

**INSTITUTE OF FORESTRY AND
ENVIRONMENTAL SCIENCES
UNIVERSITY OF CHITTAGONG**

**SYLLABUS FOR
MASTER OF SCIENCE IN
FORESTRY (THESIS)
AND
MASTER OF SCIENCE IN
FORESTRY (GENERAL)**

SESSION 2013-2014 AND 2014-2015

Courses for Master of Science in Forestry (Thesis) and Master of Science in Forestry (General)

1. M. S. in Forestry (Thesis):

Course work (five courses)	500 marks (20 cr)
Dissertation	200 marks (8 cr)
Seminar on dissertation	50 marks (2 cr)
Viva-voce on dissertation	50 marks (2 cr)

Total 800 marks (32 cr)

2. M. S. in Forestry (General):

Course work (six courses)	600 marks (24 cr)
Project work	100 marks (4 cr)
Seminar on project	50 marks (2 cr)
General viva-voce	50 marks (2 cr)

Total 800 marks (32 cr)

Core Courses (Following TWO compulsory courses to be taken by students of this option for both M. S. (Thesis) and M. S. (General))

Course No	Course Title	<u>TH</u>	<u>TP</u>	<u>TOTAL</u>
FOR 501	Forest Resource Management and Planning	75	25	100
FOR 502	Forest Resource Economics and Project Analysis	75	25	100

Selective Courses (Any THREE of the following courses for M. S. (Thesis) and FOUR for M. S. (General) from any of the branches.

Branch I: Forest Management

FOR 503	Advanced Silviculture	75	25	100
FOR 504	Forest Soils	75	25	100
FOR 505	Ecology and Management of Mangrove Forest	75	25	100
FOR 506	Advanced Mensuration and Computing	75	25	100
FOR 507	Production Planning and Optimization in Harvesting	75	25	100
FOR 508	GIS in Natural Resources Management	75	25	100
FOR 509	Tree Seed Technology	75	25	100
FOR 510	Land use Modeling and Policy	75	25	100
FOR 511	Bioinformatics	75	25	100
FOR 512	Climate change, REDD+, Carbon Measurement and Ecosystem Monitoring	75	25	100

Branch II: Participatory Forestry

FOR 513	Agroforestry and Sustainable Resource Development	75	25	100
FOR 514	Social Forestry Development and Practice	75	25	100
FOR 515	Forestry Communication and Policy Interface	75	25	100
FOR 516	Community Based Resource Management and Governance	75	25	100
FOR 517	Development Economics	75	25	100

Branch III: Forest Conservation

FOR 518	Genetics and Biotechnology	75	25	100
FOR 519	Biodiversity and Nature Conservation	75	25	100
FOR 520	Watershed Conservation and Extension	75	25	100
FOR 521	Forest Dynamics	75	25	100
FOR 522	Applied Statistics in Forestry Research	75	25	100
FOR 523	Forest Protection	75	25	100
FOR 524	Bio-ethics	75	25	100
FOR 525	Plant Stress Physiology	75	25	100
FOR 526	Forest Restoration Ecology	75	25	100
FOR 527	Wildlife Conservation	75	25	100
FOR 528	Ecotourism Management	75	25	100

Branch IV: Forest Utilization

FOR 529	Advanced Wood Anatomy and Identification	75	25	100
FOR 530	Wood Science and Technology	75	25	100
FOR 531	Wood and Bamboo composites	75	25	100
FOR 532	Pulp and Pulp Products	75	25	100
FOR 533	Management and Utilization of Non-timber Forest Products	75	25	100
FOR 534	Bamboo Resource Management and Utilization	75	25	100
FOR 535	Supply Chain Management of Forest Products	75	25	100

Project, Dissertation, Seminar (Practical) and Viva-voce

FOR 601	Master of Science in Forestry (General) Project			100
FOR 602	Master of Science in Forestry (Thesis) Dissertation			200
FOR 603	Seminar (Practical) on M. S. (General) project			50
FOR 604	Seminar (Practical) on M. S. (Thesis) dissertation			50
FOR 605	General viva-voce (M. S. General)			50
FOR 606	Viva-voce on dissertation (M. S. Thesis)			50

TH – Theoretical; TP – Term Paper

Note: 100 marks = 4 credits; 75 marks = 3 credits; 50 marks = 2 credits and 25 marks = 1 credit.
Internship Report (Non-credit) for Thesis and General Group

FOR 501 FOREST RESOURCE MANAGEMENT AND PLANNING
Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents:

- 1. Introduction to Forest Management:** Nature and purpose of forest resource management, approaches to forest management; models of forest development and their significance in plantation forestry; retention harvesting system- process, design, importance in forest management
- 2. Site, Stocking and Spacing:** Determination of Site Quality and stocking; their importance in timber production; determination of desirable stocking
- 3. Forest Growth and Yield Concept:** Yield tables in timber production, yield of even-aged and uneven-aged forest; growth information in timber production, nature and components of forest growth.
- 4. Sustainable Forest Management (SFM):** Criteria & indicators (C & I) of SFM, C&I for Asian dry forests, Trees outside forests (TOFs).
- 5. Regulation of Forests:** Nature and structure of even-aged and uneven-aged forests; yield regulation of even-aged and uneven-aged forests
- 6. Community Management of Forests (CMF):** Criteria & indicators (C & I) of CMF, CMF in Asian countries.
- 7. Management of Bangladesh Forests:** Forest resource base and growing stock in plantation and natural forest; Past and current management, Silviculture Issues and programmes; Future forest management strategy; Review of current forest management plan of Forest Department; Status, ecology and management of village forests
- 8. Management of Non-Wood Forest Products and Services:** Present status and management of bamboo, commercial palms, medicinal plants and other important NTFPs; management of soil, water and wildlife; out-door recreation in forestry

Term paper: Students will prepare term paper on topics given by the respective course teacher(s).

Recommended Bibliography:

- Davis, L.S. and Johnson, K.N. 1986. Forest Management. Third edition, McGraw-Hill Book Company.
- Davis. K. P. 1966. Forest Management: Regulation and Valuation. Second edition, McGraw-Hill Book Company.
- Duerr, W.A. et al. (eds.). 1979. Forest Resource Management: Decision Making Principles and Cases. W.B. Saunders Company.
- Forest Management Plan. 1994. Forest Management Plan. Ministry of Environment and Forest. Dhaka.
- Kohm, K. A. and Franklin, J. F. 1997. Creating a Forestry for the 21st Century- the science of ecosystem management. Island Press, Washington D. C., USA
- Pant, M.M. 1990. Forest Management. Institute of Forestry, Chittagong University.
- Shiva, M.P. and Mathur, R.B. 1996. Management of minor forest for sustainability. Oxford & IBH Publishing Co. PVT. LTD.

FOR 502 FOREST RESOURCE ECONOMICS AND PROJECT ANALYSIS

Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents:

- 1. Economic Concept and Procedures:** Concept of resource economics and forest resource economics; Over view of economic concepts and procedures involved in managing forested lands for the production of commodity and services; Use of system analysis techniques for evaluating alternative land-use programs and manipulations of the forest ecosystems; Forest as a common property resource
- 2. Economic Growth and Development:** Income distribution and inequality measures, Lorenz curve, Gini-coefficient.
- 3. Forest Investment Analysis:** Long term and short term investment; Evaluation of forest investments over time, interest rates, time preferences, compounding and discounting; accounting for inflation, nominal and real rates of return and interpretation of return rates, Capital budgeting – accepting or rejecting a forest investment project; Analysis of harvesting decision; Analysis of rotation fixation and yield regulation; Von Gehren concept and the problem of forest land value; Fustmann's soil expectation value formula, Annuity method for forest investment analysis.
- 4. Forest Business Under Risk and Uncertainty:** Difference between risk and uncertainty; risk preference; risk and uncertainty associated with natural disturbance events and market fluctuations; Risk management (strategies for minimizing the risk); Methods of incorporating uncertainty and risk into financial analysis of forest investments; evaluating investment strategies by using risk adjusted discount rates, certainty equivalents, expected values, and minimum and maximax approaches.
- 5. Valuation of Non-market Forest Products/Services:** Use and non-use forest values, positive and negative externalities, concepts of willingness-to-pay and willingness-to-accept, and valuation of forest non-market benefits using stated and revealed preference methods; Strength and weaknesses of the valuation methods, Economic estimation of the value of wildlife (product, watching, existence); Valuation of tourism prospect of Bangladesh forests; Forest certification – concepts and methods, benefits, prospects and problem of FC in Bangladesh.
- 6. Forestry Sector Analysis:** Contribution of forestry sector to GDP, computing methods, productive roles, goods not presently included in the GNP, their price, subsidy to/from public sector factories, evaluation of services; Current status and problems of forest industries, use of raw materials other than timber, non-timber forest produce based industries, Current status and prospects for employment; Problem analysis; Self-help forestry enterprises; Timber demand and supply scenario in Bangladesh; Trends of export (if at all) and import of timber; History, causes, and consequences (both financial and environmental) of ban on timber harvesting in Bangladesh
- 7. Forestry Project Development:** Concept, characteristics and components of project; Project cycle; Steps in project formulation; Classification of projects in Bangladesh.
- 8. Project Appraisal:** General idea; investment criteria; Commercial or private benefit/cost analysis vs. social cost/benefit analysis; Justification of social benefit /cost analysis; Uncertainty and sensitivity analysis.
- 9. Logical Framework Approach of Project:** Concept; Construction of the logical framework; Advantages of Logical Framework Approach; Logical Framework Approach for forestry projects; Externalities not covered by cost/benefit analysis.
- 10. Project Evaluation:** Concept; principles of evaluation; Types of Project Evaluation, Current status of forestry projects and methods of evaluation.

Steps in evaluation; techniques and methods in project evaluation; Project Evaluation and Review technique (PERT), Critical Path Method (CPM).

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended bibliography:

- Bullard, S.H. and Straka, T.J. 5000. Basic concepts in Forest Valuation and Investment Analysis, Mississippi State University, USA
- Baumol, W.J. 1970. Economic theory and Operations Analysis, Prentice-Hall of India Private Ltd., New Delhi.
- Blair, H.W. and Olpadwala, P.D. 1988. Forestry in Development planning, Lessons from the Rural Experience. International Book Distributors, Dehra Dun, India.
- Duerr, et. al. 1979. Forest Resource Management. WB Saunders Company.
- Duerr, W.A. 1960. Forestry Economics. McGraw-Hill Book Company, USA.
- FAO, 1974. An Introduction to Planning Forestry Development. FAO/SWE/TP. FAO, Rome, Italy.
- Gittinger, J. P. 1982. Economic Analysis of Agricultural Projects, Published for the Economic Development Institute of the World Bank. The John Hopkins University Press, London.
- Gregersen, H.M. and Contreras, A.H. 1979. Economic Analysis of Forestry Projects. FAO Forestry Paper 17. International Book Distributors, Dehra Dun, India.
- Gregory, G. R. 1972. Forest Resource Economics. The Ronald Press Company, New York, USA.
- Heinsdijk, H. 1983. Forest Assessment. International Book Distributors, Dehra Dun, India.
- Henry, W.R. and Hayanes, W.W. 1978. Managerial Economics, Analysis and Cases. Fourth edition. Business Publications, Inc. Texas, USA.
- Howe, C.W. 1979. Natural Resource Economics. John Wiley and Sons. New York, USA.
- Knuchel, H. 1983. Planning and Control in the Managed Forest. International Book Distributors, Dehra Dun, India.
- Leigh, J.H. 1971. The Timber Trade: An Introduction to Commercial Aspects. Second Edition. Pergamon Press. Oxford.
- Mishan, E.J. 1976. Cost-Benefit Analysis, new and expanded edition. Praeger Publishers. USA.
- Pant, M.M. 1986. Forest Economics and Valuation. Medhawi Publishers, Dehra Dun, India.
- Mohring, B. and Ruping, U. 2008. A concept for calculation of financial losses when changing the forest management strategy, Forest Policy and Economics, Vol. 10:98-107.
- Pant, M.M. 1990. Marketing of Forest Products in Bangladesh. UNDP/FAO BGD/85/011, Field Document No. 16. IFCU &FAO.
- Rich, S. U. 1970. Marketing of Forest Products: Texts and Cases, McGraw Hill Book Company.
- Tewari, D.N. 1995. Marketing and Trade of Forest Produces. International Book Distributors, Dehra Dun, India.
- Truett, L.J. and Truett, D.B. 1980. Managerial economics, analysis problems cases. South-Western Publishing Co. USA.

FOR 503 **ADVANCED SILVICULTURE**

Theory: 75 (3cr); **Term Paper:** 25 (1cr); **Total:** 100 (4cr)

Course contents:

1. **Silviculture of Natural Forests:** Recent trends of changes in silvicultural systems; Review of environmental issues associated with different silvicultural practices.
2. **Forest Biodiversity:** Natural forests and biodiversity, species richness and conservation of biodiversity; alien invasive species and threats to conservation of native biodiversity.
3. **Regeneration and Recruitment:** Strategies for improving natural regeneration; natural regeneration procedures for some important species and forests. Importance and significant of Assisted Natural Regeneration (ANR) in restoration of native tree species.
4. **Gap phase Dynamics:** Disturbance ecology; gap-phase regeneration canopy gaps and patterns of canopy tree requirement.
5. **Bamboo and Rattan and its management:** Bamboo and Rattan resources of the country and its silviculture and management systems; Propagation techniques of bamboos and rattan.
6. **Plantation Silviculture:** Plantation establishment, plantation maintenance, Nutrition of tree crops, and dynamics of stand growth; Competition and allelopathy on stand development. Manipulating forest stands related to particular end products including non-timber uses; Silvicultural treatments for maximizing forest yield and production.
7. **Threatened Tree Species:** Domestication, popularization and conservation of threatened timber species, Plantation programs of the threatened timber species in Bangladesh.

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended bibliography:

- Champion, H.G., Seth, S.K. and Khattak, G.M. 1965. Manual of Silviculture of for Pakistan. Pakistan Forestry Institute.
- Champion, H.G. and Seth, S.K. 1963. General Silviculture for India. Forest Research Institute, Dehra Dun, India.
- Daniel, T.W. et al. 1979. Principles of Silviculture. McGraw Hill Book company, NY.
- Dwivedi, A.P. 1993. A Text Book of Silviculture. International Book Distributors, India.
- Evans, J. 1993. Plantation Silviculture in the Tropics. Clarendon press, Oxford.
- Kostler, J. 1990. Silviculture. International Book Distributors, Dehra Dun, India.
- Luna, R.K. 1989. Plantation Forestry in India. International Book Distributors, India.
- Matthews, J.D. 1993. Silvicultural systems. Clarendon press, Oxford.
- Prakash, R. and Khanna, L.S. 1983. Theory and Practice of Silvicultural Systems. International Book Distributors, Dehra Dun, India.
- Smith, D.M. 1976. The Practice of Silviculture. John Wiley and Sons, NY.
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FOR 504 FOREST SOILS

Theory: 75 (3 cr);

Term paper: 25 (1 cr);

Total: 100 (4 cr)

Course contents:

- 1. Introduction:** Concept and characteristics of forest soils.
- 2. Soils associated with major ecosystems:** Forest ecosystems such as boreal, sub-alpine lowland coniferous forests, temperate zone mixed forests, temperate zone deciduous forests, temperate zone broad-leaved evergreen forests, shrub and woodland formations, temperate rain forests, tropical forests; soil orders and major ecosystems of the world.
- 3. Forest floor:** Introduction, function, layers, types of humus and properties of forest floor; characteristics and types of floors in different forests of Bangladesh.
- 4. Soil biology:** Biota including higher plants, their kinds and functions in forest soils, conditions influencing biological activity in forest soils; mycorrhizae, their forms and functions in tree growth.
- 5. Effects of vegetation on Soil:** Effects of tree growth on soil properties.
- 6. Soil water:** Role of water in forest management; soil water constants; physical classification of soil moisture; methods for expressing water tension; soil-plant-water continuum; forest management in relation to water yield; soil and site management.
- 7. Nutrient cycling:** Geochemical nutrient cycling as nutrient input, output and short-term nutrient balances and biological nutrient cycling as nutrient uptake, retention, distribution, return, internal transfer etc. in forest ecosystem.
- 8. Management of problem soils:** Management of sites such as denuded hill slopes, land slips, sandy soils, waterlogged area, saline, alkali and acidic soils.
- 9. Tropical soils:** Climate, geology, soils, nutrient cycling and traditional system of management of forests in tropical region; classification of forest soils in Bangladesh.
- 10. Soil survey:** Purpose, technique, base map used and types of soil survey; soil survey done by SRDI in Bangladesh.

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended Bibliography:

- Armson, K.M. 1979. Forest Soils: Properties and Processes. Univ. Toronto Pres. Toronto.
- N. C. Brady. 1996. The Nature and Properties of Soils 10th edition, Prentice Hall of India Private Ltd.
- Pritchett W.L. and Frisher. R.F. 1987. Properties and Management of Forest Soil. John Wiley & sons, New York.
- S.M. S. Haque. 1997. Afforestation Effects on Former agricultural Soil Ph D Thesis, Aberdeen University. UK.
- USDA, 1951. Soil Survey Manual, Hand Book No- 18, Washington D. C. U.S.A.
- Wilde S.A. 1958. Forest Soil, Ronald Press Company.

FOR 505 ECOLOGY AND MANAGEMENT OF MANGROVE FOREST

Theory: 75 (3 cr); Term Paper: 25 (1 cr); Total: 100 (4 cr)

Course contents:

- 1. Introduction:** Coastal landforms and geomorphic processes; mangrove flora and fauna and their impact on mangrove ecosystem; distribution of mangrove species; erosion and accretion of coastal lands.
- 2. Water relations and nutrients:** Photosynthesis and water relations in mangroves; leaf litter production and dynamics; litter decomposition and nutrient enrichment.
- 3. Ecology and physiology:** Ecological and physiological characteristics of mangroves; succession in mangrove communities; methods of studying mangrove structure; stand dynamic processes; ecology of coastal wet land and management of its resources.
- 4. Mangrove silviculture and management:** Pattern and processes in mangrove ecosystem and their relevance to silvicultural practice; seed production and regeneration; manmade mangrove forests and its impacts; mainland species vs. mangrove species; conversion of non-cover crop area to forests; depletion of mangroves in Bangladesh.
- 5. Integrated management:** Role of international organization in mangrove forest management; mangrove ecosystem as a production system; role of mangroves in promoting crabs, salt, shrimp, snake, fish resources and ecotourism.
- 6. Environmental impacts and heritage:** Impact of oil spills on mangrove forests; problems and management of mangrove ecosystem and coastal zones; coastal environment and its major environmental issues and development; Sundarban as a world heritage site.
- 7. Mangroves for the Future:** MFF activities in Asian countries.

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended bibliography:

- Chaffery, Miller, and Sandom, 1985. A Forest Inventory of the Sundarbans, BGD. Main Report. Appendices 1-16 Land Resources Development Center Tolworth Tower, Burton, Surrey England KT6 7DY.
- Das and Siddiqi -1985. The Mangroves and Mangrove Forests of Bangladesh. BFRI, Chittagong.
- FAO, 1994. Mangrove Forest Management Guidelines, FAO - Forestry Paper 117, FAO, Rome, Italy.
- Kamaluddin M. 1981. Forest Ecology. Institute of Forestry, University of Chittagong, Chittagong.
- Prain D. 1994, Flora of the Sundarbans, Allied Book Centre, 15 A, Rajpur Road, Dehra Dun.
- Rahman M.A. & Others – 1998. Integrated Management of Ganges Flood Plains & Sunderbans Ecosystem, BARC, Dhaka. Dept. of Agricultural Extension, Dhaka.
- Rahman, M.A. 1988. Proceedings of the Seminar on Top Dying of Sundri (*Heritiera formes*) Trees. BARC, Airport Road, Farm Gate, Dhaka.
- White, K.J. 1979. A Comprehensive Plan of Research for the Sunderban Forest, F.D. No.-14, UNDP/FAO, Project BGD/72/005, FRI, Chittagong.
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FOR 506 ADVANCED MENSURATION AND COMPUTING
Theory: 75 (3 cr); Term Paper: 25 (1 cr); Total: 100 (4 cr)

Course contents:

- 1. Measuring Tree Crops:** Classification of forest crops on the basis of species, age and diameter. Relationships between age, diameter, height etc.; Estimating of stock per hecter.
- 2. Probability Distributions:** Normal, binomial and Poisson distributions; normal distribution in even age crops of a single species; Beta distribution for young plantation and other components of plantations high forests; likelihood ratio and its application in forestry.
- 3. Advanced Regression:** Simple and multiple regression analysis, analysis of variance and selection of best model; pooled variance. Measures of variance and confidence interval. Goodness of fit, weighted regression.
- 4. Basal Area:** Estimating basal area per hecter using sample plots; estimating basal area per hecter using relascope, wedge prism and other instruments and methods.
- 5. Height Measurement:** Total height, merchantable height measurement by using different instruments and methods. Weighted averages, height distributions in plantations, crown size measurement.
- 6. Sampling:** Use of random, systematic, stratified and other important samplings used in Forestry.
- 7. Volume:** Calculation of volume per hecter using different methods, volume estimation using point sampling.
- 8. Site Assessment:** Importance of site assessment; Choice of species and prediction of growth, site assessment by dominant height and age; Constructing dominant height on age curves.
- 9. Taper Function:** Taper function for some selected tree species, taper function model, and parameter estimations.
- 10. Use of Different Computer Software Used in Forestry:** Excel, Minitab, SAS, and SPSS.

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended Bibliography :

- Chaturvedi, A.N. and L.S. Khanna, . Forest Mensuration, International Book Distributors, Dehradun-248001, India.
- Dilwarth, J.r. and J.F. Bell. . Variable Probability Sampling. Variable Plot and Three P. OSU Book stores Inc. USA.
- Hutsch, B. Miller and Beers. Forest Mensuration.
- Lauly, J.P. 1973. Manual of Forest Inventory with Special Reference to Mixed Tropical Forests. FAO. Rome.
- Loetsch, F. and K.E. Haller. Forest Inventory. HGV Verlagsgessellschaft Muucheu, Beru Wien. Vol. 1 & Vol. 2.
- Philip, M.S. Measuring Trees and Forests. Division of Forestry, University of Dar es Salaam.
- Rosner Bernard. Fundamentals of Biostatistics, Duxbury Press, Boston.

FOR 507 PRODUCTION PLANNING AND OPTIMIZATION IN HARVESTING
Theory: 75 (3 cr); Term Paper: 25 (1 cr); Total: 100 (4 cr)

Course contents:

- 1. Logging Production and Cost Analysis:** Logging as an industry; components of logging production; methods of production data collection; time study techniques – continuous timing, shift level study, activity sampling; production and cost data analysis; regression as a tool in production study; break-even analysis in production planning.
- 2. Machine Replacement:** Procedure of replacing logging equipment by ‘machine replacement’ technique.
- 3. Application of Linear Programming in forest Operation:**
Graphical *introduction* to linear programming; the mathematical model of linear programming; Linear programming as a tool of production planning; Linear programming application to *harvesting* – area constraints, harvest flow constraints, harvest planning examples, sensitivity analysis, optimal solution; and Linear programming applications in wood products – log supply limitation, veneer production planning as example, sensitivity analysis, optimal solution.
- 4. Transportation Model in Logging:** Transportation model applied to forest transportation network; application of integer programming in logging industries.
- 5. Safety and Ergonomics:** Role of safety and ergonomics in production planning; concept of workload and the evaluation of heavy work in logging; Concept of the ergonomic design of logging tools and equipment.
- 6. Training and Education:** Training to operators on product optimization in harvesting and wood industries. Education and awareness to operation technicians about appropriate technology.
- 7. Total Quality Management (TQM):** Application of total quality management (TQM) tool in production planning of harvesting and forest product industries.

Term Paper:

Project on production planning and optimization in harvesting or forest product industries- sampling design, data collection, analysis, and presentation of report; training project-formulation and presentation.

Recommended bibliography:

- Apud, E., L.Bostrand, I.D. Mobbs, and B. Strehlke. 1989. Guide lines on ergonomic study in forestry. ILO., Geneva. 241p.
- Bronson, R. 1982. Theory and problems of Operations research. Schaum’s Outline Series – McGraw-Hill Book Co. N.Y. 328p.
- Dykstra, D.P. 1984. Mathematical programming for natural resource management. McGraw-Hill Book Co. N.Y. 317p.
- Loon, J.H.V., F.J.Staudt, and J.Zander. 1979. Ergonomics in tropical agriculture and forestry. Center for Agricultural Publishing and Documentation, Wageningen. 135p.
- Olsen, E.D., M.M. Hossain, and M.E. Miller. 1998. Statistical comparison of methods used in harvesting work studies. Forest Research Laboratory, Oregon State University, U.S.A., Research Contribution 23. 41p.
- Taha, H.A. 1982. Operations Research – an introduction. 3rd. Ed. Macmillan Publishing Co. Inc. N.Y. 848p.
- Wardel, P.A. 1971. Operational research and the managerial economics of forestry. London: Her Majesty’s Stationery Office. Forestry Commission Bulletin No. 44. 140p.
- Heizer, J. and B. Render. 1999. Operations Management. 5th ed. Prentice Hall Upper Saddle River, NJ 07458. 837p.
- Lussier, L. J. 1961. Planning and Control of Logging Operations. Forest Research Foundation, University Laval, Quebec, Canada, 135p.

FOR 508 GIS IN NATURAL RESOURCES MANAGEMENT

Theory: 75 (3 cr); **Term Paper:** 25 (1 cr); **Total:** 100 (4 cr)

Course contents:

- 1. Natural Resource Management and GIS:** Natural Resources in Bangladesh; Renewable and non renewable, spatial module in resources management; Philosophy of GIS; approaches of GIS.
- 2. Digital Representation of Geographic Data:** Technical issues pertaining to digital representation of geographic data; Database and Database Management System; Raster geographic data representation; Vector data representation; Object-oriented geographic data representation.
- 3. Maps and GIS:** Map scale; Classes of maps; Mapping process; Plane coordinate systems and transformations; Geographic coordinate system; Map projection; Geo-referencing;
- 4. Data Quality and Data Standards:** Concepts and definitions of data quality; Assessment of data quality; Raster and vector data; Managing spatial data errors.
- 5. Visualization of Geographic Information**
Cartography in the context of GIS; Visualization of geographic information; Digital terrain modeling; Acquisition of digital terrain data; Data processing, analysis and visualization; Application of digital terrain models.
- 6. Spatial Analysis and Modeling:** Acquisition of spatial data for the terrain: topographic mapping; attribute data for thematic mapping; Descriptive Statistics; Spatial autocorrelation; Quadrante counts and Nearest-Neighbor analysis; Trend surface analysis; GIS modeling.

Term paper:

GIS project (emphasizing forestry) planning and geographic database design using IDRISI for windows and ArcGIS.

Recommended bibliography

- Akthar, S. and Karki, A.S. 1999. Application of GIS to Mountain Land-use planning. International center for Integrated Mountain Development. Kathmandu, Nepal.
- Avery, T.F. and Berlin, G.L.. 1985. Interpretation of Aerial Photographs. 4th edn. Burgess Publishing co. Minneapolis, Minnesota.
- Buhmann, S. 1996. Geographic Information System. Bruenig, E.F. and Bossel, H. (eds.). Natural Resource Systems Analysis.
- Burrough, P. A. and McDonnel, R. A. 1998. Principles of Geographic Information Systems. Oxford University Press. 333 p.
- Chrisman, N. 1997. Exploring Geographic Information Systems. John Wiley & Sons. 298p.
- Clarke, K. C., Parks, B. O. and Crane, M. P. 2002. Geographic Information Systems and Environmental Modeling. Prentice-Hall of India. 306 p.
- Colwell, R.N.; Esters, I.C. and Thorley, G.A. (eds.). 1983. Manual of Remote Sensing Vol. 2. Interpretation and Application. Amer. Soc. of Photogrametry, Virginia.
- De Mers, M.N. 1999. Fundamentals of Geographic Information Systems. Second edition. New York. 498p.
- EGIS. 2000. Geo-spatial tools for analysis of floodplain resources. UPL. 100 p.
- ESRI. 2007. ArcGIS 9 using ArcGIS Desktop.380 New York Street, Redlands, USA. 435pp.
- IDRISI. 2005. IDRISI softwares. IDRISI resource center, Clark University, Worchester, MA, USA.
- Korte, P and George, B. The GIS Book. Onward press. 387 p.

- Lillesand, T.M. and Kiefer, R.W. 1987. Remote sensing and Image Interpretation. Second Edition. John Wiley and Sons. New York, USA.
- Lo, C. P. and Yeung A. K. W. 2002. Concepts and techniques of Geographic Information Systems. Prentice-Hall of India. 495 p.
- Moffit, F.H. and Muhlail, G.W. 1980. Photogrammetry. 3rd Edn. Harper and Row Publishers N. York.
- Paine, D.P. 1981. Aerial Photogrammetry and Image Interpretation for Resource Management. John Wiley & Sons. New York, USA.
- Sharma, M.K. 1986. Remote Sensing & Forest Surveys. International Book Distributors. Dehra Dun, India.
- Simonett, D.S. and Ulaby, F.T. (eds). 1983. Manual of Remote Sensing. Volume One. Second edition. American Society of Photogrammetry. USA.
- Walford, N. 1995. Geographical data analysis. John Wiley & Sons. 446p.

FOR 509 TREE SEED TECHNOLOGY

Theory: 75 (3 cr); **Term Paper:** 25 (1 cr); **Total:** 100 (4 cr)

Course contents:

1. **Introduction: Seed** Biology, Flowering, Pollination, and Seed Maturation, Seed morphology and physiology, Dormancy, Germination.
2. **Seed Collection:** Genetic and phenotypical characteristics of seed trees, Seed Source, Seed Production, Collection Operations.
3. **Seed handling and Postharvest care:** Drying and Extracting, Seed Cleaning, sorting and upgrading, Storage Principles and Applications, Seed protection Physical damage, Seed Insects and pathogens.
4. **Seed Quality Evaluation: Seed Sampling:** Moisture Content, Purity and Weight, Germination Tests, Rapid Tests including Cutting, TZ, Excised Embryo, Hydrogen Peroxide, X Rays and Leachate Conductivity, Vigor Tests.
5. **Seed treatment:** Pre-storage and pre-sawing treatments, physical, chemical, biological treatments.
6. **Germination medium and containers:** sand, soil, compost, ash, sawdust, coconut husks, peat, polybags, earthen pots, bamboo baskets.
7. **Seed types and germination method:** Direct sowing, dibbing, germination trays, refrigeration, peat.
8. **Seed Programs:** National Programs, Seed Centers, Labeling and Certification, Germplasm Conservation
9. **International organizations for seed collection and technical supports:** Food and Agriculture Organization (FAO), International Union of Forestry Research Organizations (IUFRO), IUFRO Seed Problems Project Group, International Seed Testing Association (ISTA), ASEAN-Canada Forest Tree Seed Centre, Nitrogen Fixing Tree Association, International Council for Research in Agroforestry (ICRAF), DANIDA Forest Seed Centre, CSIRO Division of Forest Research, Commonwealth Forestry Institute (CFI), USDA Forest Service Tree Seed Research Unit, National Tree Seed Laboratory USDA.

Term Paper: Students will prepare term paper on topics given by course teacher.

FOR 510 LAND USE MODELING AND POLICY ANALYSIS
Theory: 75 (3 cr); Term Paper: 25 (1 cr); Total: 100 (4 cr)

Course contents:

- 1. Introduction:** Land and Land use change; land cover; Historical land use changes in Bangladesh and other countries; Drivers of land use change; effects/problems of land use change.
- 2. Land Use Planning:** Basic concepts and theories relevant to land use planning and management.
- 3. Land Use Modeling:** Definition, scope, objectives and methods of land use modeling; Need for land use modeling and their uses; Land zoning and land use.
- 4. Land Use Modeling for Climate Change:** Modeling changes in land use due to climate change impacts at different scales- global, regional to local; Land use modeling in decision making processes including trade-offs between different policy objectives like mitigation vs. adaptation.
- 5. Land Rights, Valuation and Conflict Management:** Land rights and land tenure; Process of land valuation, land use conflicts, land reforms and some experiences.
- 6. Land Use Policy:** Approaches to land and land use policies; Need, scope and objectives of land use policy; National policies covering land and land use in Bangladesh, Land use policy in other countries.
- 7. Landscape Ecology, Urban Forestry and Wetlands.**
- 8. Land Use, Wildlife Habitats and Biodiversity:** Fundamentals of Wildlife habitats and Biodiversity.

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended Bibliography:

- Brammer, H. 2002. Land Use and Land Use Planning in Bangladesh. The University Press Limited, Dhaka.
- Davidson, D.A. 1982. Soil and Land Use Planning. Longman, London.
- Davies, K.P. 1976. Land Use. McGraw-Hill Inc. USA.
- FAO, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development, UNDP/FAO Project BGD/81/035, Technical Reports 1-7, FAO, Rome.
- FAO. 1993. Guidelines for Land-use Planning. Food and Agriculture Organization of the United Nations, Rome (<http://www.fao.org/docrep/T0715E/t0715e0c.htm>).
- FAO/UNDP. 1971. Bangladesh Soil Resources, Soil Survey Project, AGL: SF/PAK 6 Technical Report 3, 185-198pp.
- Hassan, M.M. 1999. Soils of Bangladesh: Their genesis, classification and use potential. March Printers Ltd., Dhaka.
- Mandal, R.B. 1990. Land Utilization: Theory and Practice. Concept Publishing, New Delhi.
- OECD, 1976. Land Use Policies and Agriculture. Organization for Economic Co-operation and Development, Paris.
- Richards, B.N. and Hassan, M.M. 1988. A Co-ordinate Forest Soil Research Program for Bangladesh, 31-32pp.
- Richards, B.N. and Hassan, M.M. 1989. Dendroecological Regions of Bangladesh: A land capability assessment for tree species. FAO/UNDP Project BGD/81/010, Working Paper- 7, BFRI, Chittagong.
- Sabrousse, R. 1984. Preliminary Report on the Ecological Classification of Plantations in the Chittagong and Chittagong Hill Tracts District. Working Paper No. 2, FAO/UNDP Project BGD/79/017.
- Stevens, P.R. 1987. A simplified field manual for site classification and site suitability assessment in Bangladesh forests. FAO/UNDP Project BGD/81/011- Assistance to the Second Agricultural Research Project.

FOR 511 BIOINFORMATICS

Theory: 75 (3 cr); Term Paper: 25 (1 cr); Total: 100 (4 cr)

Course contents:

PART – ONE: BASICS of BIOINFORMATICS:

- 1. Introduction:** Definition, Basic concepts - Protein and amino acid, DNA & RNA, Sequence, structure and function.
- 2. Bioinformatics databases:** Introduction, Motivation, Type of databases, Nucleotide sequence databases, Primary nucleotide sequence databases - EMBL, Gene bank, DDBJ; Secondary nucleotide sequence databases - UniGene, SGD, EMI Genomes, Genome Biology; Protein sequence databases - SwissProt/TrEMBL, PIR; Sequence motif databases - Pfam, PROSITE, Protein structure databases - Protein Data Bank, SCOP, CATH; Other relevant databases – KEGG, PQS, DockGround
- 3. Sequence Alignment and Database Searching:** Single sequence alignments - Biological motivation, Pairwise alignments, Scoring matrix (PAM, BLOSUM), Gap penalty; Dynamics programming - Needleman-Wunsch, Smith-Waterman, Heuristic methods (FASTA, BLAST); Statistics of sequence alignment score - E-Value and P-Value; Multiple sequence alignments – Clustal W, Profile (Profile-sequence alignment, Profile-profile alignment); PSI-BLAST, Hidden Markov Models - Viterbi algorithm, HMM based multiple-sequence alignment, SAM
- 4. Protein Structure Alignments:** Structure superposition – RMSD, TM-score; Structure alignment - Different structure alignment algorithms (DALI, CE, VAST, TM-align); Number of protein folds in PDB

PART – TWO: PROTEIN STRUCTURE

- 1. Protein Secondary Structure Predictions:** Protein secondary structure - Hydrogen bond, Defining a secondary structure element, Methods for predicting secondary structure - Chou and Fasman method, PHD, PSIPRED, SAM.
- 2. Protein Tertiary Structure Modeling:** Basic concepts, Protein folding and dynamic simulation, Comparative modeling, Modeller-Swiss-Modeller, Threading - Bowie-Luthy-Eisenberg, Profile-profile alignment, Gen Threader, PROSPECTOR, FFAS03, Meta-threading (3D-jury, LOMETS), Ab initio modeling - Anfinsen thermodynamic hypothesis, UNRES, ROSETTA, TOUCHSTONE; Combined modeling approaches - TASSER/I-TASSER, CASP: A blind protein structure prediction competition
- 3. Experimental Methods for Protein Structure Determination:** X-ray crystallography - Diffraction theory, Phase determination, Calculating and interpreting electron density maps, Model building and refinement, Structure assessment, Crystallization of macromolecules; Nuclear magnetic resonance (NMR) - Classical NMR spectroscopy, Theoretical description of NMR spectroscopy, Experimental aspects of NMR spectroscopy, Relaxation and dynamic processes, Heteronuclear NMR experiments, Sequential assignment and structure calculations.

PART –THREE: BIOMOLECULAR SIMULATIONS

- 1. Basic Concepts:** Units and derivatives, Force field and energy landscape, Truncation of nonbonded interactions
- 2. Conformational Sampling:** Introduction, minimization and algorithms, Molecular dynamics, Ensembles (statistical mechanics), Monte Carlo simulations
- 3. Solvation:** Introduction, Periodic boundary condition, Ewald summation, implicit solvent model and continuum electrostatics, Monte Carlo simulation on parallel computers
- 4. Advanced Techniques:** Introduction, Replica-exchange simulations, Restraint potentials, Free energy calculations, Membrane simulations

PART – FOUR: OTHER AREAS OF BIOINFORMATICS

- 1. Biological Membranes:** Introductions, Roles and Structural features - Membrane lipids, General structures, Aggregation states, Polymorphism, Thermal transitions, Electrostatic effects, Molecular dynamics, Membrane proteins, Crystallization, Structure/function relations, Membrane proteins, MD simulation of Membrane proteins
- 2. Protein Function:** Sequence to function, Structure to function, Protein function identification methods and databases
- 3. Phylogenetics:** Sequence-based taxonomy, Why important, Models, assumptions, and interpretations, From multiple alignment to phylogeny - Neighbor joining, Maximum likelihood and parsimony; Computer tools for phylogenetic analysis – DISTANCES, GROWTREE, PAUP, PHYLIP
- 4. Metabolism and Networks**

Term paper: Term paper will involve the application of available bioinformatics tools for carrying out analysis on data available in online repositories and reporting the findings.

Recommended Bibliography:

- Brown, S. M., 2000, Bioinformatics : A Biologist's Guide to Biocomputing and the Internet, Claverie, J-M, Notredame, C. 2006, Bioinformatics for Dummies, 456 pp
- Gibas C, Jambeck, P, 2001, Developing Bioinformatics Computer Skills, O'Reilly Media, 411pp
- Higgins, D and Taylor, W., 2000, Bioinformatics : Sequence, Structure, and Databanks : A Practical Approach, Oxford University Press, 249pp
- Meidanis, J., Joao C., Joao S. and Setubal J. C, 1997, Introduction to Computational Molecular Biology, Pws Pub. Co, 320pp.
- Misener, S, Krawetz, S. A., 1999, Bioinformatics: Methods and Protocols, 131pp
- Stephen A., Krawetz and Womble D, (eds), 2003, Introduction to Bioinformatics: A Theoretical and Practical Approach Humana Press, Totowa, NJ; ISBN1 58829 241 X; 746 pp

FOR 512: CLIMATE CHANGE, REDD+, CARBON MEASUREMENT AND ECOSYSTEM MONITORING

Theory: 75 (3 cr); **Term Paper:** 25 (1 cr); **Total:** 100 (4 cr)

Course contents:

Section-A: Climate change, REDD+

- 1. Introduction to Climate change:** Scientific background, Concepts, definitions and basic features of CC, forms and extent of CC, Climate Change- Global and Bangladesh Perspectives
- 2. Forest and Biodiversity Conservation- The interconnectivity with CC:** Definitions, concepts and basic features, Various approaches of forest and biodiversity conservation, Legal and policy frameworks dealing forest and biodiversity conservation, Sink and sources of carbon- special discussion on forests, Monitoring of the forest and biodiversity degradation process,
- 3. Various Mitigation Strategies of Climate Change:** The CDM mechanism; A/R; REDD+; Verified Carbon Standard for AFOLU;
- 4. Introduction to REDD+:** Definitions, concept and background; Scopes and scale of REDD+; Various stages of REDD+; Global initiative for REDD+- salient features of UN-REDD Program; Governance and social issues in REDD+; Challenges in implementing REDD+ program
- 6. Stakeholder Involvement in REDD Mechanism**
- 7. Environmental and Social Benefits of REDD Programme**
- 8. Carbon Stock Measurement for REDD+ Program**
- 9. Key Issues to National Forest Monitoring and the REDD+**
- 10. Developing a Monitoring, Reporting and Verification System for REDD+**
- 11. The REDD+ Scenario in Bangladesh:** Current status of REDD+ in Bangladesh – MRV, RPP; Institutional framework of REDD+ in Bangladesh; Challenges in implementing REDD+ in Bangladesh

Section- B: Carbon Measurement and Ecosystem Monitoring

- 1. Carbon as an agent of CC; The relationship between CC and carbon**
- 2. Terrestrial Carbon:** Basic concepts and attributes of carbon, Global carbon cycle, Land use change and carbon accumulation, Role of terrestrial carbon and forests in mitigating CC,
- 3. Legal, Policy and Institutional Frameworks Related to CC and Carbon Monitoring:** Offsetting carbon; Institutional mechanism-UNEP, GEF; Framework approaches- UNFCCC, Kyoto Protocol, IPCC, CDM; Verified carbon standard (VCS) and AFOLU; Overview of REDD+
- 4. Drivers of land use change and the carbon pool;**
- 5. IPCC Approach- reference level, setting baseline:** Emission data- changes in carbon stocks; Activity data- changes in area by category
- 6. Role of Carbon Stock Measurement in Activity Data and Emission Factors:** Generation of land use maps; Generation of carbon density
- 7. Carbon Stock Measurement Methods:** Biomass estimation- methods and principles; Carbon monitoring methods; Designing sampling framework for field study and its importance; Application of statistics; Terrestrial carbon measurement method
- 8. Community Involvement in Carbon Measurement:** Importance of community engagement; Approaches to engage community- case studies
- 9. Collaborative forest management:** Approaches of collaborative forest management, Different sorts of collaborative forest management, forest co-management, History of forest Co-management in Bangladesh, co-management systems in PAs of Bangladesh, Co-management Council and Co-management Committee, Success and criticisms of Co-management in forest management of Bangladesh, Criteria Indication

FOR 513 AGROFORESTRY AND SUSTAINABLE RESOURCE DEVELOPMENT
Theory: 75 (3 cr); Term Paper: 25 (1 cr); Total: 100 (4 cr)

Course contents:

- 1. Introduction:** Concepts, Principles, Practices and Indigenous Knowledge in Agroforestry.
- 2. Agroforestry System Design and Development:** Overview of Agroforestry Systems Design; Indigenous agroforestry technology development, adoption of agroforestry systems.
- 3. Interactions:** Ecophysiological interactions for light, water, space and nutrients; soil, water, biodiversity & environmental conservation; allelopathy in agroforestry systems; Compatibility of agroforestry species mixture.
- 4. Agroforestry Project Planning and Management:** Planning and preparation of feasibility studies; Implementation, management, monitoring and evaluation of agroforestry projects; Documentation and evaluation of agroforestry systems.
- 5. Production and Management:** Component analysis; Technologies, indigenous systems; Agroforestry systems in the tropics and temperate regions; Integrated management; Farm technology and industries development.
- 6. Social Agroforestry:** Theories and concepts; Agroforestry extension; Agroforestry & community development; Gender issue in agroforestry; Limitation and prospects of agroforestry in Bangladesh.
- 7. Research and Development:** Research needs in agroforestry; Integrated research; Methods for agroforestry research and their application; Critical review of the existing agroforestry models in Bangladesh.

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended bibliography:

- Alam, M.K., Ahmed, F.U. and Amin, S.M.R. (eds.). 1997. Agroforestry: Bangladesh Perspective. BARC, Dhaka.
- Burch, W.R. and Parker, J.Kathy (eds.). 1991. Social Science Applications in Asian Agroforestry. Winrock International, USA.
- Huxley, P.A. 1983. Plant Research and Agroforestry.
- Jarvis, P.G. 1999. Agroforestry: Principle and Practices.
- Khosia, P.K. and Kholi, R.K. 1987. Social Forestry for Rural Development.
- Nair, P.K.R. 1989. Agroforestry Systems in The Tropics. Kluwer Academic Publishers, The Netherland.
- Ong, C.K. and Huxley, P.A. 1996. Tree-Crop Interactions: a Physiological Approach.
- Sinclair, F.L. 1995. Agroforestry: Science, Policy and Practice.
- Young, A. 1989. Agroforestry for Soil Conservation.

FOR 514 SOCIAL FORESTRY DEVELOPMENT AND PRACTICE
Theory: 75 (3 cr); Term Paper: 25 (1 cr); Total: 100 (4 cr)

Course contents:

- 1. Introduction:** Concepts of social forestry; participatory forestry; participatory resource management; social forestry v.s. traditional forestry; social forestry as a component of rural development.
- 2. Policy, Legislation and Governmental Support in Social Forestry:** Forest policy; frame work for forest policy development; policy issues for social forestry development in Bangladesh; institutional issues, role of NGOs and media on social forestry policy.
- 3. Technology in Social Forestry:** Identification, characterization, and assessment of appropriate production and conservation technologies in social forestry. Productivity and sustainability.
- 4. Rural social systems:** Structure and dynamics of rural social systems and their implications to social forestry; indigenous knowledge in social forestry.
- 5. Gender Issues in Social Forestry:** Productivity, efficiency and equity in women participation; opportunities and constraints for women participation in social forestry; policies on gender in relation to forestry and sustainable development.
- 6. Research Methods:** Methods, techniques and tools for assessing community resources, community selection and problem identification; choosing appropriate tools; organizing a typical PRA/RRA.
- 7. Program Planning and Project Formulation:** Social forestry project planning; project preparation; project description, strategy formulation, financial procedures, organization and management, implementation and monitoring; presentation of a project.

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended bibliography:

- Bruce, J.W. 1990. Community Forestry-Rapid appraisal of tree and land tenure. Community forestry Notes 5. FAO
- Chambers R. 1983. Putting the Last First. Longman, London.
- Chowdhury, A. N. 1989. Let grassroots speak. People's participation, self-help groups and NGOs in Bangladesh. UPL, Dhaka.
- David-Case, D. 1989. Community Forestry.. Participatory assessment, monitoring and evaluation. Community forestry note 2. FAO
- Fox, J. 1990. Diagnostics Tools for Social Forestry. In M. Poffenburger, ed. Keepers of the Forest, Kumarin Press.
- IFESCU, 1990. Reading on Rural Development, Social forestry and Forestry extension. Volume RECOFTC, Bangkok. Reports on Community Forestry on Policy Research (Report no. 5, 1990), Sustainable management (Report no. 9, 1992) and Legislation (Report no. 11, 1993).

FOR 515 FORESTRY COMMUNICATION AND POLICY INTEFACE
Theory: 75 (3 cr); Term Paper: 25 (1 cr); Total: 100 (4 cr)

Course contents:

- 1. Theories and Principles of Forestry Extension:** Forestry extension and its role in promoting sustainable forestry; Theoretical foundation of extension.
- 2. Extension Perspectives:** Extension as education, extension as communication, extension as a change process, extension as technology delivery system, extension as a participatory process.
- 3. Forestry Extension:** Technology and methods; Technology transfer.
- 4. Learning Theory and Principles:** Teaching-learning process; Cognitive dissonance theory; Three learning situations; Pedagogy and Andragogy; Conditions of learning; principles of training.
- 5. Communication Theory,** Diffusion-adoption model, Communication techniques and strategy, Oral presentation, working meetings; Extension and communication research.
- 6. Development Support Communication (DSC):** Its role, functions, components etc.
- 7. Forestry Extension:** Program development; planning, implementation and evaluation of forestry extension programs, forestry extension organizations; Institutional approach in forestry extension; human, physical and financial resources.
- 8. Forestry extension activities:** Activities in Bangladesh and countries in Asia-Pacific region.
- 9. Research survey:** Techniques in forestry extension, research needs and priorities.

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended bibliography:

- Ahmed, M. R. 2000. Compendium of the papers presented in “In country training course for DCF/ACF under Forestry Sector Project” Bangladesh Forest Academy, Chittagong.
- FAO, 1986. Forestry Extension Organization. FAO Forestry Paper no. 66. Rome.
- FAO, 1987. Forestry Extension Methods. FAO Forestry Paper no. 80. FAO, Rome.
- GCP/RAS/11/NET, 1988. Planning Forestry Extension Programmes. Field Document no. 8
- IFESCU, 1990. Reading on Rural Development, Social Forestry and Forestry extension. Volume 1 and 2.

FOR 516 COMMUNITY BASED RESOURCE MANAGEMENT AND GOVERNANCE

Theory: 75 (3 cr); **Term Paper:** 25 (1 cr); **Total:** 100 (4 cr)

Course contents:

1. **Introduction:** Concepts and theories of community based resources management; concepts of participation, groups and organizations, associations; resources identification, assessment and analysis.
2. **Cultural Anthropology:** Cultural practice, community development; Indigenous knowledge and practice; Upland/mountain resources management.
3. **Community:** Organizing, Community resources mobilization; Self-help forestry enterprises.
4. **Conceptual Framework of Participatory Resource Management:** Participatory resources management models.
5. **Concepts and Principles of Conflicts Management;** Facilitation, mediation, negotiation and resolution of resources use conflicts.
6. **Concepts of common property resources management:** sustainable management; stewardship, sharing, distribution of benefits.
7. **Integrated Conservation and Development Program (ICDP):** Ecotourism for forest conservation and community development; Community based ecotourism; Participatory Eco-park management; Ecotourism education and development.
8. **Economics and Marketing:** Marketing of community based resources management; employment regeneration, income and saving; community infrastructure development.
9. **Participatory Learning;** Participatory planning and action; PME, PAR, PRA and other research tools; Research needs and priorities.

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended bibliography:

- Burke, 1990. Common Property Resources,
RECOFTC, 1997. Ecotourism for Forest Conservation and Community Development. Report no. 15.
Roy and Chatterjee, 1994. Joint Forest Management, a Training Manual. Inter-India publications,
New Delhi.
TMI, un-dated. Community based tourism for conservation and development: a resource kit.
Kathmondu, Nepal
Willigen, Van. 1995. Applied Anthropology. Bergin and Garvey, London.

FOR 517 DEVELOPMENT ECONOMICS

Theory: 75 (3 cr.); Term Paper: 25 (1cr.) Total = 100 (4 cr.)

Course contents:

- 1. Development and Development Economics:** Development- consensus and differences in definition; Development Economics (DE) - definitions, urban and rural development; sustainability issues in development; historical legacies, global perspectives of economic development; the grounds for the study of DE
- 2. Theories of Economic Growth and Development:** modeling economic growth; major economic growth models- Solow-Swan model of growth; optimal growth model, endogenous growth model
- 3. Poverty and Inequality:** definitions, causes, sustenance, and measurement of poverty, globalization of poverty-the politics of inequality, economic growth and quality of life
- 4. Health, Education, and Human Capital:** Health and nutrition; development-environment-health-poverty trap; health and productivity; basic healthcare - a comparison between developed, developing, and under developed countries; intellectual property and health in developing countries; major ailments and economics of risky behavior, the primacy of education; facilities and outcomes of education in developing countries; educational interventions; education, income, and fertility; gender, family, and society; child labor in the global economy
- 5. Saving, Credit, and Entrepreneurship:** Credit, savings, and investment; constraints in credits access; microcredit- promises, prospects, implementation, and socio-economic development; risk and insurance, insurance failure
- 6. Political Economy and Corruption:** Public goods- ownership, markets, and economic development; national leadership and economic growth; Corruption-administrative system and corruption; culture of corruption; policy and political commitments; policy debates
- 7. Theories of Consumption, Investment and Unemployment:** Consumption under certainty and uncertainty; savings; interest rate and savings; investment and cost of capital; effects of uncertainty on investment; cash flow and investment; theories of unemployment; a generic efficiency-wage model; employment contracts- wage contract; efficient contracts; implicit contracts; implications of contracts
- 8. Inflation and Monetary Policy:** Monetary policy; Accomplishment of monetary policy; interest rate and the conduct of policy; issues in designing an interest rate, term structure of interest rate; inflation and money growth; dynamic inconsistency of and solution to inflation in monetary policy; cost of inflation; benefits of inflation
- 9. Budget Deficit and Fiscal Policy:** Government budget constraints; measurement issues in budget constraints, Ponzi scheme; strategic debt accumulation- political assumptions; economic assumption; extreme preferences; weak government and budget deficit; the cost of deficit
- 10. Development and Economic Growth- Bangladesh Perspective:** Economic growth in Bangladesh-historical trend and projection; growth and environmental responsibility; environmental accountability and economic efficiency; major industries and their contribution to national development; workplace and workers' rights in Bangladesh; development partners and foreign aid-aid availability, liberty in aid use; transparency in foreign-aided development projects; foreign aid and development policy

Objective of the course: This course is designed to acquaint the students with the development-environment interface. The students will get a clear picture on how local and global policies impact macro and microeconomic attributes of development like human capital, economic growth and development, and environment.

Term Paper: Each student will be required to work on a number of term papers on important issues of development having local, regional, and global consequences. Term papers will be both analytical and empirical. Empirical analysis **MUST** include real world development data (no matter, primary or secondary), econometric models, and relevant interpretation.

Recommended Bibliography:

Todaro, M.P. and Smith, S.C. 2009. Economic Development, 10th edition, Pearson Education, NY, USA.

Romer, D. 2006. Advanced Macroeconomics, 3rd edition, McGraw-Hill, NY, USA.

Wickens, M. 2008. Macroeconomic Theory- a dynamic general equilibrium approach, Princeton University Press, NJ, USA.

World Development Reports (<http://wdonline.worldbank.org/>)

Human Development Reports (<http://hdr.undp.org/>)

World Economic Outlooks (<http://www.imf.org/external/pubind.htm>)

Development Effectiveness Reviews: <http://www.adb.org/publications/search/1185>

A number of journal articles on development issues (will be discussed in the class)

Yusuf, S. Deaton, A. Dervis, K. Eastenly, W. I to, T. and Stiglitz, J.E. 2009. Development Economics Through the decades, The world Bank, Washington D.C.

Ray, D. 2007. Development Economic, New York University, NY, USA.

FOR 518 GENETICS AND BIOTECHNOLOGY

Theory: 75 (3 cr); Term Paper: 25 (1 cr); Total: 100 (4 cr)

Course contents:

- 1. Introduction:** Heredity and genetic materials in virus, prokaryotes and eucaryotes; chromosomes and its structure; Cell cycle and conservation of genetic materials; DNA, RNA, plasmid; DNA replication and related concepts; Gene, Genetic code, Genome, Gene naming.
- 2. Genetic Sciences:** Genetics, genomics, proteomics, transcriptomics, metabolomics; Microbial, molecular and population genetics; Evolutionary genetics; Phylogenetics; Epigenetics - cell potency and fate and bioinformatics.
- 3. Central Dogma of Biology:** Translation and transcription; Polypeptide and protein synthesis; Post-translational modifications; Gene mutations.
- 4. Gene Cloning:** Gene sequencing; isolation and purification of RNA and DNA; cDNA library construction; PCR, gel electrophoresis, blotting, microarray and other techniques used in genetics
- 5. Genetic Engineering:** Recombination - types and models; plasmids and vectors; transfection of cells; Genetic mistkers and Gene expression analysis; Use of recombinant DNA technology - GMO, GEO, Transgenic and chimeric organisms, Cloning and clones
- 6. Plant Immunity:** Immunity, immune system, genetic basis of immunity, Practical application of plant immunity knowledge in forestry
- 7. Conservation Genetics:** Genetic conservation of biodiversity; bioinformatics and system biology; Types and approaches of genetic conservation; Scope and limitations; Evolution of synthetic biology

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended Bibliography:

Genetics. M. W. Strick berger.

Molecular Biology. Robert F . weaver.

Essential Genetics. Peter J. Russel.

Principle of Gene Manipulation, Old and Primrose.

Molecular Biology of Gene. J. Watson.

Genetic Engineering. Kingman and Kingman.

Principle of Biochemistry. David L. Nelson and Michael N. Cox.

FOR 519 BIODIVERSITY AND NATURE CONSERVATION

Theory: 75 (3 cr); **Term Paper:** 25 (1 cr); **Total:** 100 (4 cr)

Course contents:

- 1. State of Biodiversity in Bangladesh:** Status and importance of genetic and species diversity. Importance of Ecosystem diversity (Forest ecosystems, Wetland ecosystems, Homestead ecosystems, Coastal and Marine ecosystems, and Agro-ecosystems). Trends of change in biodiversity of Bangladesh.
- 2. Threats to Biodiversity in Bangladesh:** Major threats causing biodiversity loss in Bangladesh. Ways forward to halt the threats.
- 3. National Biodiversity Strategy and Action Plan (NBSAP):** Analysis of current status of NBSAP. The success and obstacles to implement NBSAP and lessons learnt. Sectoral and cross-sectoral mainstreaming of NBSAP.
- 4. Biodiversity Program of Action 2020 (BPA 2020):** Introduction, implementation of BPA. Focal areas and program of action.
- 5. Convention on Biological Diversity (CBD):** Articles of the Convention on Biological Diversity. Brief description of articles 7 – 12; Status of signature, ratification, accession, acceptance and approval of CBD. Decisions of the Conference of Parties (with relevant SBSTTA recommendations). The role of Government, NGOs and other institutional mechanisms in implementing the CBD
- 6. Policies to Protect Biodiversity:** Preserving biological diversity in the tropical forests; The tropical forestry action plan. International development and the protection of biological diversity.

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended Bibliography:

Krattiger, A.F., J.A. McNeely, W.H.Lesser, K.R. Miller, Y.St. Hill and R. Senanayake (eds.). 1994. Widening Perspectives on Biodiversity. IUCN, Gland, Switzerland International Academy of the Environment, Geneva, Switzerland. Xvi & 473 pp.

UNEP. 2001. Global Biodiversity Outlook. 282 pp.

Wilson, E.O. 1988. Biodiversity. National Academy Press, Washington D.C. 521 pp.

FOR 520 WATERSHED CONSERVATION AND EXTENSION

Theory: 75 (3cr); **Term Paper:** 25 (1cr); **Total:** 100 (4cr)

Course contents:

1. **Introduction:** Conservation of basic life sustaining natural resources - land, water and vegetation in watershed.
2. **Bangladesh Watershed:** Major features and characteristics of Bangladesh watersheds.
3. **ITK:** Indigenous Technology Knowledge on Watershed Management in Bangladesh for forest, water and soil conservation and intensive production systems; uniqueness in these ITK.
4. **Land Degradation:** Land loss, land degradation, rehabilitation and restoration of land; present status, stages, causes and effects of land degradation in the world and particularly in mountainous slopes of Asia; main objectives, goals and major constraints of rehabilitation of degraded lands; driving forces, causes, impacts and state of land degradation in Bangladesh.
5. **Environmental Aspects of Surface Water Systems:** Surface water system in Bangladesh; Morphological modifications of surface water system, problems and probable solutions for water resources in Bangladesh.
6. **Water Harvesting:** Socio-economic and ethnic aspects of water harvesting systems; Constraints, opportunities and benefits from water harvesting systems.
7. **Soil Conservation Extension:** Historical perspective, causes of past failures, changed approaches,
8. **Changed Activities and Thinking on Watershed Management:** Basics and experiences of soil conservation extension - principles, guidelines, improving soil conservation extension, extension strategy in upland farming systems, aggressive soil conservation extension.
9. **Participatory Watershed Management:** Concepts, steps, participatory process in mountain watershed management, basic principles for people's participation in watershed management, participatory approaches and participatory action learning.
10. **Transfer of Technology:** Approach of extension technology, procedures of technology transfer, adoption of new technology, constraints, activities for successful adoption, effective training for adoption of technology,
Farmers' disinterest in technology adoption and participatory approach in adoption.
11. **Watershed Management Extension in CHTs:** Administrative and political settings, CHTs regulations 1900,
12. Forest Act, 1927, Headmen rules 1936, land acquisition regulation 1958, HDCs Act 1998, land and forest administration, watershed management institutions in Bangladesh, organizations for soil and water conservation, extension process in CHTs.
13. **Village Common Forests in CHTs:** History, management, sustainable management, administration pattern and significance of VCFs; variations, authority and problems in conservation of VCFs in CHTs.

Term paper: Students will prepare term paper on topics given by the course teacher (s).

Recommended Bibliography:

- S. M. Sirajul Haque and Maung Hla Myant, Watershed Management Extension and Environmental Conservation in Bangladesh, IFESCU and USDA, 2011, 188 pp.
S. M. Sirajul Haque, Watershed Management from Bangladesh Perspective, IFESCU and USDA, 2013, -
----- pp.

FOR 521 FOREST DYNAMICS

Theory: 75 (3 cr.); Term Paper: 25 (1cr.) Total = 100 (4 cr.)

Course contents:

1. **Deforestation:** Extent, intensity and causes of deforestation; impacts of deforestation in shrinkage and disappearance of different categories of plants in Bangladesh.
2. **Shifting Cultivation:** An overview of shifting cultivation worldwide and in CHTs; land administration system in CHTs; opinion, demography, duration and livelihood of shifting cultivators in CHTs; rotation cycle, types of crops grown and their yield compared to the past time from shifting cultivation, idea/knowledge about conservation aspect of land and environment; extent, intensity and causes of shifting cultivation and its impacts in shrinkage and disappearance of different categories of plants in CHTs; alternative options of shifting cultivation and village common forests in CHTs.
3. **Clear Felling and Burning:** Extent, intensity and causes of clear felling and burning; conversion of natural forest into teak and other exotic and indigenous species in different parts of Bangladesh; their impacts in shrinkage of forest, disappearance of different categories of plants and changes to other land covers in Bangladesh.
4. **Hill Cutting in Bangladesh:** Hill cutting extent and intensity; institutions and persons involved in hill cutting; hill cutting process; causes of land slides and hill cutting and their impact on imbalance ecosystem, landslide vulnerability, soil erosion, silting in river and other reservoirs, water logging in city and associated problems and sufferings to people in monsoon season; ways, means and initiatives for reducing hill cutting and land sliding taken by government of Bangladesh.
5. **Other Causes:** Shrinkage of forests through settlement and increased habitations, encroachment, agriculture, industrialization, development activities, poor and wasteful management of forests, policy weakness, law and order failures.

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended Bibliography:

- C-sequestration and CO₂ release in upland watershed of Bangladesh, S. M. Sirajul Haque, IFESCU and USDA, 2013, ----pp.
- Hill cutting in and around Chittagong city, S. M. Sirajul Haque, IFESCU and USDA, 2011, 90 pp.
- Infiltration in upland watershed of Bangladesh, S. M. Sirajul Haque, IFESCU and USDA, 2012, 75 pp.
- Soil and water in upland watershed of Bangladesh, S. M. Sirajul Haque, IFESCU and USDA, 2013, 350 pp.
- Soil erosion in upland watershed of Bangladesh, S. M. Sirajul Haque and Md. Mohitul Hossain, IFESCU and USDA, 2012, 131 pp.
- Vegetation in upland watershed of Bangladesh, S. M. Sirajul Haque and Mostafa Kamal Pasha, IFESCU and USDA, 2013, 302 pp.
- Watershed Management Extension and Environmental Conservation in Bangladesh, S. M. Sirajul Haque and Maung Hla Myant, IFESCU and USDA, 2011, 188 pp.

FOR 522 ADVANCED STATISTICS IN FORESTRY RESEARCH

Theory: 75 (3 cr.); Term Paper: 25 (1cr.) Total = 100 (4 cr.)

Course contents:

- 1. Basic Statistical Concepts:** Observations and outliers, variables and random variables, accuracy and precision, bias and efficiency; probability distribution, mean and expected value, variance, SE, joint probability, covariance and correlation, Unbiasedness and efficiency, Asymptotic properties of estimators and consistency
- 2. A Brief Overview of Classical Linear Models:** OLS assumptions; random components of regression coefficient; regression coefficients as random variables; unbiased properties of regression coefficient; efficiency of regression coefficient; maximum likelihood option; weighted generalized least square models.
- 3. Analysis of Variance: One-way Analysis of Variance-**Complete randomized design, estimation of parameters; one way ANOVA, individual contrasts, multiple comparison, model diagnostics; **Two-way layout models-**multiple comparison, contrast for main effects and interactions, two-way ANOVA, analysis of the main effect model.
- 4. Analysis of Covariance:** Variance and covariance; model structure; analysis of covariance; treatment contrast and confidence intervals
- 5. Mixed Effect Model:** an introduction; random effect one-way model; estimation of parameters in mixed effect models; Restricted maximum likelihood estimator
- 6. Generalized Linear Models:** Distinction between classical linear model and generalized linear models; elements of GLM, maximum likelihood methods; deviance and residuals
- 7. Time Series Analysis:** Data and time series; basic stochastic models; multivariate models
- 8. Nonlinear model:** Linearity and nonlinearity, Double logarithmic models, Semi-log models, Disturbance terms in nonlinear models, Nonlinear regression models
- 9. Model specifications:** Variable misspecifications- omission of a relevant variable, inclusion of an irrelevant variable; multi-collinearity and its omission; heteroskedasticity- concepts, detection through Goldfeld-Quandt test and White test, heteroskedasticity corrected SE, weighted and log-regression models; autocorrelations- concepts, detection of autocorrelation through DW test, Elimination of autoregressive conditional errors, and measurement errors

Term Paper-1: Each student will prepare a research paper. For the paper the respective student will select his/her preferred research topic. On that topic, s/he will have to collect data (no matter primary or secondary) and build his model(s) with all necessary statistical tests and quality controlling. Data analysis should be done using statistical softwares like R or SAS.

Term Paper-2: This is equivalent to a number of assignments on data analysis related to first half of the syllabus.

Term Paper-3: This is equivalent to a number of assignments on data analysis related to second half of the syllabus.

Recommended Bibliography:

- Dobson, A.J. and Barnett, A.G. 2008. Introduction to Generalized Linear Models, Taylor and Francis Group, FL, USA.
- Cowpertwait, P.S.P. and Metcalfe, A.V. 2009. Introductory time series with R, Springer, Seattle, WA, USA.
- Greene, W.H. 2003. Econometric Analysis, 5th Edition, Pearson Education, Prentice Hall, NJ, USA.
- Gujrati, D.N. 2004. Basic Econometrics, 4th Edition, McGraw-Hill, NY, USA.
- Kunter et al. 2005. Applied Linear Statistical Models, 5th Edition, McGraw-Hill, NY, USA.
- Rawlings et al. 1998. Applied Regression Analysis, 2nd Edition, Springer, NY

FOR 523 FOREST PROTECTION

Theory: 75 (3 cr.); Term Paper: 25 (1cr.) Total = 100 (4 cr.)

Course contents:

1. Brief history of Bangladesh forest management: structure, composition, problems and prospects.
2. Major threats (fire, insect, pathogens, non-pathogen, animal and natural calamities), past present and future perspectives in Bangladesh and global forests.
3. Basic fire control principals, history of fire as a management tool in the past, present, and future.
4. Forest insects and diseases, identification, hosts, life history, management implications, and interrelationship with fire and other factors.
5. Animal damage, types, reasons and control.
6. Non-pathogenic damage to forests and its management.
7. Threats from climatic change, natural and man-made calamities and management.

FOR 524 BIOETHICS

Theory: 75 (3cr);

Term Paper: 25 (1cr);

Total: 100 (4cr)

Course contents:

1. Introduction to Bioethics: Definition of Bioethics, Need for bioethics, Applications of bioethics, Moral standards and schools of thoughts in relation to biological diversity

2. Rights and responsibilities: Right of all living entities to exist, Use and abuse of nature and its ethical consequences, Interdisciplinary of bioethics, Bioethical dilemma of renewable bioenergy – cases from different countries;

3. Biosafety: Biological hazards and the concept of biosafety, Application of biosafety, Need for biosafety, Management of biosafety, Biosafety levels, Development of new technology and their bioethical consequences, Research on biological weapon and its ethical side

4. Biotechnology and Bioethics: Development of Biotechnology and creation of moral challenges; Ethical issues related to human genome project; Biotechnology Genetic engineering, GEO, GMO, GTO and the moral dilemma related to them, Patenting in Biotechnology and IPR –the emerging fronts of bioethics, GMO foods and their health issues, Labelling in relation to GMO foods,

5. Bioethics in biodiversity: Loss of biodiversity and its ethical context, Acceleration of the loss of biodiversity due to unethical behavior, ethical aspect of punishment for destruction of biological diversity, Convention on Biological Diversity (CBD)

6. Bioethical issues in forestry: The relevance of moral and ethical concerns to forest management, Recent developments in applied ethics, The relationship between bioethics and environmental ethics, Ethics in forestry, GMO and their release into the environment, Ecological restoration and its ethical consequences, Manipulation of nature – the ethical issues, Introduction of exotics and bioethics, Patenting of living organisms,

7. Experiments with Biological organisms: Bioethical perspective of cloning and synthetic biology, using plants and animals for experiments, Use of animal models in biological research and its bioethical considerations,

8. Bioethics in legal structure of Bangladesh: Biosafety, Legal and policy frameworks in relation to biosafety and bioethics in Bangladesh,

References:

1. Irland, L. 2007. Professional Ethics for Natural Resources and Environmental Managers: A Primer, Yale School of Forestry & Environmental Studies, USA. 200p
2. Galston, A.W. and Peppard C. Z. (Eds). 2005. Expanding horizon of bioethics. Springer, the Netherlands. 247p
3. Steinbock, D. 2007. The Handbook of Bioethics. Oxford University Press, UK. 737p
4. Gamborg, C. 2001. Sustainability and biodiversity: Ethical perspectives on forest management, PhD Thesis, The Royal Veterinary and Agricultural University, Department of Animal Science and Health
5. Sateesh, M.K. 2010. Bioethics and Biosafety, I. K. International Pvt Ltd, 820 p

FOR 525 PLANT STRESS PHYSIOLOGY

Theory: 75 (3 cr.); Term Paper: 25 (1cr.) Total = 100 (4 cr.)

Course contents:

1. **Introduction:** Concept of plant, plant physiology, environmental stress, stress physiology, plant response to various stress, Important biotic and abiotic stress.
2. **Major physiological processes of plants:** Plant water relations, nutrient uptake and solute transport, and carbohydrate metabolism.
3. **Major abiotic stresses and plant response:** drought, salinity, water logging, High light, hormones and temperature, mineral nutrient deficiency and heavy metal toxicity.
4. **Mechanisms of plants acclimation and adaptation to important abiotic stresses:** Elevated stress tolerance; adaptation of the photosynthetic apparatus to stress conditions; drought and salinity stress; high light and heat stress; low temperature and freezing stress; mineral nutrient deficiency and heavy metal toxicity; root responses to mineral deficiencies and toxicities; phytoremediation;
5. **Methods and technique of plant stress tolerance evaluation and plant physiology research**
6. **Plant stress signal transduction:** Hormonal alteration, gene expression in response to various environmental stresses.
7. **Plant responses to biotic stress:** pathogens and other biotic interferences, oxygen deficiency synthesis and detoxification of oxygen free radicals and oxidative cell damage under stress conditions.

Reference

Plant Physiology, Taiz and Zeiger, 4th or 5th edition. 2010. Sinauer Associates, Inc.
Introduction to Plant Physiology, 3rd edition. 2003. Hopkins and Huner. John Wiley & Sons, Inc.
Plant Physiological Ecology. 2nd edition. 2008. Lambers, Chapin, and Pons. Springer-Verlag.
Physiological Plant Ecology. 4th edition. 2003. Larcher. Springer-Verlag.
The Physiology of Plants Under Stress, Abiotic Factors. 1996. Nilsen and Orcutt. John Wiley & Sons, Inc.
Plant-Environment Interactions, 3rd edition. 2006. Huang. CRC Press.
Biochemistry and Molecular Biology of Plants. 2002. Buchanan, Grissem, and Jones. John Wiley & Sons, Inc.
Principles of Soil and Plant Water Relations. 2005. Kirkham. Elsevier Academic Press.

FOR 526 FOREST RESTORATION ECOLOGY

Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents:

- 1. Introduction to Restoration Ecology:** Definition of restoration terms; elements of restoration; ecological infrastructures and their importance in biosphere; myths, foundations and principles of restoration, multiple goals, constraints, tradeoffs, interactions, feedbacks, thresholds, context-dependence, spatial and temporal perspectives, uncertainty; ecosystem services, ecosystem restoration and restoration ecology; active restoration
- 2. Landscape Restoration:** Disturbances, Disturbance agents, Classification of disturbances; Habitat fragmentation, landscape connectivity, Biological corridor; Differences between habitat loss and fragmentation; Biological and physical effects of fragmentation; Approaches of restoration; Kinds of restoration- revegetation, Revegetation of native species; habitat enhancement and wildlife reintroduction; remediation and mitigation; ecosystem states, state transitions, resilience
- 3. Planning Restoration Projects:** Application of framework for restoration decision, Public participation in restoration decision making, Planning Restoration step by step
- 4. Forest Restoration Techniques:** Natural regeneration, differences between primary and secondary successions, time for intervention using natural regeneration; Enrichment plantings; Restoration using tree plantations; soil degradation after disturbances, use of trees to restore/rehabilitate soil properties and biodiversity; Use of pure and mixed plantations for restoration, tree species selection; Restoration techniques using agroforestry systems.
- 5. Restoring Tropical Diversity:** Restoration by intensive management, restoration through ecopark, mangrove restoration and hydrologic restoration methodology; Large scale restoration of forests in Chittagong hill tract.
- 6. Forest Restoration Projects in Different Countries:** Dryland forest restoration; forest restoration practices in Vietnam, Thailand, Malaysia, Indonesia etc.; Global change and forest restoration, forest restoration through REDD+

Term paper: Students will prepare term paper on topics given by course teacher.

Recommended bibliography

- Bennett, A, S Kimber & P Ryan. 2000. Enhancing the value of revegetation for wildlife. In: Revegetation and Wildlife: a guide to enhancing revegetation habitats for wildlife conservation in rural environments. Bushcare national and research development program research report 2/00.
- Bradshaw, A. D. 1996. Underlying Principles of Restoration, 1996. NRC, Canada.
- DeFries, Foley and Asner. 2004. Land-use choices: balancing human needs and ecosystem function. Frontiers in Ecology and Environment.
- Donald A. Falk, Margaret A. Palmer, and Joy B. Zedler, 2006. Foundation of Restoration Ecology, Society for Ecological Restoration International (SERI)
- Gray, AJ. 2002. The evolutionary perspective. In: Perrow, MR & AJ Davy (eds.). Handbook of ecological restoration. Volume 1: Principles of restoration. Cambridge University Press. pp. 68-80
- Kormondy, EJ & DE Brown. 1998. Fundamentals of Human Ecology. Upper Saddle River: Prentice Hall.
- MacDonald, DW, TP Moorhouse & JW Enck. 2002. The ecological context: a species population perspective. In: Perrow, MR & AJ Davy (eds.). Handbook of ecological restoration. Volume 1: Principles of restoration. Cambridge: Cambridge University Press.

- Perrow, MR & AJ Davy (eds.) Handbook of ecological restoration. Volume 2: Restoration in practice. Cambridge: Cambridge University Press. pp. 267-296.
- Perrow, MR & AJ Davy (eds.). Handbook of ecological restoration. Volume 1: Principles of restoration. Cambridge: Cambridge University Press.
- Society for Restoration Ecology (SRE). 2004. The SER International Primer on Restoration Ecology. 14 pp
- Tewksbury et al. 2002. Corridors affect plants, animals, and their interactions in fragmented landscapes. PNAS 99(20): 12923-12926
- Valluari, D et al. 2005. An attempt to develop a framework for restoration ecology. 65-72
- Whisenant SG. 2002. Terrestrial systems. In: Perrow, MR & AJ Davy (eds.). Handbook of ecological restoration. Volume 1: Principles of restoration. Cambridge: Cambridge University Press.
- Whisenant, SG. 1999. Repairing damaged wildlands: a process-oriented, landscape-scale approach. Cambridge: Cambridge University Press.
- Young, Betty. 2004. How plants for revegetation are grown differently than landscape plants.

FOR 527 WILDLIFE CONSERVATION

Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents:

- 1. Introduction:** A brief history of wildlife conservation; The philosophical background of wildlife conservation; Wildlife conservation is an interdisciplinary approach; Role of academia in wildlife conservation and protection; Guiding principles for wildlife conservation; Pervasive aspects of wildlife conservation; Diversity of wildlife; Extinction of wildlife; Values and ethics of wildlife conservation.
- 2. Degradation, fragmentation and loss of wildlife habitat:** Mechanism of habitat degradation; Patterns of habitat transformation; Human activities and habitat degradation; Pollution as a form of habitat degradation; Fragmentation and heterogeneity; Quantifying landscape pattern and fragmentation; Biological consequences of fragmentation; Nested species distribution; Species vulnerable to fragmentation; Approaches to wildlife habitat conservation.
- 3. Species invasions in wildlife habitat:** Conservation implications of introduced species; Impacts of invasion on native wildlife species; Factors determine whether a non-native species becomes invasive; Control of species invasion.
- 4. Impacts of climate change on wildlife diversity:** The nature of climate change; Predicted and observed impacts of climate change on wildlife; Conservation implications of climate change.
- 5. Conservation genetics:** Genetic variation and its importance in wildlife conservation; Measures of genetic diversity; Coadaptation, local adaptation and outbreeding depression; Estimation of effective population size; Calculation of Fixation indices; Genetic information and design and implementation of breeding strategies; Analyses of parentage and system of mating; Limitations of using genetics in conservation planning.
- 6. Wildlife conservation at the population and species levels:** Conserving species by conserving populations; Small populations are especially threatened; the problems of small populations, natural history and ecology; Establishment of new wildlife populations; Ex situ conservation strategies for wildlife; Conservation categories of species; Legal protection of wildlife species.
- 7. Wildlife conservation at the community level:** Protected areas; Designing protected areas; Habitat management; Restoration ecology; Ecological restoration; Animal reintroduction; Genetic considerations in reintroduction; Historic assessment of wildlife restoration; Environmental regulations that drive restoration practice; Restoration of some endangered species; Developing a restoration plan; Monitoring of reintroduced wildlife.
- 8. Wildlife conservation and sustainable development:** Government actions; Traditional societies and sustainable development; International approaches to wildlife conservation and sustainable development.
- 9. The integration of conservation science and policy:** The interface between the pursuit and use of scientific knowledge in wildlife conservation; The interaction of science, policy, politics and litigation; Integrating scientific information to guide policy; The importance of public education for wildlife conservation.

References:

- Morrison ML (2002). Wildlife Restoration. Society for Ecological Restoration. Island Press, London.
- Groom MJ, Meffe GK, Carroll CR (2006). Principles of Conservation Biology. Siinauer Associates, USA.
- Ranga MM (2005). Wildlife Management and Conservation. Agrobios, India.
- Hosetti BB (2008). Concepts in wildlife Management. Daya Publishing House, Delhi.
- Reddy MV (2008). Wildlife Biodiversity Conservation. Daya Publishing House, Delhi.

FOR 528 ECOTOURISM MANAGEMENT

Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents:

1. **Nature and Scope of Ecotourism:** History of ecotourism and its definitions; Nature based tourism, Characteristics of ecotourism; Benefits of ecotourism; Environmental, socio-cultural and economic impacts of ecotourism;
2. **Ecotourism Management:** Concept and procedures; Recreation and the environment; recreational impacts on the environment; ethical and legal concerns; code of practice for ecotourism operators; incorporating ecotourism principles into activities; interpretation; visitor guidelines; planning for minimal impact; quality control; Waste management – concept, needs, design and implementation.
3. **Ecotourism and Protected Areas:** Protection of the ecosystems; Conservation of forests, biodiversity, local cultures and heritage; Assessing Eco-Tourism Potential of a particular area/forest; Role of private sectors in Ecotourism and forest conservation; Co-management of protected areas and Ecotourism in Bangladesh
4. **Ecotourism and Development Issues:** Ecotourism as a growth sector within the tourism industry; Ecotourism and community development;
5. **Marketing Ecotourism:** The ecotourism market; Situation analysis; Market research; Promotion; Advertising; Sales; Trends in international tourism; Understanding the needs of the consumer; Consumer expectations; Development, Promotion and Marketing of ecotourism in Bangladesh; Ecotourism branding, certification and labeling.
6. **Ecotourism Facility Development:** Infrastructures and signage; Interpretations; Accommodation facilities including camp sites, cabins, resorts, etc.; Layout of facilities; Accepted practices for service facilities; Identifying catering options for different ecotourism activities; Tourism attractions and infrastructures in Bangladesh.
7. **Safety in Ecotourism:** Safety strategy, hazards and first aid; Identify/establish safety precautions/requirements/procedures for an ecotourism enterprise.
8. **Sustainability of Ecotourism:** Maintenance of Carrying Capacity; Environmental education program; Community livelihoods; Legal and policy supports from the government;
9. **Ecotourism Management Plan (EMP):** Concept, procedures and implementation of EMP.
10. **Planning an Ecotourism Activity:** A special project where the student plans out an ecotourism activity including: budget, accommodation, licenses, meals, destination, etc.

References :

- Drumm, A. & Moore, A. (2005). *Ecotourism Development: An Introduction to Ecotourism Planning* (Vol. I). (A. Singer, Ed.) Arlington, VA, USA: The Nature Conservancy.
- Drumm, A. & Moore, A. (2004). *Ecotourism Development: Volume II - The Business of Ecotourism Development and Management* (Vol. II). Arlington, VA, USA: The Nature Conservancy.
- Mowforth, M., & Munt, I. (2009). *Tourism and sustainability* (3rd Edition). London, UK: Routledge.
- Newsome, D., Moore, S.A., & Dowling, R.K. (2002). *Natural area tourism*. Bristol, UK: Channel View Publications.
- Weaver, D. (2008). *Ecotourism* (2nd Edition). Hoboken, NJ: JS Wiley.

FOR 529 ADVANCED WOOD ANATOMY AND IDENTIFICATION
Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents:

1. Introduction to Wood Anatomy.
2. **Gross structures of wood:** Cellular composition, wood rays, planes of wood, sapwood and heartwood, growth increments, Axial parenchyma, intercellular canals
3. **Microscopic structure of wood:** Wood cell and tissues, the plant body – Cell and organelles, major cell types, cell sorting and arrangement, cell inclusions (tyloses, crystals, oil cells, gums and resins), meristems, promeristem, primary meristem, secondary meristem, apical and intercalary meristems. Simple tissues- parenchyma, collenchyma, sclerenchyma. Complex and vascular tissues. Organization of cell wall-microfibril, microfibrillar orientation, cell wall sculpturing; Anatomy of stems and roots of dicots and monocots.
4. **Wood formation:** The secondary growth in woody plants. Mechanism of wood and bark formation. Formation of early and late wood, growth rings, transformation of sapwood to heartwood.
5. Reaction wood anatomy and ultrastructure-compression and tension wood.
6. **Chemical composition of wood:** Characteristics of principal wood constituents- cellulose and hemicellulose in hardwood and softwoods, other wood polysaccharides, lignin; wood extractives, distribution of chemical constituents in wood
7. **Defects and abnormalities of wood:** Natural defects and defects due to processing- disruption of continuity of inner wood, shakes, included bark, resin pockets, pith flecks, knots (live and dead); deviation from typical growth form (leaning, bending, crook, fork, buttress), grain deviation, false and discontinuous growth rings.
8. **Identification of wood** - scientific basis, fingerprints of wood. Equipment and procedure. Keys and modern techniques for identification and description of wood by species- key to hardwoods (gross features and minute features), key to coniferous wood (gross features and minute features), description of hardwoods by species, wood identification by chemical means.

References

8. Hoadley, R. B. 2000. Understanding Wood: A Craftsman's Guide to Wood Technology.
9. Hoadley, R. B. 1990. Identifying Wood: Accurate Results With Simple Tools. Available at: <http://www.amazon.com/Identifying-Wood-Accurate-Results-Simple/dp/0942391047>
10. Alexis John Panshin, Carl De Zeeuw, 1980. Textbook of wood technology: structure, identification, properties, and uses of the commercial woods of the United States and Canada, Volume 1. McGraw-Hill publications. 722 p.
11. Mississippi State University Extension Service. Basic Guide to Identification of Hardwoods and Softwoods Using Anatomical Characteristics. Available at: <http://msucare.com/pubs/publications/p2606.pdf>
12. University of Kentucky, 1997. An introduction to Wood Anatomy Characteristics common To Softwood Softwoods & Hardwoods & Hardwoods & Hardwoods.
13. Flynn, J.H. and C.D. Holder (Eds.) 2001. A Guide to Useful Woods of the World. Forest Products Society, Madison, WI. <http://www.forestprod.org/>
14. Rao, K.R. and Juneja, K.B.S. 1992. Field identification of 50 important timbers of India. ICFRE Publi. Dehradun 123 p.

FOR 530 WOOD SCIENCE AND TECHNOLOGY
Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents:

1. **Introduction:** Wood as raw material; kinds of woods; Hardwood, softwood; bamboos and canes. Merits and demerits of wood as raw material.
2. **Properties of wood:** The physical features of wood. Mechanical properties of wood like tension, compression, bending, shearing cleavage, Hardness, impact resistance, nail and screw holding capacities. Electrical and acoustic properties of wood. Suitability of wood for various uses based on mechanical and physical properties.
3. **Moisture content in Wood:** Wood water relationship. Shrinkage, swelling, movement, fibre saturation, equilibrium moisture content in relation to wood structure and species.
4. **Seasoning:** Wood seasoning – merits, principles and types. Timber species specific seasoning methods for different important end use. Refractory classes of timbers, kiln schedules. Seasoning defects and their control. Seasoning in timber based industries of Bangladesh.
5. **Preservation:** Wood preservation – principles, processes, need, types of wood preservatives (Water soluble, oil based, etc.); Merits, demerits and suitability of different preservative treatment methods (i.e. Non-pressure methods and pressure methods). Effectiveness and impacts of different preservatives on wood, users and environment. Economic aspects of preservative treatment. Properties of treated wood. Fire retarding treatment. Pollution control. Preservation in timber based industries of Bangladesh.
6. **Classification of timbers based on durability.** General idea about fire retardants and their usage.
7. **Wood machining:** Wood machining; Sawing – techniques, kinds of saws; Cross cut, edging, cudless, hand, circular and bow saws; applicability and general use of different cuts.
8. **Wood working:** Wood working, tools used in wood working (parting, slicing, shaping, measuring and marking tools). Various stages in wood working. Dimensional stabilization of wood by surface coating method, bulking method, Impregnation of resins and polymers.

Suggestive reading:

1. Franz Friedrich Paul Kollmann; Wilfred A Côte, 1984. Principles of wood science and technology. Available at: <http://link.springer.com/book/10.1007%2F978-3-642-87928-9>
2. Mehta, T. 1981. A handbook of forest utilization. Periodical Expert Book Agency, Delhi. 298 p.
3. Anonymous. 1976. Indian forest utilization. Volume I and II ICFRE Publication, Dehradun.
4. Rao, K.R. and Juneja, K.B.S. 1992. Field identification of 50 important timbers of India. ICFRE Publi. Dehradun 123 p.
5. Sharma, L.C. 1977. Development of forests and forest based industries, Bishen Singh Mahendra Pal Singh, Dehradun.
6. Trotter, H. 1940. Manual of Indian forest utilization. Oxford University Press, New Delhi.
7. Trotter, H. 1982. Indian forest utilisation, Forest Research Institute and Colleges, Dehradun.
- Wadoo, M.S. 1992. Utilization of forest resources. Idris Publi. Srinagar 252 p.

FOR 531 WOOD AND BAMBOO COMPOSITES
Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents:

1. **Introduction:** Wood composites and prospects of wood composites industries in Bangladesh
2. **Conventional wood based composites:** Raw materials and production process of plywood, laminated wood, particle board, oriented strandboard, suitability of different plant species for production of different wood composites; manufacture of tea chest; specialty composite materials; performance and standards of composite products.
3. **Wood-plastic and cement bonded composites:** Raw materials and production process of wood-plastic composites and cement bonded composites, merits, demerits and use of different composites.
4. **Glulam Timber:** Types of Glulam Combinations, Standards and Specifications, Manufacture, Advantages
5. **Structural Composite Lumber:** Laminated veneer lumber, parallel strand lumber, laminated strand lumber and oriented stand lumber, advantages and uses, standards and specifications
6. **Bamboo composites:** Suitability and prospects of bamboo as fibre composite materials; bamboo fibre extraction, raw materials and production process of different bamboo fibre composites (i.e. Bamboo-fibre reinforced biocomposites, bamboo based polymer composite, reinforced polymer composite from bamboo fibre, Engineered bamboo, moldable bamboo fiber-epoxy composites); adhesives, additives, hardeners, extenders and different ratios of their mixture used for bamboo composite, bamboo based products as replacement of wood.
7. Structural, decorative and specialized uses of wood and bamboo composites.
8. Wood and bamboo composite based industries and research institutes in Bangladesh, their products and technologies.

Suggestive readings:

1. Ross, Robert J. 2010. Wood handbook : wood as an engineering material. Centennial ed. General technical report FPL ; GTR-190. Madison, WI : U.S. Dept. of Agriculture, Forest Service, Forest Products Laboratory, 2010: 1 v.
2. Khalil HPSA, Bhat IUH, Jawaid M, Zaidon A, Hermawan D, Hadi YS. 2012. Bamboo fibre reinforced biocomposites: A review. Materials and Design, Vol. 42: 353-368.
3. Vivek Kumar, Sanat Mohanty. High performance moldable bamboo fiber-epoxy composites. Indian Institute of Technology and Delhi Inkilab Technologies Private Limited. Available at: <http://www.speautomotive.com/SPEACD/SPEA2013/pdf/BNF/BNF5.pdf>
4. P. Zakikhani, R. Zahari, M. T. H. Sultan, D. L. Majid, 2014. Bamboo Fibre Extraction and Its Reinforced Polymer Composite Material. International Journal of Chemical, Molecular, Nuclear, Materials and Metallurgical Engineering Vol:8, No:4, 2014.
5. Kazuya Okubo*, Toru Fujii, Yuzo Yamamoto, 2004. Development of bamboo-based polymer composites and their mechanical properties, Composites: Part A 35:377–383

FOR 532 PULP AND PULP PRODUCTS

Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents

1. **Pulp and pulping process:** Types of raw materials, composition and chemical properties of wood suitable for pulping, plant species suitable for pulping and availability in Bangladesh. Preparation of raw material for pulping. Comparative assessment of the different pulping processes. Kraft process: chemistry, digesters, black liquor and chemical recovery.
2. **Adhesives and additives:** Production, use and different combinations of adhesives, additives, hardeners and extenders used in manufacture of pulp products.
3. **Fibreboard and paper boards:** Raw materials used, manufacturing processes of fibreboard and paper board; uses and parameters affecting board properties
4. **Paper:** Paper making; bleaching, beating and sizing of pulp, sizing agents and chemistry of sizing agents, fibre modification, fibre bonding, pulp conditioning and paper properties variation; Paper making process and equipment; paper machine water chemistry and microbiology. Types of paper; physical and mechanical properties and use of paper, factors affecting paper properties.
5. **Pulp and paper industries:** The world pulp and paper market. Pulp and paper production and industries in Bangladesh. Explanation and evaluation of the technical developments within the pulp and paper industry. Energy management and water needs of pulp and paper industries, Environment issues for paper industries.

Suggestive reading

1. Brit KW. 1984. Handbook of Pulp and Paper Technology, 2nd edition. CBS Publishers & Distributors. Delhi, India
2. Environmental Issues and Technology in Pulp and Paper Industry – TAPPI Press Anthology of Published Papers, 1991-94
3. Eklund D. and Lindstrom T.D. 1991. “Paper Chemistry: An Introduction”, TAPPI Press
4. Gullichsen J. and Paulapuro H. 1999. “Papermaking Science and Technology, Book 4: Papermaking Chemistry (Ed. Neimo L.)”, Finnish Paper Engineers’ Association and TAPPI.
5. Smook, G. A. Handbook for Pulp and Paper Technologists, 3rd edition, available at: <http://www.tappi.org>

FOR 533 MANAGEMENT AND UTILIZATION OF NON-TIMBER FOREST PRODUCTS

Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents

1. **Introduction on NTFPs:** Introduction, historical context and attributes of NTFP, methods of collection, NTFPs towards balancing economic and environmental goals, importance of Non-Timber Forest Products (NTFP) in Bangladesh- NTFPs in sustainable forest management.
2. **NTFPs in Bangladesh:** NTFPs -fibers and flosses, forest species, bamboos and canes, oils, tans and dyes, gums, resins and oleoresin, khair, agar, charcoal, honey, lac, silk and medicinal plants; natural occurrence of NTFPs outside the forest areas, highly traded NTFPs in different areas of Bangladesh
3. Cultivation, practices, problems and prospects of selected NTFPs of Bangladesh.
4. **Gender in NTFP:** Women in the informal economy, Women and NTFPs- Opportunities and constraints, NTFP Value chains and women's empowerment.
5. **NTFP Management:** Institutional arrangements for NTFP collection and management in Bangladesh; problems and prospects of NTFPs in Bangladesh; biological, sociocultural, and economic issues associated with NTFP management; ecology and silviculture of non-timber forest species; sustainable management strategy for NTFPs in Bangladesh; diversification of NTFPs.
6. **Community based NTFP management:** Inventory of local NTFPs, revival of local knowledge, processing and preserving plant products, monitoring market chains, transport and marketing, ecologically sustainable management, factors motivating stakeholders to favor NTFPs, organizing NTFP harvesters and other relevant stakeholders; indigenous knowledge and ethnobotany with NTFPs.
7. **NTFPs domestication:** prospects of domestication, influencing factors of NTFP domestication, land suitability and preference of farmers, farmers' criteria for species selection, constraints to domestication; existing plans, rule and regulations supporting NTFP domestication, NTFPs as agroforestry systems.
8. **NTFPs economics and markets:** NTFPs trading and rural economy in Asia, NTFP markets and marketing systems, product development, marketing capabilities of farmers, marketing margin and trade of NTFPs in Bangladesh, marketing channels, NTFPs for income generation and its role for rural development.
9. **NTFPs processing:** Raw-materials, production and prospects of NTFP based industries in Bangladesh. Demand and supply of raw-materials of NTFP industries of Bangladesh.

References

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7. Kleinn, C., Yang, Y., Weyerhäuser, H. and Stark, M. 2006. The Sustainable Harvest of Non-Timber Forest Products in China Strategies to balance economic benefits and biodiversity conservation, Sino-German Symposium 2006, Symposium Proceedings. <http://worldagroforestry.org/downloads>

FOR 534 BAMBOO RESOURCE MANAGEMENT AND UNILIZATION
Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents

1. Introduction: Bamboo resources, distribution and diversity
2. Bamboo and environment under the climate change scenario
3. Bamboo propagation and conservation: Past, present and future aspects
4. Bamboo management: Local and global perspectives
5. Bamboo morphology and anatomic structure
6. Protection of bamboo: Pests, diseases, non-pathogenic, man-made and natural damage
7. Treatment and preservation
8. Bamboo utilization
9. Bamboo technology, design and product development
10. Supply chain, marketing and economics

References

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2. Dart, D.L. 1999. The Bamboo Handbook: : A farmers, growers & product developers guide. Belli Park, Queensland. 120pp.
3. Negi, S.S. 1995. Bamboos and Canes. Bishen Singh Mahendra Pal Singh, Dehra Dun. 118 pp.
4. Choudhury, M.R. 194. A Study on Supply and Demand of Bamboos and Canen in Bangladesh. Field Document No. 9. UNDP/FAO Project BGD/7/010. Institute of Forestry and Environmental Sciences, University of Chittagong. 81 pp.
5. Islam, M.S., Bhuiyan, M.K., Hossain, M.M. and Hossain, M.A. 2011. Clonal Propagation of *Bambusa vulgaris* Schrad ex wendl by Leafy Branch Cuttings. *Journal of Forestry Research*. 22:387-392
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FOR 535 SUPPLY CHAIN MANAGEMENT OF FOREST PRODUCTS

Theory: 75 (3cr); Term Paper: 25 (1cr); Total: 100 (4cr)

Course contents

1. Definition of supply chain, the importance of supply chains in the forest sector, challenges of the forest sector, the main forest sectors
2. Supply chain management and supply chain optimization, different chains within the forest products supply chain, forest supply chain decisions (strategic, operational and tactical) made at different planning horizons, complexity of supply chain management in forest industrial sector
3. Models, their uses, general guidelines in developing, issues and trends in modeling of forest products supply chains, validation and verification of a model
4. Supply chain process integration
5. Supply chain of non-timber forest products, bio-fuels
6. Supply chains and e-commerce

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- Stefan Holmberg (2000) A systems perspective on supply chain measurements. *Division of Logistics, Lund University, Sweden*
- Eldon Gunn (2007) Models for Strategic Analysis of Forest Management and the Forest Products Supply Chain. Department of Industrial Engineering, Dalhousie University
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