community forestry and social forestry, linear strip plantations.

UNIT V

Trends in agroforestry systems research and development, Diagnosis and Design –PRA-RRA tools in agroforestry problem diagnosis.

UNIT VI

Climate Change mitigation and adaptation through agroforestry- climate negotiations- LULUCF-agroforestry options.

Practical

Survey and analysis of land use systems in the adjoining areas. Study of tree crown architecture. Design and plan of suitable models for improvement. PRA-RRA tools in agroforestry problem diagnosis.

Suggested Readings

Buck LE, Lassoie, Fernandes ECM 1999. *.Agroforestry in Sustainable Agri. Systems*. CRC Press.

Kumar BM and Nair PKR. 2006. *Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry.* Springer publication.

Kumar BM and Nair PKR. 2013. *Carbon Sequestration Potential of Agroforestry Systems: Opportunities and Challenges (Advances in Agroforestry*). Springer publication.

Nair PKR and Latt 1998. *Directions in Tropical Agroforestry Research*. Kluwer.

Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic Pub.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF.
Peter Huxley. 1999. *Multiple Cropping with Woody and Non-Woody Plants*. John Wiley and Sons Ltd, Oxford, United Kingdom.
Tejwani KG. 1994. *Agroforestry in India*. Oxford & IBH Publishing Co. Pvt Ltd.
Thampan PK. 1993. *Trees and Tree Farming*. Peekay Tree Crops Development Foundation.
Young A. 1997. *Agroforestry for Soil Management*. CABI.

SAF-523 MODERN NURSERY TECHNOLOGIES 1+1

Theory

UNIT I

Introduction and importance of nursery. Types of nurseries-temporary and permanent, bare root, containerized and clonal 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.

UNIT II

Physiology and nursery environment interaction affecting seedling growth. Root culturing techniques. Containerized nursery - type and size of containers including root trainers, selection of growing medium. Types of green house and mist chamber for propagation.

UNIT III

Vegetative propagation - importance, selection of superior genotypes, Advanced methods of propagation, containers, growing media, fertilizers, sanitation and management in vegetative propagation. Special requirement for clonal propagation. Propagation Structures and Management,

UNIT IV

Clonal propagation: miniclonal and micro cuttings technology. Vegetative propagation of bamboos and canes. Factors affecting rooting of cuttings. Lifting windows. Important forest nursery pests and diseases and their management. Seedling quality assessment, grading, packaging, storing and transportation.

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 operations. Preparation and planting of cuttings. Use of vegetative propagation methods such as budding, grafting and layering. Miniclonal and microcutting technology. Use of plant bio-regulators for rooting. Assessment of seedling quality. Maintenance of nursery records. Identification of nursery insects and diseases and their control measures. Visit to forest nurseries. Nursery practices of commercially important tree species.

Suggested Readings

Bhardwaj RL and Sarolia DK. 2011. *Modern Nursery Management.* Published by Agrobios Publishing. New Delhi (India).
Kumar GA and Gopikumar. 2003. *Forest Nursery and Tree Husbandry.*
Kumar V. 2012. *Nursery and Plantation Practices in Forestry.* Scientific Publishers (India).
Saini RS, Kaushik N, Kaushik RA and Godara NR. 2012. *Practical Nursery Production.* Agrobios, New Delhi (India).

SAF-524 INDUSTRIAL AGROFORESTRY 1+1

Theory

UNIT I

Role of forests in industrial sector, industrial raw material, demand and supply, indigenous and exotic industrial resources, extent of area, policy and legal issues towards industrial wood plantation. Major wood based industries in India; timber, pulp wood, plywood, matches etc. Raw material requirements and their procurements.

UNIT II

Industrial wood plantations – status in India and different states, preferred species – current plantation management and establishment, propagation and plantation technique, economics of industrial agroforestry, pest and disease management for major industrial wood species, harvesting, reduced impact logging, mechanization.

UNIT III

Supply chain; definition, concept, supply chain network, logistic activities, Marketing system; marketing type and channel, price patterns of various industrial wood agroforestry plantations. Contract farming: concept and methods, contract tree farming system in India. Industrial experiences– price support system – constraints. Corporates in industrial agroforestry: International and National corporate, success stories. Corporate social responsibilities. Tree insurance.

UNIT IV

Impacts of industrial agroforestry – ecological impacts; climatic, edaphic and biotic– carbon sequestration. Carbon storage potential of industrial agroforestry and carbon trading mechanism of industrial agroforestry, socio-economic impacts–clean development mechanism. Certification of industrial plantations.

Practical

Study of various wood based industries. Study on raw material requirement and sourcing of plywood, pulp and paper, matchwood, timber processing. Biomass power generation industries. Value addition technology of various wood products. Industrial wood plantations – economics and impact assessment.

Suggested Readings

Cosasalter C and C Pye-Smith. 2003. *Fast Wood Forestry - Myths and Realities*. CIFOR. Bogor, Indonesia. 50p.

Mehta T. 1981. *A Hand Book of Forest Utilization.* International Book Distributors, Dehradun.

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic publishers.

Parthiban KT, Umarani R, Umesh Kanna S, Sekar I, Rajendran P and Durairasu P. 2014. *Industrial Agroforestry : Perspectives and Prospectives*. Scientific Publishers.

Tejwani KG. 1994. *Agroforestry in India*. Oxford and IBH publishing Co., New Delhi.

SAF-525 TREES AND SHRUBS FOR AGROFORESTRY 1+1

Theory

UNIT I

Introduction, importance of woody elements in agroforestry systems, their role in biomass production. Suitability of species for different purposes. Multipurpose trees in agroforestry systems. Fodder from trees/shrubs and their nutritive value, propagation techniques.

UNIT II

Role of nitrogen fixing trees/ shrubs. Choice of species for various agro-climatic zones for the production of timber, fodder, fuel wood, fibre, fruits, medicinal and aromatic plants. Generic and specific characters of trees and shrubs for agroforestry.

UNIT III

Fruit crop and small timber trees and their need and relevance in agroforestry, trees suitable for various assemblage and their planting plan in different agroclimatic zones and agroforestry system. Intercropping in fruit orchards like Apple, Walnut, Jack fruit, Mango, Sapota, Pomegranate, Orange, Citrus, Guava etc. Modification in tending and pruning operations and canopy management. Fertility management, yield and quality improvement.

Practical

Field survey and acquaintance with specialized features of trees, shrubs and fruit species and varieties for Agroforestry. Planting plans including wind breaks. Training and pruning of forest trees, shrubs and fruit trees for enhancing production in agroforestry system.

Suggested Readings

Dwivedi AP. 1992. *Agroforestry: Principles and Practice*s. Oxford & IBH.

Nair PKR, Rai MR & Buck LE. 2004. *New Vistas in Agroforestr*y. Kluwer.
Nair PKR. 1993. *An Introduction to Agroforestr*y. Kluwer.
Ong CK and Huxley PK. 199*6. Tree Crop Interactions – A Physiological Approac*h. ICRAF.
Srivastava KK. 2007. *Canopy Management of Fruit Crops*, IBD.
Thampan PK. 1993. *Trees and Tree Farmin*g. Peekay Tree Crops Development Foundation.

SAF-526 FOREST TREE SEED TECHNOLOGY 2+1

Theory

UNIT I

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.

UNIT II

Reproductive biologyof seed plants - development and maturation of seed bearing organs and seeds - morphology of fruit and seed - seed dispersal - ecological fruit and seed types- seasonality and periodicity of flowering and fruiting - reproductive age - influence of external factors on seed production. Seed structure and chemical composition – development and maturation – germination – breakdown of storage products – endogenous hormonal regulation – effect of stimulators and inhibitors– dormancy – its causes and breakage specific problems of seeds of woody plants.

UNIT III

Determining maturity indices. Factors influencing choice of collection methods. Methods of seed collection and processing. Storage methods – loss of viability during storage. Dormancy and pre-treatment. Germination and seedling establishment and seed testing techniques.

UNIT IV

Quality seed production technologies - seed certification.

UNIT V

Eco-physiological role of seed storage. Classification of seed storage potential. Factors affecting seed longevity. Pre-storage treatment. Physiological change during ageing. Storage of orthodox, recalcitrant and 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/ fruit. Tests of viability viz., cutting, hydrogen peroxide, excised embryo, tetrazolium, seed health testing primarily to the presence or absence of disease-causing organisms such as fungi, bacteria, virus and animal pests, recording, calculation and use of results of seed treatment.

Suggested Readings

Baldwin HI. 1942. *Forest Tree Seed of the North Temperate Regions*. Periodical Experts Book Agency, Delhi.
Bedell PE. 1998. *Seed Science and Technology: Indian Forestry Species*. Allied Publisher Limited.
Chin HF and Roberts EH. 1980. *Recalcitrant crop seeds*. Tropical Press Sdn. Bhd. Malaysia.
Dutta M and Saini GC. 2010. *Forest Tree Improvement and Seed Technology.*
Hong TD and Ellis RH. 1996. *A protocol to determine seed storage behaviour*. IPGRI Technical Bulletin No. 1. (J. M. M. Engels and J. Toll, vol. Eds.) International Plant Genetic Resources Institute, Rome, Italy.
ISTA. 1993. *International Rules for Seed Testing*. International Seed Testing Association, Zurich, Switzerland.
Khullar P. *et. al*. 1992. *Forest Seed*. ICFRE, New Forest, Dehra Dun.
Leadem CL. 1984. *Quick Tests for Tree Seed Viability*. B.C. Ministry of Forests and Lands, Canada.
Schmidt L. 2000. *Guide to handling of tropical and subtropical forest seed*. DANIDA Forest Seed Centre, Denmark.
Umarani R and Vanangamudi K. 2004. *An Introduction to Tree Seed Technology*. IBD, Dehradun.
Vanangamudi K. 2007. *Advances in Seed Science and Technology*: (Vol. 1. to 5).

Willan RL. 1985. *A guide to forest seed handling*. FAO Forestry Paper 20/2, DANIDA Forest Seed Centre, Denmark and FAO, Rome.

SAF-527 CROPS AND LIVE STOCK MANAGEMENT IN AGROFORESTRY 2+0

Theory

UNIT I

Choice of inter-crops for different tree species, sowing and planting techniques. Planting patterns, crop geometry, nutrient requirements, and weed management. Management of fodder tree species, thinning, lopping, pruning. Ecological and socio-economic interactions.

UNIT II

Role of tree architecture and its management on system's productivity. Production potentials of fodder based agroforestry systems in different agro-climatic conditions and crop combinations. Importance of cattle, sheep and goat vis-à-vis agro-forestry systems. Feed and fodder resources in agro-forestry systems and live stock management.

UNIT III

Nutrient analysis of forages derived from fodder trees/shrubs. Nutrient requirement for various livestock and their ration computation with agroforestry forages and tree leaves. Forage and tree leaves preservation.

UNIT IV

Calendars for forage crop production in agro-forestry systems including lopping schedules. Optimization of animal production. Animal products technology and marketing.

UNIT V

Integrated Agroforestry Farming System.

Suggested Readings

Bran Powell. 2017. *Livestock Production and Management.* L & K Education.

Kundu SS, Dagar JC, Prakash O, Chaturvedi and Sirohi SK. 2008. *Environment, Agroforestry & Livestock Management.*

SAF-531 SILVICULTURAL PRACTICES 1+1

Theory

UNIT I

Sivilculture under changing context of forestry- sivilculture and ecosystem management, stand dynamics, silvicultural practices for pure and mixed stand, even aged and uneven aged stand – silvicultural practices for changing climatic conditions.

UNIT II

Silvicultural practices for natural and artificial regeneration – Ecology of regeneration, forest site management- enrichment of site – quality classes and site index models – stand density – spacing and tree growth – forest vegetation management – techniques for early stand growth- tending operations. Biomass allocation: belowground and aboveground. Changing trends in adoption of silvicultural systems.

UNIT III

Stand development – stages- crown dynamics, Crown Competition factor, Maximum crown area, thinning - pruning – response of trees and impact on wood quality, salvage cutting – improvement felling and enrichment planting – management of weeds, Invasive weeds in forests, Silvicultural practices for short rotation forestry- coppice forestry, Continuous cover forestry.

UNIT IV

Site specific selection of tree species. Precision silviculture –silvicultural practices for important fast growing trees and bamboos of India- *Populus species*, *Neolamarkia cadamba*, *Eucalyptus sp., Casuarina sp.,Tectona grandis*, *Melia dubia*, *Dalbergia sissoo, Gmelina arborea, Leucaena leucocephala, Ailanthus excelsa, Azadirachta indica, Swietenia macrophylla, Dendrocalamus* sp., *Bambusa* sp., - Mechanization of silvicultural practices.

Practical

Visit to different forest sites to study the influence of site factors on composition, Determination of site quality; Studies on stand structure and composition of different forest types; Practicing pruning and its impact on wood quality; Characterizing methods of thinning; Working out intensity of thinning; Study of stand densities in natural forest stand and plantation stand, Afforestation techniques, Wood management techniques for forest tree crops. Planning and designing a tree planting programme. Exercise on precision silviculture practices. Exercise on mechanized silvicultural practices.

Suggested Readings

Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture.* McGraw-Hill Book Company.

Julius E. 1992. *Plantation Forestry in the Tropics*. Oxford University Press.

Khanna LS. 1996. *Principle and Practice of Silviculture*. International Book Distributors.

Khanna LS. 2015. *Theory and Practice of Indian Silviculture Systems.* Bio-Green Publisher.

Lamprecht. 1986. *Silviculture in the Tropics*-Verlag Paul Parey, Hamburg und Berlin.

Nyland RD, Laura S, Kenefic, Kimberly K, Bohn and Susan LS. 2016 *Silviculture: Concepts and Applications* (III edition), Kindle Edition, USA.

Shepherd KR. 1986. *Plantation Silviculture.* Springer.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture- Applied Forest Ecology*. John Wiley & Sons.

SAF-532 ECONOMICS OF AGROFORESTRY SYSTEMS 2+1

Theory

UNIT I

Basic principles of economics applied to agroforestry. Financial measures. Quantification and valuation of inputs and outputs- direct and indirect methods.

UNIT II

Optimization techniques-Planning, budgeting and functional analysis. Role of time, risk and uncertainty in decision making. Agroforestry budgeting. Risk analysis, re-assessment.

UNIT III

Financial and socio-economic analysis of agroforestry projects. Principles of financial management and harvesting, post harvest handling, value addition, marketing of agroforestry products including benefit sharing.

UNIT IV

Valuation of ecosystem services in agroforestry and payment for ecosystem systems. Bankable agroforestry projects, incentives, tree insurance etc. Certification process in agroforestry based carbon projects, carbon finance etc.

Practical

Exercises on agroforestry production relationships. Preparation of agroforestry based 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. Valuation of ecosystem services in agroforestry and payment for ecosystem services.

Suggested Readings

Alavalapati JRR and Mercer D Evan. 2004 *Valuing Agroforestry Systems: Methods and Applications*. Kluwer Academic Publishers.

Kant S and Janaki A. 2014. *Handbook of Forest Resource Economics*. Publisher: Routledge

Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer Academic Publishers.

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic Publishers.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF.

Sullivan Gregory M, Susan Hoke M and Jefferson M. Fox (editors). 1992. *Financial and Economic Analyses of Agroforestry Systems. Proceedings of a workshop held in Honolulu. Hawaii. USA. July* 1991. Paia, Ill: Nitrogen Fixing Tree Association.

Thampan PK. 1993. *Trees and Tree Farming*. Peekay Tree Crops Development Foundation.