Fisheries Economics, Ph.D. Syllabus

Fisheries Economics, Extension and Statistics Division

Central Institute of Fisheries Education, Mumbai-400061

Ph.D.(Fisheries Economics)Syllabus

Courses Offered

S. No.	Course No	Titles	Credits	Minimum Credit Requirements
A	**A1**	**MAJOR CORE COURSES**		**9 Credits**
1.	FEC 601	Advanced Microeconomics	2+0	
2.	FEC 602	Advanced Macroeconomics	2+0	
3.	FEC 603	Advanced Econometrics	2+1	
4.	FEC 604	Advanced Marketing and Price Analysis	2+1	
	A2	**MAJOR OPTIONAL COURSES**		**6 Credits**
1.	FEC 605	Environmental Economics II	2+1	
2.	FEC 606	Fisheries Planning and policies	2+0	
3.	FEC 607	Advanced Aquaculture Production Economics	2+1	
4.	FEC 608	Marine Resource Economics	1+1	
5.	FEC 609	International Economics and trade II	2+1	
6.	FEC 610	Market Intelligence	0+1	
7.	FEC 611	Linear Programming	1+1	
8.	FEC 612	GIS Applications in Fisheries	0+2	
B	**MINOR COURSES** (Courses outside major discipline/ from other relevant disciplines)			**8 Credits**
C	**SUPPORTING COURSES** (for all disciplines)			**5 Credits**
1.	FST 601	Advanced Statistical Methods	2+1	
2.	FST 602	Design of Experiments	1+1	
3.	FST 603	Forecasting Techniques	1+1	
4.	FST 604	Advanced Research Methodology for Social Sciences	1+1	
TOTAL COURSE WORK CREDITS				**28 Credits**
D	**DOCTORAL SEMINAR**			**2 Credits**
1.	FEC 691	Credit Seminar I	0+1	
2.	FEC 692	Credit Seminar II	0+1	
E	**DOCTORAL RESEARCH**			**45 Credits**
	FEC 699	**Doctoral Research (Semester III)**	0+11	
	FEC 699	**Doctoral Research (Semester IV)**	0+11	
	FEC 699	**Doctoral Research (Semester V)**	0+11	
	FEC 699	**Doctoral Research (Semester VI)**	0+11	
TOTAL MINIMUM PH.D. CREDIT HOURS				**45 Credits**

MAJOR CORE COURSES:

FEC 601 ADVANCED MICROECONOMICS (2+0)

Objectives

- To teach economic theories that are applicable to firm
- To familiarize with the nature and functions of product markets
- To study factors influencing markets and evaluation of government regulation for markets.

Theory:

UNIT I

Perfect Competition- characteristics and equilibrium of the firm under perfect competition in short run and long run. Monopoly markets: characteristics and equilibrium of firm under monopoly, comparison between perfect competition and monopoly, price discrimination, effect of price discrimination. Monopolistic markets, chamberlin's model.

UNIT II

Oligopoly markets- Non collusive oligopoly- Cournot's Duopoly model- Stackelberg's Duopoly model- Kinked demand model- Collusive Oligopoly- Cartels and profit maximization- Market sharing cartel- Price leadership in oligopoly- Models of low cost and dominant firm price leader- Theory of games- Two person Zero sum game- Certainty and uncertainty models. Bain's limit pricing theory.

UNIT III

Pricing of factors of production and Income distribution- Demand/supply/ pricing of single and multiple factors- Factor pricing in perfectly and imperfectly competitive markets- Monopolistic power in product market- monopsonistic power in factor market- Bilateral monopoly-elasticity of factor substitution- Technological progress and income distribution- Pricing of fixed factors- The adding- up and product exhaustion theorems- Euler's and Walras theorems.

UNIT IV

General Equilibrium theory- The Walrasian system-Two commodity exchange, Production exchange, Multimarket equilibrium, General equilibrium and allocation of resources, Factor ownership and income distribution, Welfare economics, Pareto optimality, Maximization of social welfare, Welfare maximizing state, The efficiency of perfect competition and imperfect competition markets.

Suggested Readings:

1. Ahuja. A.L., Microeconomics- Theory and Practice S Chand and Company, New Delhi
2. Henderson, J.M. and Quandt, R.E. *Microeconomic Theory: A Mathematical*

Approach.
3. Koutsoyiannis , Modern Micro economics The McMillan Press limited, UK
4. Varian, Hal R. 1992. *Microeconomic Analysis*. W. W. Norton and Co.

FEC 602 ADVANCED MACROECONOMICS (2+0)

Objectives:

- To provide an analytical background on macro-economic issues
- To provide an understanding of policy concerns such as inflation, trade cycles, stabilization policies and international financial markets.

Theory:

UNIT I

Introduction to dynamic macro-economic models, Inflation, Deflation and stagflation: cost push and demand pull inflation, structural inflation, effects of inflation, Inflation-unemployment tradeoffs, Phillips curve, recent developments in Inflation theory, and empirical policy aspects of inflation, productivity and inflation, supply side economics.

UNITII

Monetary theory, Classical and neo-classical theories of Investment, Acceleration principle, Trade cycles: its nature and causes, theories of capital and investment, Hicks model of trade cycles, role of economic policies.

UNITIII

The instruments and impact of monetary and fiscal policies as an instrument of development, incidence of tax and fiscal policies, extension of Keynesian model: investment and economic growth, review of economic policies in India, case studies.

UNITIV

Internal and external borrowings, Deficit financing, International trade theories and exchange rates, International macro-economic policies and Institutions.

Suggested Readings:

1. Gardner Ackley1987.*Macroeconomics: Theory and Policy*. Macmillan Publishing Co., Inc., NewYork.
2. Robert J. Gordon. *Macro economics*, Addison-Wesley, New York.
3. Shapiro, E. *Macro economic Analysis*. Galgotia Publications, Delhi.
4. Thomas, F. Dernburg. *Macro-economics-Concepts, theories and policies*, Mc Graw Hill Book company, London.

FEC 603 ADVANCED ECONOMETRICS (2+1)

Objective:

- To provide comprehensive knowledge of advanced econometric tools for better understanding of economic problems.

Theory:

UNIT I

Review of classical regression model, hypothesis testing, estimation subject to linear restriction, Mixed estimation - use of instrumental variables in regression analysis,

UNIT II

Use of Dummy variables, Models for qualitative dependent variable-LPM, multinomial logit models.

UNIT III

Simultaneous equation systems: Basic rationale, identification problems, Single equation methods of estimation-indirect least squares, two stage least squares and K-class estimators, limited information maximum likelihood, three-stage least squares, and full information maximum likelihood; Relative merits of these methods and their small and large sample properties. SURE estimates.

UNIT IV

Distributed lag models, Analysis of economic time series – Stationarity and unit root test, ARIMA, ARCH group of models and co-integration. Neural Network Models, Pooling of cross-section and time series data.

Practicals:

Estimation of multiple regression model - estimation of LPM, Logit and Probit models – comparing two regressions - Chow test - Indirect least squares 2SLS, SURE, 3SLS, estimation of simultaneous equation models – unit root tests for stationarity, fitting of ARIMA and ARCH group of models –cointegration.

Suggested Readings:

1. Gujarati, Damodar, Econometrics, McGraw Hill, latest edition
2. Greene, W.H. 2002. Econometric Analysis. Pearson Edu.
3. Johnston, J. and Dinardo, J. 2000. Econometric Methods. McGraw-Hill.
4. Maddala, G.S. 2002. Econometrics. McGraw Hill.

FEC 604 ADVANCED MARKETING AND PRICE ANALYSIS (2+1)

Objectives:

- To familiarize students with advanced concepts and principles of marketing
- To provide an interface between marketing and management decision

Theory:

Unit I

Markets and market structure, Government and Co-operative in fisheries marketing, marketing efficiency and integration, marketing cost and price spread, marketing planning, marketing strategy, marketing research, Marketing infrastructure, Marketing regulations, constraints and approaches to fish marketing development.

Unit II

Supply Chain Management: Concepts and Evolution, value addition in fish marketing. Constraints and approaches to SCM in fisheries sector; Value-chain analysis; Market Integration and its effect on price determination; Domestic and external markets for fisheries products.

Unit III

Marketing information system and e-marketing. Dynamics and innovations in fisheries marketing system. Analysis of market behaviour.Computer application in marketing management: Market intelligence, its need, analysis and dissemination.

Unit IV

Principles of price determination. Price difference and variability, Price analysis, Price elasticities, Price determination of fish and fishery products, Characteristics of demand and supply of fish and fishery product, Supply responses, Seasonality, Future trading, Price support measures. Price stabilisation policies-Market interventions

Unit V

Seafood and Aquaculture Markets World-wide international Marketing Channels, Economies of Scale, Economics of Processing, Policies and Regulations0, its impact on aquaculture Marketing. Indian Seafood and Aquaculture marketing Environment.

Practicals/ Case studies:

Price difference and variability, price analysis, price elasticities, Price determination, Estimation of market integration and marketing efficiency, Case studies of supply chains in urban and rural fish markets, Export Composition and destination of Indian seafood products. Analysing Trade performance before and after WTO; Analysis of International price trends and volatility. Case studies in e-marketing dynamics and innovations in fisheries marketing.

Suggested Readings:

1. S Acharya & N.L. Agrawal : Agriculture Marketing in India, Oxford and IBH Publication
2. Shepherd SG & Gene AF. 1982. *Marketing Farm Products*. Iowa State Univ. Press.
3. Singhal AK. 1986. *Agricultural Marketing in India*. Annual Publ., New Delhi
4. Uhl& Kohl : Agricultural Marketing
5. Phillip K & Armstrong G. 2007. *Principles of Marketing*. Prentice Hall.
6. Phillip K. 2008. *Marketing Management*. 12th Ed. Prentice Hall of India.

OPTIONAL COURSES

FEC 605 ENVIRONMENTAL ECONOMICS II (2+1)

Objectives:

- To familiarize students with strategic importance and role of Environmental Economics

Theory:

Unit I

Recap on basic concepts of environmental economics –

Welfare criteria and environmental analysis – Pareto criteria, Pigovian analysis of externalities, compensation criterion, social choice and justice, property rights and Coase theorem, environmental quality as public good, market failure- incomplete markets, common property resources, externalities, public goods and bads.

Unit II

Economic growth and environment – the costs of economic growth, the limits to growth models, social limits, environmental quality and economic development, sustainable development – Green marketing, clean technology of production and transfer of technology, environmental management systems and environmental auditing.

Unit III

Water resources – water resource planning, problems of water sustainability and management- conservation and management of natural resources – meaning and objectives of conservation, conservation of renewable resources and non-renewable resources – Natural resources policy of India.

Unit IV

Concepts of maximum sustainable yield, Theory of natural resource extraction, simple optimal resource depletion model, optimal extraction of non-renewable resources; optimal extraction of renewable resources with special reference to fisheries, open access fishery versus private property fishery; Tragedy of Commons, Environmental costs of technological development.

Unit V

Introduction to climate change economics and global warming – global environmental externalities, the great green divide, Objectives of environmental laws, The role of Ministry of Environment and Forests GoI, Environmental hazards and disaster management – National Environment Policy 2006**.**

Practicals / Case studies:

Case studies on environmental economics of shrimp farming (intensive/ semi-intensive/ extensive) – case studies on pollution of aquatic resources; lakes and rivers and its impact on fishery, Application of Extended Domestic Resource Cost Ratio and Policy Analysis Matrix for aquaculture - Case studies on the sustainability of various capture fishery systems - Economics of inland water and marine pollution – Case studies on evaluation of aqua ecological zones.

Suggested Readings:

1. R. Perman, Y Ma., J Mc Gilvray and M Common. 1999. Natural Resource and Environmental Economics. 2nd edition. Harlow: Longman. N
2. Hanley, J. Shogren and B. White. 1997. Environmental Economics in Theory and Practice.1st edition only. Basingstoke: Macmillan
3. T Tietenberg, 2000. Environmental and Natural Resource Economics; 5th edition.
4. D W Pearce. 1976. Environmental Economics. Harlow: Longman.
5. Hartwick, JM & Olewiler ND. 1998. The Economics of Natural Resource Use. 2nd Ed. Addison-Wesley Educational Publ.

FEC 606 FISHERIES PLANNING AND POLICIES (2+0)

Objectives:

- To familiarize students with the planning, policies tools and techniques at various stages.

Theory:

Unit I

Planning Commission - Organization, role and functions, Planning in India-Objectives, Strategy, allocation, achievements and bottlenecks, Types of planning, stages in planning

process, planning models. Impact of development plans, international co-operation programmes.

Unit II

Fisheries Development and policy under the plans, Fisheries schemes; State and center sector schemes and centrally sponsored schemes, Agriculture policies, Need for a separate fishery policy. Leasing policies for inland and brackish water bodies in different states, Inputs Policy, Financing and Credit Policy, marketing and pricing policy, Export-Import Policy.

Unit-III

Fisheries legislation in India- background, Indian Fisheries Act of 1897 and subsequent amendments; Marine capture fisheries, comparative study of Marine Fishery Regulation, Acts of coastal Indian States – licensing/registration of vessels and mechanization – declaration of closed season, protection of endangered species, prohibition of destructive fishing methods, regulation of mesh size, filing of return on fish catch and income. Features of MPEDA Act and Rules, 1972 – guidelines for operation of Indian deep sea fishing vessels in Indian EEZ – Maritime Zone of India (regulation of fishing by foreign vessels) Act 1981 - aquatic exotics and quarantine regulations - Marine Fisheries Policy, 2004. Coastal Aquaculture authority; Aquaculture Guidelines under CRZ notification of 1991 and its Amendments, land leasing policies - regulations on use of chemicals and antibiotics - features of Aquaculture Seed (Quality Control) Relevant Central/state legislative provisions of Environmental, Wildlife, Water, Biodiversity: (riverine, reservoir and aquaculture), processing in different States.

Unit-IV

Socioeconomics – An overview of the socio economic status (literacy, poverty, income, woman empowerment, housing, indebtedness and saving, marginalization) of the fishers in India, overview of various welfares schemes, Disaster management. Role of fisheries co-operatives, corporation, SHG's and NGOs in the development of the fishers, Labour market relation- wage, employment, migration, livelihood security, income generation.

Suggested Readings:

1. Higgins, Benjamin. Economic Development, Problems, Principles and Policies. Universal Book Stall, New Delhi.
2. Kindleberger, Charles P. Economic Development. McGraw-Hill, New Delhi.
3. Todaro, Machael P. Economic Development in the Third World. Orient Longman, New Delhi.
4. Meier, Gerald M. Leading Issue in Economic Development. Oxford University Press, Delhi.
5. Diana Tussie and David Glover, 2000. The Developing countries in world trade- Policies

and Bargaining Strategies, Lynne Rienner/ IDRC, Washington.
6. Soumyen Sikder, 2001. Contemporary Issues in Globalisation- an Introduction to Theory and Policy in India, OUP, New Delhi
7. James D. Gaisford & William A. Kerr, 2001. Economic analysis for international trade negotiations, John Wiley and Sons.
8. Green D and Griffith M, 2002. Dumping on the poor: The Common Agricultural Policy, the WTO and International Development, CAFOD, London.
9. Michael L Weber, 2001. From Abundance to Scarcity: A History of U.S. Marine Fisheries Policy, Island Press, New York.
10. Govt of India Marine Fisheries census report

FEC607 ADVANCED AQUACULTURE PRODUCTION ECONOMICS (2+1)

Objectives:

- To familiarize students with the basic concepts and principles of advanced aquaculture production economics.
- To understand different types of input-output cost and prices and relevant analytical tools.

Theory:

UNIT I

Production functions-Concepts of homogeneity, APP, MPP, elasticity of substitution and their economic relevance, Production relations and optimality; Estimation and interpretation of linear, Spillman -Cobb Douglas, quadratic, multiplicative (power) functional forms – Trans log, and transcendental functional forms -CES, production functional forms-Conceptual and empirical issues in specification, estimation and application of production functions, Analytical approaches to economic optimum-determination of economic optimum with constant and varying input and output prices, Economic optimum with production function analysis - input use behaviour.

UNIT II

Decision making with multiple inputs and outputs, MRT and product relationship, cost of production and adjustment in output prices, single input and multiple product decisions, Multi input, and multi product production decisions - Decision making with no risk, Cost of wrong decisions, Cost curves, Principles and importance of duality theory, Correspondence of production, cost, and profit functions, Principles and derivation of demand and supply functions.

UNIT III

Technology, input use and factor shares, effect of technology on input use, decomposition analysis-factor shares and estimation methods, Economic efficiency in agricultural

production – technical, allocative and economic efficiency, measurement, Yield gaps analysis, concepts and measurement, Risk and uncertainty in aquaculture, risk and uncertainty in decision making.

UNIT IV

Simulation and programming techniques in aquaculture production, Multiple Objective Programming, Goal programming, Compromise programming and its applications.

Practicals:

Estimation of different forms of production functions- Optimal input and product choice from estimated functions-Derivation of demand and supply functions and estimation-Estimation of cost function and interpretations-Optimal product and input choice under multi input and output system-Estimation of factor shares from empirical functions estimated-Estimating production functions incorporating technology changes: Decomposition analysis and incorporation of technology- Estimation of efficiency measures- Stochastic, probabilistic and deterministic frontier production functions-Risk programming-MOTAD-Quadratic programming-Simulation models for agricultural production decisions-Goal programming, Weighted, lexicographic and fuzzy goal programming- Compromise programming.

Suggested Readings:

1. Chambers RG. 1988. *Applied Production Analysis*. Cambridge Univ. Press.
2. Gardner BL &Rausser GC. 2001. *Handbook of Agricultural Economics*. Vol. IA
3. Palanisami KP, Paramasivam & Ranganathan CR. 2002. *Agricultural Production*
4. *Economics: Analytical Methods and Applications*. Associated Publishing
5. Co.Beattie, B.R. and Taylor, C.R. 1985. The Economics of Production. John Wiley & Sons.
6. Doll, J.P. and Frank, O. 1978. Production Economics - Theory and Applications. John Wiley & Sons.
7. Gardner, B.L. and Rausser, G.C. 2001. Handbook of Agricultural Economics. Vol. I. Agricultural Production. Elsevier.
8. Heady, E.O. Economics of Agricultural Production and Resource Use. Prentice- Hall.
9. Sankhyan, P.L. Introduction to the Economics of Agricultural Production, Prentice Hall of India Pvt ltd.
10. Heady, E.O. and Dillon, J.L. (1961): Agricultural Production Functions, Kalyani Publishers, New Delhi.
11. Shang, Y.C., Aquaculture Economic Analysis – An Introduction, The World of Aquaculture Society Ltd
12. Cunningham, S., Dunn, M.R. and Whitmarsh, D., Fisheries Economics – An Introduction, Mansell Publishing Ltd., London.

FEC 608 MARINE RESOURCE ECONOMICS (1+1)

Objectives:

- To familiarize with concepts and principles of economics applied to marine resources
- To provide understanding of various bio economic models and analytical tools used
- To familiarize with legal issues of marine resourcesand international treaties pertaining to fisheries conservation and management

Theory:

Unit I

Economic concepts applied to marine fisheries, Economics of fishing methods, resource efficiency, capital and labour productivities, break-even catch and price.

Unit II

Fisheries surplus production models, Schaefer's model, logistic growth model,estimation of MSY, MEY, Optimum fleet size, Bio economic models, open access equilibrium.

Unit III

Historical developments of the Laws of seas; New legal regimes of1982EEZ, Sovereign rights of coastal states, Fisheries treaties, Geneva Convention on the law of seas, conservation of resources and its economic value, International commission on fisheries and its role for Global development.

Unit IV

Marine Fisheries Management, paradigm shift, Traditional community based fisheries management systems, Government management interventions, Input and output based regulation measures; their impact on the marine fisheries sector, Ecosystem based marine fisheries management, Fisheries Governance.

Practicals:

Estimation of fisheries production, cost and revenue functions; Logistic growth models-Schaefer's model-Other models, Estimation of MSY, MEY; Assessment of economic performance of various fishing methods, craft-gear combinations, Resource use efficiency-capital and labour productivities; Caste studies-Multi-species management; Review of management interventions and fishery regulations on marine fisheries management.

Suggested Readings:

1. Bjorndal, T.; Daniel, V. Gordon; Ragnar Arnason and U. Rashid Sumaila.2007. Advances in Fisheries Economics. Blackwell Publishing
2. Ola Flaaten.2010. Fisheries Economics and Management, Norwegian college of Fisheries Science, University of Tromso. Norway

3. Anderson, Lee G. and Juan Carlos Seijo. 2010. Bioeconomics of Fisheries Management, Blackwell Publishing, A John Wiley & Sons, Ltd., Publication
4. Clarke CW. 1976. Mathematical Bio-economics: The Optimal Management of Renewable Resources. John Wiley.
5. Cunningham S, Dunn MR & Whitmarsh D. 1985. Fisheries Economics. St. Martin's Press.
6. Grafton QR, Kirkley J, Kompas T & Squire D. 2006. Economics for Fisheries Management. Ashgate Publ. Co.
7. Hartwick JM & Olewiler ND. 1998. Economics of Natural Resource Use. 2nd Ed. Addision Wesley.
8. Munro GR & Scott A. 1984. The Economics of Fisheries Management. University of British Columbia.
9. The International Law of the Sea(2012)by Donald R. Rothwell & Tim Stephens
10. The International Law of the Sea(2012)by Yoshifumi Tanaka
11. Fisheries Economics and Development in India (1983) by Rao P.S.
12. Law of the Sea(1999)by R.R. Churchill & A.V. Lowe
13. Law of the Sea(2010) by Francis Mohan Hayes
14. Sathiadhas, R. 1996. Production and Marketing management of Marine Fisheries in India
15. Methodology for the estimation of Marine Fish Landings in India-Srinath, M.; Kuriakose, Somy and Mini, K.G. (2005) CMFRI, Cochin Special publication.
16. Gulland J.A. (2000). Fish Population University Microfilms.
17. Devaraj, M. (1983). Fish Population Dynamics, Course Manual, CIFE, publication.

FEC 609 INTERNATIONAL ECONOMICS AND TRADE II (2+1)

Objectives:

- To gain clear understanding of linkages between domestic and international economy.
- To incorporate International issues in designing strategies changing environment.

Theory:

Unit-I

Theories of international trade, Classical theories, Reciprocal demand, Offer curve technique; terms of trade and gains, international trade as a substitute for growth, theory of immesirising growth; Modern theory of international trade-Hecksher, -Ohlin theory, factor price equalization theory, Stolper Samuelson theory, Rybczynski theorem, recent theories of international trade.

Unit-II

Balance of payment- concern of developing countries; Exchange Rate; International capital movements; types of protection; Free trade Vs Protection; Anti-dumping measures and trade.

Unit-III

International Financial institutions (WB, IMF, ADB); International Monetary Systems: International Business Environment, European Monetary System and Emergence of Euro.

Unit-IV

GATT and WTO, transition from GATT to WTO, WTO provision and its agreements: Agreement on Agriculture(AoA), Agreement on SPS measures, Role of Codex Alimentarius Commission (CAC) and Agreement in Trade Related Intellectual Property rights (TRIPs) and TRIMS; Challenges, strategies and opportunities in seafood exports; Need for Agreement on Fisheries; Export/Import regulations; entry process for imports, Export promotion-New Avenues and measures, Market Access and Trade liberalisation, Trade and Environment; Trade and labour standards.

Practicals/Case Studies:

Determination of absolute and comparative advantage and Gains from trade. Estimation of terms of trade, Derivation of offer curves and effects of technological change and factor supply, Estimation of protection coefficients, Measurement of effects of tariff imposition. Effects of tariff and non-tariff barriers on domestic supply and imports. Preparation of BOP, Performance of Export/import accounts, Policy analysis matrices (PAM).

Suggested Readings

1. Kindleberger Charles, P.: International Economics, Richard D. Irwin Inc., New York.
2. Cherumilam, Francis (1999): International Economics. Tata McGraw Hill, New Delhi.
3. Murray, C. Kemp: Pure Theory of International Trade, Prentice Hall, New Delhi.
4. Walterjngo and Areskoug, Kaaj(1981): International Economics, 3rd Edition,
5. Wilfred J.Ethier (1995): Modern International Economics, Norton International Edition
6. Elsalvador International Economics and Trade
7. Policy Analysis Matrix

FEC 610 MARKET INTELLIGENCE (0+1)

Objective:

- To familiarize students with the evolution, growth and performance of the Indian and Global fish industry

Practicals:

Market research and intelligence-concepts, methods, tools and data; Developing cases on important Indian and global fish products markets and their intelligence gathering (shrimp/prawn, pomfret, squid and cuttlefish, surumi, Bombay duck, carps, hilsa, etc. in India and tuna, salmon and trout in the world markets); World fishing industry-Fresh, frozen, cured, canned, meat and oil; Fisheries industry in US, Japan, European Union, Thailand, China, Vietnam, Indonesia, Bangladesh and Sri Lanka; Case studies on world shrimp, tuna, salmon and cephalopods industries; Trend analysis of fisheries production and productivity of major producers; SWOT analysis of fisheries industry of major producers.

Suggested Readings:

1. FAO, Fisheries Statistics, Rome (various years).
2. Min. of Agriculture, Handbook of Fisheries Statistics, New Delhi (various years).
3. FAO, Globefish Commodity Updates, Rome (various years).
4. Gareth Porter, 1998. Fisheries Subsidies – Over fishing and Trade, Geneva.
5. Oscar J Barros, 1999, Export Competitiveness in South-East Asia: Policy Initiatives and Corporate Actions in Marine Products Industry, Wheeler Publishing, New Delhi.

FEC 611 LINEAR PROGRAMMING (1+1)

Objective:

- To impart knowledge of various linear programming techniques.

Theory:

UNIT I

Decision Making- Concepts of decision making, introduction to operations research, linear programming- Introduction and uses, formulation of problems, graphical method of solution.

UNIT II

Simplex Method: Concept of Simplex Method, solving profit maximization and cost minimization problems. Formulation of farms and non-farm problems as linear programming models and solutions

UNIT III

Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming.

UNIT IV

Game Theory- Concepts of game theory, two person constant sum and zero sum games, saddle point, solution to mixed strategies, the rectangular game as Linear Programming.

Practicals:

Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method. Formulation of the simplex matrices for typical farm situations.

Suggested Readings:

1. Taha, H.A. 2007. *Operations Research: An Introduction, 9th Edition, Pearson Education Inc., New Jersey*.
2. Swarup, K. Gupta, P.K. and Mohan, M, 1996. *Operations Research,* Sultan Chand & Sons, New Delhi.
3. Thierauf, R.J. & Klekamp, R.C. 1975. *Decision making through Operations Research*. 2nd Edition, John Wiley & Sons, New York.

FEC 612 GIS APPLICATION IN FISHERIES (0+2)

Objectives:

- To provide hands-on training on ArcGIS and ERDAS software
- To equip students with the spatial analytical tools used for GIS project

Practicals:

Basics of ArcGIS: ArcMap, Arc-Toolbox and ArcCatalog, displaying, projecting and editing data, working with tables, working with geo-referenced data, simple editing and digitizing, querying your database and selecting features by location, making good maps from the data, creation of thematic layers, overlay, surface modelling using spatial Analyst / GRID, digital elevation model creation and surface analysis, surface modelling - 3D analyst, Arc Scene and TIN and Final Project Presentations, introduction to ERDAS software, Digital Image Processing, importing and displaying raster data, image rectification, sub setting, raster attribute tables, classification.

Suggested Readings:

1. Peter Kasianchuk and Marnel Taggart, Introduction to ArcGIS Part 1, ESRI, Redlands.
2. Paul Longley and More, Advanced Spatial Analysis, ESRI, Redlands.
3. Arthur H. Robinson and More, Elements of Cartography, John Wiley & Sons, New York
4. Michael N. D. Meves, Fundamental of GIS, Second Edition with Integrated GIS Manual, John Wiley & Sons, New York.
5. Michael N.D. Mers, GIS Modelling in Raster, John Wiley & Sons, New York
6. Course Manual of Winter School on Remote Sensing and GIS Applications in Fisheries Research and Management, 5-25 January, 2005, CIFE, Mumbai.
7. Anon, ERDAS Imagine Tour Guide, GIS & Mapping, Atlanta, Georgia.

SUPPORTING SUBJECTS (FOR ALL DISCIPLINES)

FST 601 ADVANCED STATISTICAL METHODS (2+1)

Objective:

- To provide exposure on advanced statistical methods to students
- Hands-on-training for analysis of data using statistical software

Theory:

UNIT I

Probability distributions: Negative Binomial, Hyper-geometric, Exponential and their applications in fisheries; Multiple and partial correlation and regression; Path coefficient method; Transformation of data.

UNIT II

Matrix algebra; Multivariate normal distribution; MANOVA; Principal component analysis; Canonical correlation; Discriminant analysis; Factor analysis, Cluster analysis; Multi-Dimensional Scaling.

UNIT III

Linear programming: Objective function, graphical solution of linear programming problem, Simplex method.

UNIT IV

Analysis of Categorical Data: Logistic regression, Log-linear models; Tau, Kappa and Deviance measures.

UNIT V

One sample tests: Binomial, Fisher's exact probability; Two related samples tests: McNemar, Wilcoxon signed rank tests; Two independent samples tests: Median and Wald-Wolfowitz run tests; Kruskal Wallis One-way ANOVA and Friedman Two-way ANOVA for rank data. Measures of association in nominal data: Spearman and Kendall rank correlation coefficients, Kendall partial rank correlation coefficient of concordance.

Practicals:

Exercises on Negative Binomial, Hyper-geometric and Exponential distributions; Multiple and partial correlations; Multiple and partial regression analysis; Path coefficient method; MANOVA; Principal component analysis; Canonical correlation; Discriminant analysis; Factor analysis, Cluster analysis; Multi-Dimensional Scaling; linear programming; Logistic regression and log-linear models; Non-parametric tests; Familiarization of statistical software viz., SAS, SPSS and R.

Suggested Readings:

1. Anderson, T.W. (2003). *An introduction to multivariate statistical analysis*, Wiley.
2. Christensen, R. (1990). *Log linear models*, Springer Verlag, New York.
3. Gupta, S.C. and Kapoor, V.K. (2007). *Fundamentals of Mathematical Statistics.* Sultan Chand and Sons, New Delhi.
4. Hair, J.F.Jr, Black, W.C., Babin, B.J. and Anderson, R.E. (2010). *Multivariate Data Analysis*, 7th Edition, Pearson-Printice hall
5. Hosmer, D.W. and Lemeshow, S. (2005). *Applied Logistic Regression*, Wiley.
6. Sharma, S. (1996). *Applied Multivariate analysis*, John Wiley & Sons, New york.
7. Siegel, S. and Castellan Jr., N.J. (1988). *Non-parametric statistics for the behavioural sciences*, McGraw Hill Company Limited, New York.
8. Swarup, K., Gupta, P.K. and Mohan, M. (1996). *Operations Research*, Sultan Chand & Sons, New Delhi.

FST 602 DESIGN OF EXPERIMENTS (1+1)

Objective:

- To familiarize students with various statistical designs for planning of experiments and data analysis.

Theory:

UNIT I

Principles of design of experiments, randomization, replication and local control, Introduction to linear models; Completely Randomized, Randomized Complete Block and Latin Square Designs; Comparison of treatment means: critical difference and Duncan's Multiple Range Test.

UNIT II

Missing Plot Techniques, Factorial experiments (2^n, 3^n), simple and partial confounding, Bioassays.

UNIT III

Groups of Experiments, Split and strip plot designs and Repeated measurement analysis, ANCOVA, Response surface methodology.

Practicals:

Exercises on completely randomized: randomized complete block and latin square designs: Duncan's Multiple Range Test, factorial experiments; Simple and partial confounding, split-plot design, strip plot design, ANCOVA, Response surface methodology.

Suggested Readings:

1. Biradar, R.S., 2002. *Course manual on Fisheries Statistics*, 2nd edition, CIFE, Mumbai.
2. Box, G.E.P., Hunter, W.G. and Hunter, J.S. (1978). *Statistics for experimenters: An introduction to design, data analysis and model building*, John Wiley & Sons, New York.
3. Cochran, W.G. and Cox, G.M. (1992). *Experimental Designs*, 2nd Edition, Wiley.
4. Das, M. N. and Giri, N.C. (1986). *Design and Analysis of Experiments*, New Age, Delhi
5. Ghosh, S. (1999). *Multivariate Analysis, Design of Experiments and Survey Sampling*. Marcel Dekkar Inc., New York

FST 603 FORECASTING TECHNIQUES (1+1)

Objective:

- To familiarize students with various forecasting techniques.

Theory:

UNIT I

Forecasting needs and uses of forecasting; Fundamentals of quantitative and qualitative forecasting; basic forecasting tools; Autocorrelation; Measures of forecast accuracy.

UNIT II

Time series decomposition; Averaging methods and exponential smoothing methods, Trend fitting, ratio-to-moving average method, forecasting with simple and multiple regression methods; Non-linear models, Stationary and non-stationary time series data; Seasonal and non-seasonal models; Box-Jenkins model/Auto-regressive moving average (ARMA) and Auto regressive integrated moving average (ARIMA) models.

UNIT III

Artificial Neural Networks (ANN), Fuzzy Logic, Fuzzy Regression, Genetic Algorithms, Decision trees- CART and Bayesian classifiers, Introduction to Support Vector Machines.

Practicals:

Moving average, autocorrelation, linear, exponential smoothing and decomposition methods, trend fitting, ratio to moving average, regression methods, fitting of ARMA and ARIMA models.

Suggested Readings:

1. Brockwell, P.J. and Davis, R.A. (1996). *Introduction to time series forecasting*, Springer Verlag, New york.
2. Harvey, A.C. (1984). *Time series models*, Phillip Allan, Oxford.

3. Makridakis S., Wheelwright, S.C. and Hyndman, R.J. (1998). *Forecasting: Methods and Applications* (3rd Ed.), John Wiley and Sons, New York.
4. Pankratz, A. (1983). *Forecasting with univariate Box–Jenkins models: concepts and cases*, John Wiley, New york
5. Rajasekaran, G.M. and Pai, V. (2003). *Neural networks, fuzzy logic, and genetic algorithms: Synthesis and applications*, Prentice Hall, New Delhi.

FST 604 ADVANCED RESEARCH METHODOLOGY FOR SOCIAL SCIENCES (1+1)

Objectives:

- To understand and acquire skills in different measurement concepts and techniques
- To understand and acquire skills in important techniques of scaling techniques in social science research.

Theory:

UNIT I

Components of social science research - theory, method and epistemology; Epistemology and Ontological considerations in social science research; qualitative and quantitative methods; units of analysis and field work in social science research.

UNIT II

Measurement and scaling techniques; rating scales and comparative or ranking scales; construction of arbitrary scale, differential scale (Thurston scale), summative (Likert scale), cumulative (Guttmann's scalogram) and factor scales (semantic differential scale and multi-dimensional scale).

UNIT III

Case study method and applications; Content analysis and media studies; Sociometry method; Psychometric analysis; Critical incidence technique; Q-sort technique; Multi-Dimensional Scaling Technique; Mixed methods research.

Practicals:

Review of studies in fisheries social science research in India and world; case studies / exercises on qualitative and quantitative research designs; Case studies / exercises on construction of differential scale (Turnstone scale), summative scale (Likert scale), cumulative scale (Guttmann's scalogram), factor scales (semantic differential scale and multi-dimensional scale); exercises on tests of reliability and validity; exercises on commonly used non-parametric tests; exercises on mixed methods research.

Suggested Readings:

1. Junker, B.H., 1979. Field Work: An Introduction to the Social sciences, University of Chicago Press, Chicago.
2. Goode, W.J. and P.F. Hatt, 1985. Methods in Social research, McGraw-Hill Book Company, New York.
3. P.V. Young, 1997. Scientific Social Surveys and Research, Prentice - Hall of India, New Delhi.
4. Charles B. Teddlie and Abbas Tashakkori (Ed.), 2008. Foundations of Mixed Methods Research: Integrating Quantitative And Qualitative Approaches in the Social And Behavioral Sciences, Sage Publications
5. Jacques Tacq, 1997, Multivariate Analysis Techniques In Social Science Research: From Problem To Analysis, Sage Publications
6. http://www.statsoft.com/textbook, http://www.scribd.com/

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