Department of Soil and Water Conservation Engineering
Mahatma Phule Krishi Vidyapeeth
Rahuri-413 722, Dist. Ahmednagar (MS)

Doctoral Programme in Soil and Water Conservation Engineering

Course Layout

Minimum credit requirements

Sr. No.	Subject	Minimum Credits
1.	Major	15
2.	Minor	08
3.	Supporting	05
4.	Seminar	02
5.	Research	45
	Total credits	**75**
	Non Credit Compulsory Courses (Optional)	06

Sr. No.	Course Number	Course Title	Credits
A) Major Subjects (Min. 15 Credits)			
1	SWCE 601*	Advanced Hydrology	3 (3+0)
2	SWCE 602*	Modeling Soil Erosion Processes	3 (2+1)
3	SWCE 603	Soil and Water Systems' Simulation and Modeling	3 (2+1)
4	SWCE 604	Hydrological Analysis of Watershed	3 (2+1)
5	SWCE 605	Hydrological Models	3 (2+1)
6	SWCE 606	Advanced Hydro informatics	3 (2+1)
7	SWCE 607	Risk Management in Soil and Water Conservation	3 (2+1)
8	SWCE 693*	Special Problem	1 (0+1)
9	SWCE 694*	Case Studies	1 (0+1)

B) Minor Subjects (Min. 8 Credits)			
1	AE 601	Environmental Impact Assessment	3 (1+2)
2	AE 602	Climate Change Impact Adaptation and Mitigation	3 (2+1)
3	AE 603	Research Techniques	3 (2+1)
4	AE 604	Bench Marking and Performance Analysis	3 (2+1)
5	IDE 511	Introductory hydro informatics	3 (2+1)
6	IDE 605	Pipe Network Analysis	3 (2+1)
7	IDE 606	River Basin Models	3 (1+2)
C) Supporting Courses (Min. 5 Credits)			
1	BSCT 601	Object Oriented Programming	3 (2+1)
2	MATH 601	Mathematical Modelling and Mat lab Applications	3 (1+2)
3	STAT 609	Operations Research	3 (2+1)
4	STAT 610	Probabilistic Approach in Design	2 (2+0)
5	STAT 611	Geostatistical Analysis	2 (1+1)
D) Seminar (2 Credits)			
1	SWCE 691	Doctoral Seminar I	0+1=1
2	SWCE 692	Doctoral Seminar II	0+1=1
E) Doctoral Research (45 Credits)			
1	SWCE 699	Doctoral Research	45
F) Non credit Compulsory courses (Optional)$			
1	PGS 501	Library and Information Services	1 (0+1)
2	PGS 502	Technical Writing and Communications Skills	1 (0+1)
3	PGS 503 (e-Course)	Intellectual Property and its Management in Agriculture	1 (1+0)
4	PGS 504	Basic Concepts in Laboratory Techniques	1 (0+1)
5	PGS 505 (e-Course)	Agricultural Research, Research Ethics and Rural Development Programmes	1 (1+0)
6	PGS 506 (e-Course)	Disaster Management	1 (1+0)

*** Compulsory**

$ Ph.D. student exempted, if completed in Master's degree

Course Contents

A) Major Subjects		
SWCE 601*	**ADVANCED HYDROLOGY**	**3(3+0)**

Theory:
UNIT I
Hydrologic models, processes and systems. Uncertainty in hydrological event. Statistical homogeneity.
UNIT II
Probabilistic concept. Frequency analysis. Co-relation and regression analysis. Probability distribution of hydrological variables.
UNIT III
Time series analysis. Markov processes.
UNIT IV
Formulation of various steps of statistical models and their application in hydrology.

Practical:

Suggested Books

Linsley, RK Jr., Kohler MA & Paulhus JLH. 1975. *Applied Hydrology*. McGraw Hill.
Hann, C.T. 1978. *Statistical Methods in Hydrology*. Iowa University Press, Ames.
Salas, J.D. J.W. Delleur, V. Yevjevich, and W.L. Lane. 1980. *Applied Modeling of Hydrologic Time Series*. Water Resources Publications, Colorado, USA.
Mutreja, KN.1986. *Applied Hydrology*. Tata McGraw Hill, New Delhi.
Garg, S.K.1987. *Hydrology and Water Resources Engineering*. Khanna Publ., Delhi.
Hann, CT. *Advanced Hydrology*. Oxford Publ. House.

SWCE 602*	**Modelling Soil Erosion Processes**	**3(2+1)**

Theory:
UNIT I
Overland flow, basic theory of particle movement and sediment transport; sediment deposition process.
UNIT II
Estimation of sediment load; mechanics of soil erosion by water and wind.
UNIT III
Water and wind erosion control measures.
UNIT IV
Universal soil loss equation; stochastic models and dynamic models.

Practical:

Computation of soil erosion index; Estimation of soil erodibility factor; Design of erosion control structures. Computation of suspended load and sediment load using empirical formulae; Application of sediment yield models, prediction of sediment loss – computation of reservoir sedimentation – sounding method.

Suggested Books:

USDA. 1969. *A Manual on Conservation of Soil and Water*. Oxford & IBH.
Garde RJ & Ranga Raju KG. 1977. *Mechanics of Sediment Transport and Alluvial Stream Problems*. Wiley Eastern Ltd.
Morgan RPC. (Ed. D. A. Davidson). 1986. *Soil Erosion and Conservation*. ELBS, Longman.
Singh, V.P. 1988. *Hydrologic Systems- Volume II- Watershed Modeling*. Prentice Hall, New Jersey, USA.

SWCE 603 SOIL AND WATER SYSTEMS' SIMULATION AND MODELLING **3(2+1)**

Theory:
UNIT I
Systems engineering for water management; Complexity of resources management process, systems analysis.
UNIT II
Rainfall-runoff models - Infiltration models, Simulation methods, structure of a water balance model.
UNIT III
Channel flow simulation - parameters and calibration – Streamflow statistics, surface water storage requirements.
UNIT IV
Flood control storage capacity; total reservoir capacity - surface water allocations. Ground water models.
UNIT V
Design of nodal network, General systems frame work – Description of the model; Irregular boundaries, General –Numerical approaches.

Practical:

Rainfall - Runoff models - Infiltration models - Stanford watershed model (SWM) - channel flow simulation problems - stream flow statistics – model parameters and input data requirements of various softwares of surface hydrology and groundwater – Hydrologic Modelling System – Soil Water Management Model – Soil Water Assessment Tool – Catchments, Simulation Hydrology Model – Stream flow model and use of dimensionless unit hydrograph – Generalized groundwater models.

Suggested Books:

Schwar RS & Friedland B. 1965. *Linear Systems*. McGraw Hill.
Cox DR & Mille HD. 1965. *The Theory of Stochastic Processes*. John Wiley & Sons.
Eagleson PS. 1970. *Dynamic Hydrology*. McGraw Hill.
Himmel Blau DM & Bischoff KB. 1968. *Process Analysis and Simulation Deterministic Systems*. John Wiley & Sons.
Biswas AK. 1976. *Systems Approach to Water Management*. McGrawHill.
Singh, V.P. 1988. *Hydrologic Systems- Volume I- Rainfall-Runoff Modeling*. Prentice Hall, New Jersey, USA.
Ven Te Chow, David R Maidment & Mays LW. 1998. *Applied Hydrology*. McGraw Hill.

SWCE 604 HYDROLOGICAL ANALYSIS OF WATERSHEDS 3(2+1)

Theory:
UNIT I
Introduction: review of basic hydrology, Hydrologic processes- deterministic, probabilistic, stochastic and dynamic.
UNIT II
Basic characteristics of small watersheds. Geomorphology of watersheds- basic concepts, linear aspects, areal aspects and relief aspects of drainage basins and channel networks.
UNIT III
Rainfall runoff relationships-estimation of surface runoff volume (SCS curve number method) and peak runoff rate.
UNIT IV
Flood routing- concepts and classification, hydrologic reservoir and channel routing, basic concepts of hydraulic flood routing.
UNIT V
Analysis and synthesis of hydrographs- unit hydrograph. Distribution and dimensionless unit hydrographs, synthetic unit hydrograph and instantaneous unit hydrographs. Geomorphological Instantaneous unit Hydrograph. Theoretical background Different models for GIUH.

Practical:

Geomorphic analysis of small watersheds.
Analysis of precipitation data: Presentation of data, Consistency of data, estimation of missing data and determination of mean areal precipitation.
Estimation of surface runoff volume by SCS curve number method and Estimation of peak runoff rate.
Hydrologic Reservoir and Channel routing
Analysis and synthesis of hydrographs. Derivation of UH and SH, IUH by Clark and Nash Model

Suggested Books:

Mutreja KN.1986. *Applied Hydrology*. Tata McGraw Hill.
Singh, V.P. 1994. *Elementary Hydrology*. Prentice Hall of India.
Ven Te Chow, David R Maidment & Mays LW. 1998. *Applied Hydrology*. McGraw Hill.
Ghanshyam Das. 2000. *Hydrology and Soil Conservation Engineering including Watershed Management.* Prentice Hall of India.

SWCE 605	**HYDROLOGICAL MODELS**	**3(2+1)**

Theory:
UNIT I
The role of hydrology models: Objectives and concepts. Types of models. Model components.
Modelling procedures: problem definition, boundary identification, data requirements, calibration and validation.
Designing a conceptual model
Rainfall-runoff models: conceptual models, unit hydrograph models, mechanistic catchment models.
Sensitivity analysis, parameterisation, calibration, validation, and evaluation. Stanford Watershed model
UNIT II
HEC-RAS (Hydrologic Engineering Center- River Analysis System) model, HEC-HMS (Hydrologic Engineering Center- Hydrologic Modelling System) model, HEC-WMS (hydrologic Engineering Center- Watershed Modelling System) model
UNIT III
TR-20 (Technical Release No. 20) model- Computer Program for Project Formulation Hydrology
UNIT IV
MODFLOW (USGS Modular Three-Dimensional Groundwater Flow Model)
UNIT V
Watershed Hydrologic and Water Quality Modeling- HSPF (Hydrologic Simulation Program Fortran) model for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants

Practical:

Exercises with case studies for validation, calibration and use of HEC-RAS model for water resources and hydrology
Exercises with case studies for validation, calibration and use of HEC-HMS model for water resources and hydrology
Exercises with case studies for validation, calibration and use of HEC-WMS model for water resources and hydrology
Exercises with case studies for validation, calibration and use of TR20 model for water resources and hydrology

Exercises with case studies for validation, calibration and use of MODFLOW model for water resources and hydrology
Exercises with case studies for validation, calibration and use of HSPF model for water resources and hydrology

Suggested Books:

Vijay P. Singh and Donald K. Frevert. 2005. Watershed Models. CRC Press, Taylor and Francis Group
Technical document and user manual of HEC-RAS
Technical document and user manual of HEC-HMS
Technical document and user manual of HEC-WMS
Technical document and user manual of TR20
Technical document and user manual of MODFLOW
Technical document and user manual of HSPF

SWCE 606	**ADVANCED HYDRO INFORMATICS**	**3(2+1)**

Theory:
UNIT I
Data driven investigation in hydrology
Unified Modeling Language: What is UML?, The Framework of the UML, Object Model Diagrams, Database Design and Deployment.
Digital Library Technology: Introduction, Building the Hydrologic Information System Digital Library
Hydrologic Metadata: Introduction to Metadata, Definition of Metadata Categories, Metadata: Problems and Standardization, Hydrologic Metadata
Hydrologic Data Models: Data Models, Geodata Models, The ArcHydro Data Model
Modelshed Data Model: Modelshed Framework, The Modelshed Geodata Model Structure
UNIT II
Managing and accessing large data sets
Data Models for Storage and Retrieval: Survey of Different Types and Uses of Data, Who are the Users? Gathering, Using, and Archiving Data, Data Management Challenges
Data Formats: Formats and Abstraction Layers, Concepts of Data File Formats, Hierarchical Data Format (HDF5) data model
UNIT III
Data communication and data processing and analysis
UNIT IV
Statistical Data Mining: Supervised Learning, Unsupervised Learning
Neural Networks: Introduction, Methods, Back-Propagation Neural Networks, Synthetic Data Generation Based on Neural Networks
Genetic Algorithms: Introduction, GA Basics, Methods; other evolutionary algorithms.
Fuzzy Logic: Introduction, Fuzzy Sets Essentials, Fuzzy Modeling, Methods, Bayesian Networks

Practical:

Data driven investigations in hydrology
Managing and accessing large data sets
Data communication and data processing and analysis
Application of artificial neural network in water resources
Application of Gas and other evolutionary algorithms in water resources
Application of fuzzy logic in water resources
Application of Bayesian Networks in water resources

Suggested Books:

Pratihar, D.K. 2008. *Soft Computing*. Narosa Publications.

Praveen Kumar and Marukus. 2005. *Hydroinformatics: Data Integrative Approaches in Computation, Analysis, and Modeling*. CRC Press, Taylor and Francis Group.

Robert J. Abrahart; Linda M. See; Dimitri P. Solomatine. 2008. *Practical Hydroinformatics*. Springer Publications

Kishan Mehrotra, Chilukuri K. Mohan and Sanjay Ranka. 1996. *Elements of Artificial Neural Networks*. The MIT Press.

Melanie Mitchell. 1998. *An Introduction to Genetic Algorithms*. The MIT Press

Thomas Bäck. 1996. *Evolutionary algorithms in theory and practice: evolution strategies, evolutionary programming, genetic algorithms*. Oxford University Press.

Sakawa, Masatoshi. 2001. *Genetic Algorithms and Fuzzy Multiobjective Optimization*. Operations Research/Computer Science Interfaces Series. Springer Publications.

Randy L. Haupt. 2004. *Practical genetic algorithms*. Wiley-IEEE

Kazuo Tanaka, Tak Niimura. 1996. *An Introduction to Fuzzy Logic for Practical Applications*. Springer Verlag.

Masao Mukaidono, Hiroaki Kikuchi. 2001. *Fuzzy Logic for Beginners*. World Scientific Pub Co Inc.

Vilem Novak, Jiri Mockor, Irina Perfilieva. 1999. *Mathematical Principles of Fuzzy Logic*. Kluwer Academic Pub.

SWCE 607 RISK MANAGEMENT IN SOIL AND WATER CONSERVATION 3(2+1)

Theory:
UNIT I
Risk, hazard, vulnerability, probability: definition, concept, interrelationships, methods and tools, uncertainty, sources of uncertainty, methods and tools for estimation of uncertainty.
UNIT II
Understanding risk, risk management, issues and challenges involved in risk management
UNIT III
Risk management: watershed, drought, water resources
UNIT IV

Multi criteria analysis: composite and compromise programming, Analytical hierarchical Process (AHP), fuzzy risk, aggregative risk analysis, spatial and temporal risks, reliability analysis

Practical:

Assessment of hazards, vulnerability and risk
Examples of multi criteria analysis
Examples of AHP
Examples of composite and compromise programming
Examples of fuzzy risk
Risk management case studies: rainfed agriculture
Risk management case studies: drought
Risk management case studies: watershed development

Suggested Books:

Vairavamoorthy, K., S. D. Gorantiwar, J. Yan, H. M. Galgale, M. A. M. Mansoor and S.Mohan. 2006. *Water Safety Plans: Risk Assessment for Contaminant Intrusion into Water Distribution Systems*. Water Engineering Development Center, UK, ISBN No. 1 84380 102 7.

Lumbroso, D., S.D. Gorantiwar, D. Nichols, E. Penning-Rowsell, S. Surendran and H. Stolk. 2007. *Risk assessment for flood incident management: Framework and tools.* Science Report: SC050028/SR1. Environment Agency, Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol, BS32 4UD .

Goranitwar, S.D. and I.K.Smout. 2007. *Risk assessment for flood incident management Risks and consequences of failure of reactive mitigation measures*. Science Report – SC050028/SR4. Environment Agency, Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol, BS32 4UD.

Pollard, S. 2007. *Risk management for the water utility sector*. London, UK, IWA Publishing. (Water and wastewater process technologies series) - ISBN: 1843391376

SWCE 693	**SPECIAL PROBLEM**	**1 (0+1)**

Special Problem related to any topic in Soil and Water Conservation Engineering. A report on the study to be submitted for evaluation.

SWCE 694	**CASE STUDIES**	**1 (0+1)**

Case study on any topic from Soil and Water Conservation Engineering selected in consultation with Research Guide. The case study report to be submitted for evaluation.

B) MINOR SUBJECTS (8 CREDITS)

AE 601 ENVIRONMENTAL IMPACT ASSESSMENT 3 (1+2)

Theory:

UNIT I

Introduction: terminology, environment and sustainability, classification of the environment, livelihoods and natural resources, EIA concepts, nature of EIA, diffusion and evolution of EIA, the Government of India's directives on EIA, environmental policy and institutional framework in India, legal basis for EIA in India, Law on Ecological Expert Evaluation and the Evaluation of Impact on the Environment.

UNIT II

Environmental impact assessment process

Planning and Management of Impact Studies: conceptual approach for environmental impact studies, proposal development, interdisciplinary team formation, team leader selection and duties, general study management, fiscal control.

Simple Methods for Impact Identification – Matrices, Networks, and Checklists: background information, interaction-matrix methodologies, network methodologies, checklist methodologies

Description of Environmental Setting (Affected Environment): conceptual framework, initial list of factors, selection process, documentation of selection process, data sources, special issues and concerns.

Environmental Indices and Indicators for Describing the Affected Environment: background information, environmental-media indices (air quality, water quality, noise, ecological sensitivity and diversity, archeological resources, visual quality, quality of life), development of indices.

UNIT-III

Public Participation in Environmental Decision Making: definitions, regulatory requirements, advantages and disadvantages of public participation, public participation in the environment impact assessment process, objectives of public participation, identification of publics, selection of public participation techniques, techniques for conflict management and dispute resolution, practical considerations for public participation program implementation, incorporation of results in decision making,

UNIT-IV

Preparation of Written Documentation: initial planning phase, detailed planning phase, writing phase.

Practical:

Prediction and Assessment of Impacts on the Surface-Water Environment: basic information on surface-water quantity and quality, legislation and regulations (national and international), conceptual approach for addressing surface-water-environment impacts (identification of surface-water quantity or quality impacts, description of existing surface-water resource conditions, procurement of relevant surface-water quantity-quality standards, impact predictions, assessment of impact significance, identification and incorporation of mitigation measures), case study.

Prediction and Assessment of Impacts on the Soil and Groundwater Environments: background information on the soil environment, background information on groundwater quantity and quality, legislation and regulations (national and international), conceptual approach for addressing soil- and groundwater-environment impacts (identification of soil and / or groundwater quantity-quality impacts, description of existing soil and / or groundwater resources, procurement of relevant soil and / or groundwater quantity-quality standards, impact prediction, assessment of impact significance, identification and incorporation of mitigation measures), case study
EIA of irrigation projects
EIA of watershed development projects
EIA of drainage projects

Suggested Books:

Jain, R.K., et al. 2001. *Environmental Assessment*. Second Edition. McGraw-Hill Professional Publishing.
Canter, Larry W. 1996. *Environmental Impact Assessment.* Second Edition. McGraw-Hill Inc. Series in Water Resources & Environmental Engineering.
Timothy O'Riordan (Ed.) 2000. *Environmental Science for Environmental Management.* Second Edition. Prentice Hall. Pearson Education Limited.
Glasson, John. 1999. *Introduction to Environmental Impact Assessment: Principles and Procedures, Process, Practice, and Prospects*. UCL Press.
Wood, Christopher. 1995. *Environmental Impact Assessment / A Comparative Review.* Prentice Hall. Pearson Education Limited.
Calow, Peter. 1999. *Handbook of Environmental Impact Assessment*. Blackwell Science
Westman, Walter E. 1985. *Ecology, Impact Assessment, and Environmental Planning*. Wiley-Interscience.
Gilpin, Alan. 1995. *Environmental impact assessment (EIA): cutting edge for the twenty-first century*, Cambridge University Press.

AE 602 CLIMATE CHANGE IMPACT ADAPTATION AND MITIGATION 3 (2+1)

Theory:
UNIT I
Understanding of climate science, An Introduction to Climate Change: The Science behind the Phenomenon, What is Climate Change? Impacts of a changing climate, The link between the science, the effects and business, Key economic impact issues, **Vulnerability and coping with impacts**
UNIT II
Policy and Regulation, UNFCCC: Outline of the treaty, The Kyoto Protocol, 'Post **2012' and the Bali Roadmap', other treaties.**
UNIT III
Carbon Finance; An Introduction to the Flexible Mechanisms: Emissions trading. The Flexible Mechanisms of the Kyoto Protocol: International Emission Trading (IET) and The Project-Based Mechanisms; The EU Emission Trading System: The First International Emissions; Trading Scheme in Practice: Risks and Opportunities for Participating Companies, Who loses and who gains from the EU ETS?; Market Developments in the EU ETS and the Kyoto Market: The voluntary market, The role of different countries; How financial institutions can encounter the challenges related to climate change and emissions trading?
UNIT IV
Climate change models, Understanding the interaction between the climate system and the hydrological cycle. Being aware of the impacts of climate change on the natural environment and on society; Understanding of dealing with risk and uncertainty and Understanding of adaptation and mitigation in relation to water and climate change
UNIT V
Climate change mitigation: issues and challenges, Mechanisms of climate change mitigation; methods and tools; developing scenarios, Climate change adaptation: issues and challenges, Climate change adaptation techniques, methods and tools; developing scenarios.
UNIT VI
Links between climate change, water availability and agricultural production, effect of climate changes on climatolgical variables (rainfall, temp., humidity etc), soil moisture sea water level, water availability, agricultural production, floods, dry spells and drought. Direct and indirect impacts due to climate change.

Practical:

Impact of climate changes on agricultural production
Impact of climate changes on water availability
Impact of climate changes on rainfed agriculture
Impact of climate changes on flood
Impact of climate changes on drought
Impact of climate changes on irrigation water management
Studies on different mitigation measures
Studies on different adaptation measures

Suggested Books:

Intergovernmental Panel on Climate Change. 1996. *Climate Change* 1995: *Impacts, Adaptations, and Mitigation: Contribution of Working Group II to the Second Assessment Report*, Cambridge University Press.
Frederick, K. D., D. C. Major, and E. Z. Stakhiv, eds.1997. *Climate Change and Water Resources Planning Criteria*, Kluwer Academic Publishers, Dordrecht, The Netherlands.
James J. McCarthy. 2001. *Climate change 2001: impacts, adaptation, and vulnerability*. Cambridge University Press.
B Smit, O Pilifosova, I Burton, B Challenger, S. 2001. *Adaptation to climate change in the context of sustainable development and equity*. Cambridge University Press
Bert Metz. 2007. Climate Change 2007. Cambridge University Press.
Intergovernmental Panel on Climate Change Reports

AE 603	RESEARCH TECHNIQUES	3 (2+1)

Theory:
UNIT I
Basic concept of principal component analysis, Geometrical properties of principal components, Decomposition properties of principal components, Rotation of principal components, Use of principal components in regression analysis and cluster analysis, Use principal components to detect outlying and influential observations.
UNIT II
Dimensional homogeneity, Buckingham pi theorem, Model and Prototype Similarity Linear, Areal, kinematic and dynamic similarity.
UNIT III
Measuring systems and control of measuring instruments. Sensors and Transducers, Various sensors available for pressure measurement / load measurement / strain measurement/ moisture measurement, etc.
UNIT IV
Basic research, applied research and development, Administration of research. PERT and CPM for management of Research

Practical:

Numerical on dimensional homogeneity, Numerical on Buckingham Pi theorem
Study of sensors for pressure, strain, moisture measurement.
Numerical on PERT and CPM.
Hands on for Computer software for Principal Component Analysis.

Suggested Books:

Huntley, H.E. 1974. *Dimensional Analysis*. Dover Publ.
Riggs, J. L., L. L. Bethel, F. S. Atwater, G.H.E. Smith, H. A. Stackman Jr. 1979. *Industrial Organization and Management*. McGraw-Hill, Kogakusha, Tokyo.

Sharma, S. D. 1999. *Operations Research*. Kedar Nath-RamNath and Co. Publishers, Meerut.
Sawhney AK. 2008. *Electrical and Electronics Measurement and Instrumentation*. Dhanpat Rai & Sons.
Jolliffe, I.T. 1986. *Principal Component Analysis*. Springer-Verlag, New York.
Dunteman, George H. 1989. *Principal Component Analysis*. SAGE Publication India Pvt. Ltd. New Delhi-110 048.

AE 604	**BENCH MARKING AND PERFORMANCE ANALYSIS**	**3 (2+1)**

Theory:
UNIT I
What is benchmarking? Why is benchmarking needed? , What is The Benchmarking Process? Recognising the Need for Benchmarking, What should be benchmarked?, Who does the benchmarking? What are the benefits of benchmarking? What extra tasks and costs does benchmarking involve? What is the relationship between benchmarking and performance assessment? Different sectors that need benchmarking with emphasis on the project in water and environmental sectors.
UNIT II
Benchmarking theory, Scoping Benchmarking Activity
Data requirement, capture and gathering
Types of Benchmarking, How to conduct a study, Benchmarking methods
Rapid Appraisal Process (RAP), Explanation and Tools, External and internal indicators
UNIT III
Analysing and identifying best practices, Identifying best utilities/companies/projects, Competencies and Competition, Objective Analysis of Service Delivery, Reviewing performance, identifying gaps in performance, Developing performance improvements, Implementing and monitoring progress on performance structures., Preparation and presentation of action plans, programme implemenation
UNIT IV
Performance, their measures: productivity, equity, adequacy, reliability, flexibility, sustainability, efficiency etc, characteristics of performance measures, types: allocative type, scheduling type, different phases of performance measures: planning, operation and evaluation, spatial and temporal variation of performance measures, indicators of different performance measures

Practical:

Benchmarking of irrigation projects
Benchmarking of watershed projects
Performance evaluation of irrigation project
Performance evaluation of watershed projects
Case studies on benchmarking and performance evaluation**.**

Suggested Books:

IPTRID. August 2001. *Guidelines for benchmarking performance in the irrigation and drainage sector*, by Malano, H. & Burton, M. IPTRID Knowledge Synthesis Report No. 5. FAO. Rome.

Mark. T. Czarnecki. *Benchmarking Strategies for Health Care Management*. Aspen Publishers, Inc.

Gorantiwar, S.D. and I.K.Smout. 2005. *Performance assessment of irrigation water management of heterogeneous irrigation schemes*. Irrigation and Drainage Systems, 19:1-60.

Charles Burt. 2001. *Rapid Appraisal Process (RAP) and Benchmarking Explanation and Tools.* FAO.

Hector Malano and Martin Burton. 2001. *Guidelines for benchmarking performance in the irrigation and drainage sector*. FAO.

Sanford Berg.2009. *Water Utility Benchmarking*. IWA Publishing.

IDE 511	**INTRODUCTORY HYDRO INFORMATICS**	**3 (2+1)**

Theory:
UNIT I
Introduction to Hydroinformatics, Need and Applications of Hydroinformatics. Various tools in Hydroinformatics. The role of internet and web technologies in Hydroinformatics and gathering data. Sources of data, Telemetry/SCADA and other techniques of data collection.
UNIT II
Process of schematisation/discretisation (in space and time domain). The role of calibration and validation process in modelling. Solution of simple advection equation using FDM, sample code to show how these equations are used. Introduction to basic concepts of hydraulic modelling and governing equations. Use flow simulation models in networks. Hydrologic model-concept and need. Classification of hydrologic models. Physical, empirical, lumped, distributed models with examples, deterministic and probabilistic models. Introduction to popular hydrologic models
UNIT III
Physically-Based Vs Data-Driven Models. Examples of data-driven modelling. Introduction to modern techniques used in hydroinformatics: artificial intelligence, expert systems, neural networks. The use of artificial intelligence (AI) techniques for prediction, simulation, identification, classification and optimisation in the water resources engineering field. Example application of Artificial neural networks and Fuzzy logic techniques to water resources engineering.
UNIT IV
Potential benefits of applying optimisation to water resources problems. Optimisation techniques including evolutionary algorithms (genetic algorithms and genetic programming). Applications of genetic algorithms for water resources.
UNIT V
What is GIS? Fundamentals, Components and Various data structure of GIS, Need of GIS, Applications of GIS. Introduction to ArcView GIS, How to use ArcView GIS to build various themes, query themes, perform spatial analysis & 3D analysis. 3D and 2D data visualisation. What is decision support systems (DSS) and spatial decision support system (SDSS). Components of DSS and SDSS. How to build DSS & SDSS. Demonstration of DSS for water resources problems.

Practical:

Data sources, collection and organization of data
Use of Telemetry/SCADA for data collection
Schematization/ discretisation of data
Application of Artificial neural networks and Fuzzy logic techniques to water resources engineering
Applications of genetic algorithms for water resources
Application of GIS
Building of DSS and SDSS
Demonstration of DSS for water resources problems.

Suggested Books:

Pratihar, D.K. 2008. *Soft Computing*. Narosa Publications.

Praveen Kumar and Marukus. 2005. *Hydroinformatics: Data Integrative Approaches in Computation, Analysis, and Modeling*. CRC Press, Taylor and Francis Group.

Robert J. Abrahart; Linda M. See; Dimitri P. Solomatine. 2008. *Practical Hydroinformatics*. Springer Publications

Kishan Mehrotra, Chilukuri K. Mohan and Sanjay Ranka. 1996. *Elements of Artificial Neural Networks*. The MIT Press.

Melanie Mitchell. 1998. *An Introduction to Genetic Algorithms*. The MIT Press

Thomas Bäck. 1996. *Evolutionary algorithms in theory and practice: evolution strategies, evolutionary programming, genetic algorithms*. Oxford University Press.

Sakawa, Masatoshi. 2001. *Genetic Algorithms and Fuzzy Multiobjective Optimization*. Operations Research/Computer Science Interfaces Series. Springer Publications.

Randy L. Haupt. 2004. *Practical genetic algorithms*. Wiley-IEEE

Kazuo Tanaka, Tak Niimura. 1996. *An Introduction to Fuzzy Logic for Practical Applications*. Springer Verlag.

Masao Mukaidono, Hiroaki Kikuchi. 2001. *Fuzzy Logic for Beginners*. World Scientific Pub Co Inc.

Vilem Novak, Jiri Mockor, Irina Perfilieva. 1999. *Mathematical Principles of Fuzzy Logic*. Kluwer Academic Pub.

IDE 605	**PIPE NETWORK ANALYSIS**	**3 (2+1)**

Theory:
UNIT I
Introduction to pipe network, Components of piped systems and pipe material selection, bedding and laying.
Type of water supply system, type of piping system, type of water distribution network, labeling network elements, network components, design requirements and problems.
Basic hydraulic principles, energy and hydraulic grade lines, functional head losses in pipe, minor head losses, equivalent pipes.
UNIT II
Economic principle, cash flow diagram and methods of analysis, cost functions.

UNIT III
Optimization: principles and its application in network analysis.
UNIT IV
Reservoir, Pumps and Valves: Types of reservoir, service and balancing reservoir, three and multiple reservoir systems.
Pumps: system head–discharge curve and pump head-discharge curve, pump characteristics, Pump combination, valves on pipe network.
UNIT V
Network parameters and types of analysis.
Network parameters, parameter interrelationship, formulation of equations
Types of analysis- Hardy cross method other analysis methods for branched and looped network
Network models: minimal spanning tree algorithm, shortest route problem, maximum flow model. Optimal layout, Network design for special cases

Practical:

Pipe network analysis for branched network by Hardy-Cross method
Pipe network analysis for looped network by Hardy-Cross method
Optimal design of rising main for irrigation network.
Optimal design of branched network using LP, Successive pipe size reduction method.
Optimal layout using network models (TORA).
Optimal design of looped network using LP, Successive pipe size reduction method.
Optimal design of pumped network.
Optimal design of gravity network.

Suggested Books:

Bhave, P.R. 2003. *Optimal Design of Water Distribution Networks.* Narosa Publishing House, New Delhi.

Taha, H.A. 2007. *Operations Research an Introduction* (eighth Ed.). Prentice-Hall of India Private Limited, New Delhi.

Bhave, P.R. and Gupta R. 2006. *Analysis of Water Distribution Networks*. Narosa Publishing House, New Delhi.

Trifunovic, N. 2006. *Introduction to urban water distribution*, Taylor & Francis/Balkema

Brandon, Thomas W. 1984. *Water distribution systems.* Institution of Water Engineers and Scientist.

IDE 606	RIVER BASIN MODELS	3 (2+1)

Theory:
UNIT I
The processes in river basin models; their coneptualisation and need for modeling, the processes of data collection, model validation and calibration.
UNIT II
Integrated surface water and groundwater modelling
MIKE SHE Model: The hydrologic processes simulated by MIKE SHE
The mechanisms used to couple the hydrologic processes in MIKE SHE
Basic hydraulic flow modelling in streams and canals us-ing MIKE 11
Setting up a model in MIKE SHE
Evaluation of results of an integrated groundwater/surface water model
Calibration strategies for an integrated model, in-cluding a brief introduction to automatic calibra-tion tools.
UNIT III
River Basin Modelling,
MIKE Basin Model: General introduction to river basin management
Introduction to processes described in MIKE BASIN
Defining and conceptualising the problem scenarios
MIKE BASIN Graphical User Interface (GUI)
Model schematisation
Introduction to the MIKE BASIN process descriptions
Data management incl. Temporal Analyst
Result analysis and presentation (including statistical analysis and results interpretation)
Assessing water demands for water supply, irrigation and hydropower
Reservoir operation
Development of simple models
UNIT IV
Introduction to river and channel modelling
MIKE 11 Model: Theoretical background to hydrodynamic modelling
Model build
Understanding data requirements
Working with editors for network, cross section and time series data
Defining boundary conditions and estimating parameters
Running simulations and understanding the results
Introduction to structures
UNIT V
Finite Element Model for Flow and Mass/Heat Transport in Sat/Unsat Porous Media
FEFLOW Model: Groundwater modeling for
Density-dependent flow (salt water intrusion)
Transient or steady-state flow

Saturated and unsaturated flow
Multiple free surfaces (perched water table)
Mass and heat transport

Practical:

Exercises with case studies for validation, calaibration and use of MIKE SHE model for water resources
Exercises with case studies for validation, calaibration and use of MIKE BASIN model for water resources
Exercises with case studies for validation, calaibration and use of MIKE 11 model for water resources
Exercises with case studies for validation, calaibration and use of FEFLOW model for water resources

Suggested Books:

DHI.2005. *MIKE-SHE: An Integrated Hydrological Modelling System*. DHI Water and Environment, Agern Alle 5, DK- 2970, Horsholm, Denmark, 454 PP.
DHI.2004. *MIKE 11: A Modelling System for Rivers and Channels*. DHI Water and Environment, Agern Alle 5, DK – 2970, Horsholm, Denmark, 454 pp.
DHI.2005. *MIKE ZERO: Preprocesing and Postprocessing.* DHI Water and Environment, Agern Alle 5, DK – 2970, Horsholm, Denmark, 457 pp.
DHI.2005. *MIKE-SHE: An Integrated Hydrological Modelling System*. DHI Water and Environment, Agern Alle 5, DK – 2970, Horsholm, Denmark, 149 pp. (Exercise)
DHI.2004. *MIKE View: A Results Presentation Tools for MOUSE, MIKE SWMM, MIKE NET and MIKE 11*. DHI Water and Environment, Agern Alle 5, DK – 2970, Horsholm, Denmark, 130 pp.
DHI.2004. *MIKE 11: A Modelling System for Rivers and Channels*. DHI Water and Environment, Agern Alle 5, DK – 2970, Horsholm, Denmark, 1-1: 9-14 pp. (Exercise)
DHI.2004. *MIKE Basin: River Basin Modelling*. DHI Water and Environment, Agern Alle 5, DK – 2970, Horsholm, Denmark
Technical and User Manual of FEFLOW
Technical and User Manuals of MIKE SHE, MIKE 11 and MIKE Basin models.

C) SUPPORTING SUBJECTS (5 Credits)		
BSCT 601	**OBJECT ORIENTED PROGRAMMING**	**3 (2+1)**

Theory:
UNIT I
Introduction to Computer Systems, Hardware and Software; Computing Environments- Personal, Time sharing and Client Server Computing.
UNIT II
Types of programming languages. Software Development Process Models. Differentiation between Procedural and Object Oriented approach;
UNIT III
Programming Language: Object oriented approach Using C++, Data Abstraction and Classes, Class Constructors and Destructors. Working with Classes- friends, Operator overloading;
UNIT IV
Automatic Conversions and type casts for classes, Dynamic memory and classes. Class Inheritance- An Array base Class, Deriving a class, Virtual Function, Classes with member classes, multiple Inheritance,
UNIT V
Output and Files- Overview of C++ Input and Output, Output with cout, Input with cin, file Input and output

Practical:

Study of Programming Language: Object oriented approach Using C++, Data Abstraction and Classes, Class Constructors and Destructors. Study of Automatic Conversions and type casts for classes, Dynamic memory and classes. Study of Output and Files- Overview of C++ Input and Output, Output with cout, Input with cin, file Input and output.

Suggested Books:

Stephen Prata. *C++ Primer plus*. Galgotia publications
E. Balguruswamy. *Object Oriented Programming with C++*. Tata Mc-Graw Hill Publications Ltd. New Delhi.

Ian Sommerville. *Software Engineering*. Pearson Education Asia

MATH 601 MATHEMATICAL MODELING AND SOFTWARE APPLICATIONS 3 (2+1)

Theory:
UNIT I
Introduction, stages in mathematical modeling, importance of mathematical modeling.
UNIT II
Classification of mathematical models: Continuous and discrete models, linear models and its applications, quadratic models and its applications, exponential models and its applications, empirical models and its applications.
UNIT III
Introduction to MAT LAB, Desktop tools
UNIT IV
MAT LAB basics: variables and arrays, Initialization variables, Matrix manipulation, linear algebra, roots of polynomials, data analysis and statistics. Solution of the mathematical problems using MAT LAB and MAT LAB tools. Graph plotting: 2-D, 3-D, Contour.
UNIT V
Simulation of mathematical models using MAT LAB programming.

Practical:

Hands on for UNIT III, IV and V.

Suggested Books:

Dym, Clive L. *Principles of Mathematical modeling*.
Chapman, Stephen J. *MAT LAB programming for Engineers*.

MATH 609 OPERATIONS RESEARCH 3 (2+1)

Theory:
UNIT I
Definition and scope of operations research. Management applications of operations research. Main characteristics of operations research
UNIT II
Linear programming, LP models, formulation of problems, limitations, simplex method, complications and their resolution, duality principle, application of LP
UNIT III
Transportation type problems, formulation, basic concepts, finding initial basis, feasible and optimal solutions, degeneracy, Transportation Problem with minimum time requirements, the unbalanced Transportation Problem. Assignment problem: formulation and solution.
UNIT IV

Dynamic programming: multistage problems, recursive equation approach.
UNIT V
Inventory control, economic lot size model, production planning, single and multi-period models.
UNIT VI
Replacement problems: models: basic concepts, replacement of items that fail completely, replacement of equipment deteriorating with time, staffing and other problems of replacement.
UNIT VII
Queuing Theory and applications. M/M/1, M/M/s type models

Practical:

Numerical on formulation and solution of LP problems
Numerical on formulation and solution of Transportation problems
Numerical on formulation and solution of Assignment problems
Numerical on formulation and solution of DP problems
Numerical on Inventory control models
Numerical on Replacement problems
Numerical on Queuing models

Suggested Books:

Rao, S.S. 1990. Optimization- Theory and Applications.
Sharma, S.D. 1999. Operations Research. Kedar Nath Ram Nath and Co. Publishers, Meerut.
Taha, H.A. 1989. Operations Research- An Introduction. Maxwell Macmillan, New York.
Vohra, N.D. 1990. Quantitative Techniques in Management. Tata McGraw-Hill Publishing Co. New Delhi.

MATH 610	**PROBABILISTIC APPROACH IN DESIGN**	**2 (2+0)**

Theory:
UNIT I
Review of various approaches in engineering design and introduction of probabilistic approach.
UNIT II
Random variables. Probability distribution and density functions. Expected values, Mean. Variance, Conditional probability. Characteristic functions.
UNIT III
Function of random variable. Concepts of stationary, ergodic and nonstationary processes.
UNIT IV

Auto correlation. Cross-correlation. Covariance functions. Power spectral and cross spectral density functions and their determination from experimental data.
UNIT V
Broad-band and Narrow band random processes, White noise. Application in various disciplines of engineering.

Suggested Books:

Benjamin JR & Allen C. 1975. *Probability Statistics and Decision for Civil Engineers.* MGH New York.
Evan DH.1992. *Probability and its Applications for Engineers.* ASQC Press & Marcel Dekker.

MATH 611	**GEOSTATISTICAL ANALYSIS**	**2 (1+1)**

Theory:
UNIT I
Overview of Classical statistics, Normal and Log-normal distributions.
UNIT II
Concept of geospatial analysis and database design. Spatial statistics. Covariogram, Semivariogram and Variogram, Regularization.
UNIT III
Dispersion variance and grade- tonnage relationship. Extension variance and estimation variance
UNIT IV
Optimal valuation, kriging. Cross validation.
UNIT V
Use of data mining concepts in geospatial analysis.

Practical:

Numerical on UNIT I, II, III, IV and V.

Suggested Books:

David, M. 1977. *Geostatistical ore Reserve Estimation.* Elsevier, New York.
Rendu, J. M. 1978. *An Introduction to Geostatistical Methods of Mineral Evaluation.* South African Institute of Mining and Metallurgy, Johannesburg.

D) SEMINAR SUBJECT (2 Credits)		
SWCE 691	**DOCTORAL SEMINAR I 1**	**(0+1)**

Student will have to deliver seminar(s) on the topics related to Soil and Water Conservation Engineering in consultation with Research Guide.

SWCE 699	**DOCTORAL SEMINAR I 1**	**1 (0+1)**

Student will have to deliver seminar(s) on the topics related to Doctoral Research Area in consultation with Research Guide.

E) DOCTORAL RESEARCH (20 Credits)		
SWCE 699	**DOCTORAL RESEARCH**	**45 (0+45)**

Student will have to carry out the research and submit the thesis in consultation with Research Guide.

F) NON CREDIT COMPULSORY COURSES (OPTIONAL) (6 Credits)		
PGS 501	**LIBRARY AND INFORMATION SERVICES1**	**1 (0+1)**

Practical:

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM
Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; eresources access methods.

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS 1(0+1)

Practical:

Technical Writing **-** Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.
Communication Skills **-** Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Books:

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
Collins' Cobuild English Dictionary. 1995. Harper Collins.
Gordon HM & Walter JA. 1970. *Technical Writing*. 3rd Ed. Holt, Rinehart & Winston.
Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.
James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.
Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.
Mohan K. 2005. *Speaking English Effectively*. MacMillan India.
Richard WS. 1969. *Technical Writing*. Barnes & Noble.
Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*. Abhishek.
Sethi J & Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
Wren PC & Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (e-Course) 1(0+1)

Theory:
Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity
protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant

Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Books:

Erbisch FH & Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.
Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundation.
Rothschild M & Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.
The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES 1(0+1)

Practical:

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Suggested Books:

Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
Gabb MH & Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

PGS 505	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (e-Course)	1(0+1)

Theory:
UNIT I
History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.
UNIT II
Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.
UNIT III
Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Books:

Bhalla GS & Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.

Punia MS. *Manual on International Research and Research Ethics*. CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.

Singh K. 1998. *Rural Development - Principles, Policies and Management.* Sage Publ.

PGS 506	DISASTER MANAGEMENT (e-Course)	1 (1+0)

Theory:
UNIT I
Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion
UNIT II
Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III
Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

Suggested Books:

Gupta HK. 2003. *Disaster Management.* Indian National Science Academy. Orient Blackswan.
Hodgkinson PE & Stewart M. 1991. *Coping with Catastrophe: A Handbook of Disaster Management.* Routledge.
Sharma VK. 2001. *Disaster Management.* National Centre for Disaster Management, India.