HWRM-312 ELECTIVE (I) (03) Credit hrs)

One course will be adopted from the list of elective courses

Sr. No	Subject	Credit Hours
1	Advances In GIS and Remote Sensing	3(2-1)
2	Ground Water and Surface Water Interaction	03
3	Environmental Issues in Water Resources	03
4	Hydrometry	3(2-1)
5	Integrated Water Resources Management	03
6	Applications Of Economics in Water Resources	03
7	Advance Mathematics in Hydrology	03
8	Research Methods	03

ADVANCES IN GIS AND REMOTE SENSING (THEORY) (02 Credit hrs)

PRE-REQUISITE: HWRM-308

LEARNING OUTCOMES

Following are the learning outcomes of the course:

- Student will learn about Data Processing and Application of GIS and Remote Sensing
- Student will learn about Use of Scripting Languages in Hydrology
- Student will learn about Multi Criteria Decision Analysis (MCDA)
- Student will learn about Applications of GIS and Remote Sensing in Hydrology
- Student will learn about Flood analysis using GIS and Remote Sensing

Contents

Remote sensing and GIS theories, satellites systems, image interpretation, and applications in hydrology. Practical performance of advances in GIS and remote sensing.

Theory

Unit-1 Data Processing and Application of GIS and Remote Sensing

1.1. Preprocessing data for model uses
1.2. Application of GIS for data preprocessing
1.3. Remote sensing in GIS and Remote sensing
1.4. Data Tabulation
1.5. conversion
1.6. projection
1.7. catchment delineation
1.8. Use of OSGEO software (Quantum GIS, GDAL)

Unit-II Use of Scripting Languages in Hydrology

2.1. Using scripts (shell and Python) to batch process datasets
2.2. High resolution DEM generation
2.3. Pre and Post flood damage assessment
2.4. Using Earth observation satellite data and DEM
2.5. Spatio-temporal analysis for water quality assessment
2.6. Python scripts to calculate a water surface profile for wetland decision making

Unit-III: Multi Criteria Decision Analysis (MCDA)

3.1. Analytical Hierarchy process for Weight calculation,
3.2. Dam site selection using Multi Criteria analysis (MCDA)
3.3. Computation and assessment of water balance

Unit-IV: Applications of GIS and Remote Sensing in Hydrology

4.1. Retrieval of hydro-metrological parameters using remote sensing
4.2. Integration in hydrological models with GIS and Remote Sensing
4.3. Mapping and monitoring snow cover, glaciers, and surface water
4.4. Snow-glacier melt analysis using GIS and Remote Sensing
4.5. Applications of GIS and Remote Sensing to rainfall-runoff models
4.6. Surface runoff computation using rainfall – runoff modeling

Unit-V: Flood analysis using GIS and Remote Sensing

5.1. Hydrological modeling approach using GIS and Remote Sensing
5.2. Flood analysis using geospatial techniques
5.3. Design flood computation using geospatial techniques
5.4. Flood forecasting and Modeling
5.5. Groundwater and urban hydrological/hydrodynamic modeling studies
5.6. Geo-spatial data creation, integration and assimilation for flood simulation in 1/2 D HD models

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after mid term assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- attitude and behavior,
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Brown, C. And Harder, C., (2016). *The ArcGIS Imagery Book*. Esri Press, Redlands, Califorinia.
2. Heywood, i., Cornelius, A. and Carver, S. (2006). *An introduction to Geographical Information Systems*. 3rd ed.Perason Education Limited.
3. Aspinall, R., (2003). *Modelling land use change with generalized linear models-a multi-model analysis of change between 1860 and 2000 in Gallatin Valley, Montana*. Journal of Environmental Management 73-91.
4. Jansen, M., Judas, M.E. and Saborowski, J. (2002). *Spatial Modelling in Forest Ecology and management-A Case Study*. Springer 223.
5. Kohsaca, H. (2001). *Applications of GIS to urban planning and management: Problems facing Japanese local governments.* Geojournal, 52: 271-280
6. Michael, Z. (1999). *Modeling Our World: The ESRI Guide to Geodatabase Design*. ESRI Press, 216 pp.

ADVANCES IN GIS AND REMOTE SENSING (LAB) (01 Credit hr)

PRE-REQUISITE: HWRM-308

LEARNING OUTCOMES

Following are the learning outcomes of the course:

- Student will learn about Use of Advance GIS Software
- Student will learn about Use of QGIS and Google Earth Engine
- Student will learn about Use of Scripting Languages

CONTENTS

Remote sensing and GIS theories, satellites systems, image interpretation, and applications in hydrology. Practical performance of advances in GIS and remote sensing.

PRACTICAL

Unit-1 Use of Advance GIS Software

Use of Software like

1.1. OSGEO
1.2. Quantum GIS
1.3. GDAL

Unit-II Use of QGIS and Google Earth Engine

2.1. QGIS
2.2. Google earth engine

Unit-III: Use of Scripting Languages

3.1. using scripts (shell and Python) to execute water resources and modeling applications.

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- attitude and behavior,
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

- Brown, C. And Harder, C., (2016). *The ArcGIS Imagery Book*. Esri Press, Redlands, Califorinia.
- Heywood, i., Cornelius, A. and Carver, S. (2006). *An introduction to Geographical Information Systems*. 3rd ed.Perason Education Limited.
- Aspinall, R., (2003). *Modelling land use change with generalized linear models-a multi-model analysis of change between 1860 and 2000 in Gallatin Valley, Montana*. Journal of Environmental Management 73-91.
- Jansen, M., Judas, M.E. and Saborowski, J. (2002). *Spatial Modelling in Forest Ecology and management- A Case Study*. Springer 223.
- Kohsaca, H. (2001). *Applications of GIS to urban planning and management: Problems facing Japanese local governments.* Geojournal, 52: 271-280
- Michael, Z. (1999). *Modeling Our World: The ESRI Guide to Geodatabase Design*. ESRI Press, 216 pp.

GROUND WATER AND SURFACE WATER INTERACTION (03 Credit hrs)

Pre-requisite: HWRM-102

Learning Outcomes

Following are the learning outcomes of the course:

- Student will learn fundamental of ground and surface water interaction
- Students will be trained about ground water flow analysis
- Students will learn about hydrodynamics of unsaturated flow
- Students will learn about infiltration theory and its applications
- Student will also learn ground water interaction with different mediums

Contents

This course provides deep learning of surface and ground water interaction and its significance with reference to hydrology and water resources management

Theory

Unit-1 Fundamental of Ground and Surface Water Interaction

1.1. Basics of groundwater & surface-water hydrology
1.2. Base flow analysis and separation techniques
1.3. Geologic aspects of ground and surface water interaction
1.4. landscape control analysis of ground and surface water interaction
1.5. climate controls on groundwater-surface water interaction
1.6. Local & Regional flow systems

Unit-2 Ground Water Flow Analysis

2.1. Flow nets
2.2. Equipotential lines and flow lines.
2.3. Soil Water Hydrostatics
2.4. Soil water content
2.5. Soil water retention
2.6. Potential, Soil water retention curves & hysteresis.
2.7. Estimation of characteristics curves
2.8. Pedo-transfer functions

Unit-3 Hydrodynamics of Unsaturated Flow

3.1. Soil Water Hydrodynamics
3.2. Darcy's Law in the unsaturated zone
3.3. Unsaturated steady state flow
3.4. Unsaturated hydraulic conductivity models & applications

Unit-4 Infiltration Theory and its Applications

4.1. Infiltration theory
4.2. Approximate Solutions to Infiltration
4.3. Green Ampt
4.4. Philip Equations
4.5. Numerical Modeling in Variably Saturated Porous Media
4.6. 1-D Spreadsheet Model Applications.

Unit-5 Ground Water Interaction with different Mediums

5.1. Interaction of Groundwater and Streams
5.2. Interaction of Groundwater and Lakes
5.3. Interaction of Groundwater and Wetlands. Chemical
5.4. Interactions of GW & SW in Streams, Lakes, and Wetlands

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- attitude and behavior,
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. McWhorter, D.B. and Sunada, D.K. (2010), *Ground-Water Hydrology and Hydraulics, Water Resources* Pubns; Reprint edition.
2. Cushman, J. H. and Tartakovsky, D. M. (2016) *The Handbook of Groundwater Engineering* (Boca Raton: CRC Press, 07 Nov 2016), accessed 07 Dec 2020, Routledge Handbooks Online.
3. Guthrie. M. (2018). *Ground and Surface Water Hydrology*, Larsen and Keller Education ISBN-13: 978-1635496949.
4. Winter, Thomas C., Harvey, J.W. Franke, O. L. and Alley, W. M (1998) *Ground water and surface water:* a single resource. Vol. 1139. DIANE Publishing Inc.
5. Pringle, C.M. and Triska, J. F. (2000) in *Streams and Ground Waters*, Elsevier Publishers

ENVIRONMENTAL ISSUES IN WATER RESOURCES (03 Credit hrs)

PRE-REQUISITE: HWRM-302

LEARNING OUTCOMES

Following are the learning outcomes of the course:

- Student will learn about Basic Concept of Environment
- Student will be trained about Components of Environment
- Student will learn about Environmental Challenges
- Student will learn about Global Environmental Issues
- Student will learn about Pollution and its Control
- Student will learn about Pollution and its Control
- Student will learn about Energy and Economics of Environment

CONTENTS

Unit-1 Basic Concept of Environment

1.1. Introduction to environmental issues
1.2. basic concepts, environment
1.3. History, nature and scope of Environmental Science
1.4. Environmental Sciences and its contribution to society.
1.5. physical, ecological, socio-economic, ethical, philosophical aspects of Environment

Unit-II Components of Environment

2.1. Major components of environment:
2.2. Physico-chemical Components of environment
2.3. Biological components of environment
2.4. Social, and their relationships with various environmental factors
2.5. Human environment and its problems
2.6. global, national, regional aspects of environment

Unit-III: Environmental Challenges

3.1. Environmental challenges for sustainable development
3.2. Current and future trends in population growth
3.3. Environmental pollution
3.4. Development in industry and agriculture
3.5. Urbanization, poverty and resource depletion

Unit-IV: Global Environmental Issues

4.1. Why Environmental Education? Across the
4.2. Globe-Environmental Issues,
4.3. Cultural Changes,
4.4. Population Dynamics and Control,
4.5. Ecosystems, Air Pollution and
4.6. Global Warming

4.7. Ozone Depletion
4.8. Acid Rain, Solutions
4.9. Water Pollution; Rivers, Lakes, Groundwater, Solutions
4.10. Ultimate Global Problems of Deforestation and loss of Biodiversity
4.11. Mangroves and their disappearance
4.12. Solid and Hazardous Waste
4.13. Food Resources and World Hunger

Unit-V: Pollution and its Control

5.1. Soil Pollution
5.2. Fertilizers, Pesticides and their harmful effects on environment
5.3. Pest Control, Social Environment
5.4. Common Drug in Pakistan: Heroin and Alcohol, Nicotine etc.
5.5. Women and Environment, Chipko Movement, Chance and catastrophes
5.6. Air pollution (outdoor and indoor),
5.7. Treating wastes
5.8. Sustainable Development, Environment of Cities
5.9. Noise and Noise pollution
5.10. Water supply use and management

Unit-VI: Energy and Economics of Environment

6.1. Energy concepts in environment,
6.2. Fossil Fuels (oil, natural gas and coal)
6.3. Alternate Energy and Environment (wind, solar etc.)
6.4. Nuclear energy and Environment, Mining and Environment
6.5. Environmental economics
6.6. Environmental health and toxicology

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- attitude and behavior,
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details

1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Montgomery, C. (2005) *Environmental Geology*. McGraw-Hill.
2. Nebel, BJ & Wright, R. (2004) *Environmental Science: Toward a Sustainable Future*. Prentice-Hall.
3. Miller G.T. (2005) *Living in the Environment: Principles, Connections, and Solutions*. Belmont, Calif.: Brooks/Cole (14th International student edition)
4. Wright, R.T. (2005) *Environmental Science - toward a Sustainable Future.* (9th International Edition), Pearson Education International, Prentice Hall Publishers.
5. Botkin, D.B. and Keller, E.A. (2007). *Environmental Science: Earth as a Living Planet*. 6th and 12th Ed., John Wiley & Sons.
6. McKinney, M.L., Schoch, R.M. & Yonavjak, L. (2007). *Environmental Science: systems and solutions*. 4th Ed., Jones & Bartlett Publishers.
7. Wright, R.T. and Nebel, B.J. (2007). *Environmental Science: Toward a Sustainable Future*. 10th Ed., Pearson Educational.
8. Miller, G. (2002). *Environmental Science: Working with the Earth*. Thomson Learning.

HYDROMETRY (03 Credit hrs)

PRE-REQUISITE: HWRM-204

LEARNING OUTCOMES:

- This course will provide an introduction to the metrological science and fundamentals of Hydrometry.
- The students will learn about Units & measurement techniques.
- They will have the knowledge about different measurement instruments.
- The students will get used to velocity determination methods.
- The students will be equipped with the climatology & sedimentation.
- They will become conversant with sedimentation process.

CONTENTS

Unit-I Introduction

1.1. Introduction to metrological science
1.2. Fundamental of Hydrometry
1.3. Measurement Units
1.4. Hydrologic Cycle

Unit-II: Units & Measurement Techniques

2.1. Measurement methods in hydrology
2.2. Flow measurement velocity-area method
2.3. Measurement of stage
2.4. State-discharge relationships

Unit –III: Measurement Instrumentation

3.1. Current meters
3.2. Slope-area method
3.3. Weirs and flumes
3.4. Ultrasonic cross-path method
3.5. Electromagnetic methods

Unit-IV: Velocity Determination methods

4.1. Acoustic Doppler velocity meters
4.2. Local methods
4.3. Rain measurements and rain gauges

Unit-V: Climatology

5.1. Measurements of weather parameters
5.2. Water table measurements methods and techniques

Unit-VI: Sedimentation

6.1. Sediments measuring methods and instruments
6.2. Remote sensing techniques in Hydrometry

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- attitude and behavior,
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Boiten W. (2013) *Hydrometry*: IHE Delft Lecture Note Series, CRC Press, ISBN 9789054104230
2. Boiten W., (2007) *Hydrometry* (IHE Delft Lecture Note Series) 1st Edition, Kindle Edition. Wiley, ASIN: B000Q361PE
3. Gupta S.V., (2002) *Practical Density Measurement and Hydrometry* (Series in Measurement Science and Technology) 1st Edition, CRC Press. ISBN-13: 978-0750308472
4. Herschy, R.W., (1999). *Hydrometry: Principles and Practice*. 2nd Ed., Wiley. ISBN-13: 978-0471973508
5. Herschy, R.W., (2008). *Streamflow Measurement.* 3rd Ed., CRC Press. ISBN-13: 978-0415413428
6. Shaw E. M., Beven K. J., Chappell N. A., Lamb R., (2010) *Hydrology in Practice* 4th Edition, CRC Press. ISBN-13: 978-0415370424
7. Stevenson D., (2017) *A Treatise on the Application of Marine Surveying Hydrometry*: To the Practice of Civil Engineering, Forgotten Books. ISBN-13: 978-1332001354

INTEGRATED WATER RESOURCES MANAGEMENT (03 Credit hrs)

PRE-REQUISITE: HWRM-205

LEARNING OUTCOMES:

- This course will provide an introduction to the Integrated water resources management and key issues of Pakistan with reference to water resources management.
- The students will learn about the status of waters Classes & water quality.
- They will have the knowledge about Rivers-Estuaries.
- The Introduction to Indus Basin and its treaties will be elaborated to them.
- The students will get used to Climate, glaciology, and agro-ecosystems.
- The students will be equipped with the know-how of Indus Basin Environmental Management strategies & issues.
- They will become conversant with Water Management Decision Support Systems.

CONTENTS

Unit-1 Introduction:

1.1. Concept and objectives of sustainable development
1.2. Global environmental problems
1.3. Integrated Water Resources Management (IWRM).
1.4. Global water policy
1.5. Legislative and institutional framework.

Unit-II Status of waters Classes of water quality:

2.1. The WFD, Status of waters Classes of water quality
2.2. Reference conditions, typology, and water bodies,
2.3. Analysis of the pressures and impacts on water bodies
2.4. Modelling and Decision Support Systems (DSS) in IWRM,
2.5. Rivers-Estuaries:
2.6. Water quality modelling.

Unit-III: Rivers-Estuaries:

3.1. River restoration
3.2. Lakes-Reservoirs: IWRM in lakes
3.3. IWRM in urban areas
3.4. Groundwater management
3.5. Economic analysis of water use
3.6. Presentation and analysis of a RBMP

Unit-IV Introduction to Indus Basin:

4.1. Indus basin-salient features,
4.2. Overview of surface water resources,
4.3. Groundwater resources,
4.4. Multiple use of water systems, water management challenges in the ibis.
4.5. Indus Water Treaty: the context, Indus water treaty and apportioned rivers,
4.6. Wular Barrage on river Jhelum, Kishenganga hydropower project,
4.7. Key policy issues. Pakistan Water Apportionment Accord: the context,

4.8. Disputes on water entitlements,
4.9. Water apportionment accord, key issues and challenges

Unit-V: Climate, glaciology, and agro-ecosystems:

5.1. Climate in the Indus basin
5.2. Agro-climatic zones of Pakistan
5.3. Snow and ice melt contribution to the total flow in the Indus basin
5.4. Climate change impacts on the Indus basin
5.5. Integrated Flood and Drought Management
5.6. Causes of floods, impacts of floods
5.7. Causes and impacts of droughts
5.8. Flood and drought management options in Pakistan

Unit-VI: Indus Basin Environmental Management

6.1. Flows below Kotri barrage
6.2. Rivers to low flows below Kotri
6.3. Minimum environmental flows (e-flows)
6.4. Issues of degradation of delta below Kotri
6.5. Wastewater – industrial and domestic effluents

Unit-VII: Water Management Decision Support Systems:

7.1. Need of optimization and different system levels,
7.2. What is optimization
7.3. Optimization models and tools
7.4. Decision support system models
7.5. Example of DSS model.

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- attitude and behavior,
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.

3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXTBOOKS / SUGGESTED READINGS

1. Lenton, R. and Muller, M. (2008) *IWRM in Practice Better Water Management for Development*. ISBN: 978-1-84407-650-5.
2. Moriarty, P. and Butterwoth, J. (2004), *Integrated Water Resources Management*.IRC.
3. Nijland H., and Menke U. (2005*). Flood Risk Management and Multifunctional Land Use in River Catchments*. Conference Proceedings Mainz, Germany 17th – 19th Oct.
4. Serban P. and Galie A. (2006). Managementul apelor - principii şi reglementări europene. TIPORED Edition.
5. Bund W. (2002). *Assigning water body types: an analysis of the refcond questionnaire results*, European Commission, Joint Research Centre, Italy
6. Groot S. and Villass M. (1995). *Monitoring water quality in the future*. Delft Hydraulics.
7. Ahmad, N. (1993). *Water Resources of Pakistan*, Shahzad Nazir, 61 B/2, Gulberg, III, Lahore.

APPLICATIONS OF ECONOMICS IN WATER RESOURCES (03 Credit hours)

Pre-requisite: F.Sc OR Equivalent

Learning Outcomes:

- This course will provide an introduction to the applications of economics in Water Resources.
- The students will learn about the different economical approaches to manage water.
- They will have the knowledge about
- As part of the course, a role-play game will be conducted with the course participants to help understanding of water resource management in the real world.
- The students will get used to various Economic Models.

Contents

Unit-1 Introduction

1.1. Economics definitions, history, principles, theories.
1.2. Importance of economics in water management,
1.3. Cases and examples in which economics can play or have played a role,
1.4. Principles of water management economics.

Unit-2 Approaches to Managing water

2.1. Including quantity and price based policy instruments
2.2. Institutional role, and benefit-cost analysis
2.3. Money-time relationships
2.4. Present and future worth of capital, cash flow diagrams
2.5. Defining alternatives, alternative evaluations using B/C ratio
2.6. NPV & IRR, public Vs. Private projects

Unit-3 Economic Models;

3.1. Economic valuation of water uses and decision-making context.
3.2. Institutional economics,
3.3. Water law, how economics is used in policy and cost-benefit analysis,
3.4. The roles of water marketing and water pricing.
3.5. Demand and supply estimation,
3.6. Privatization, and modeling with demand and supply functions

Unit-4 Presentation

4.1. As part of the course, a role-play game will be conducted with course participants to help understanding of water resource management in the real world.
4.2. Group work,
4.3. Presentation,
4.4. And individual assignment will be part of learning process to improve understanding

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,

- attendance, assignments and presentation,
- homework
- attitude and behavior,
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. 1.Chandarkanth. M.G. (2015) *Water Resources Economics*. Springer Publishers.
2. Merrett, S. (2014). *Introduction to the Economics of Water Resources: An International Perspective.* Routledge, USA.
3. Griffin, R. C. (2006). *Water Resource Economics: The Analysis of Scarcity, Policies, and Projects*. Massachusetts Institute of Technology, USA.
4. Karamouz, M., Szidarovszky, F. and Zahraie, B. (2003). *Water Resources System Analysis with Emphasis On Conflict Resolution.* LEWIS Publisher.
5. Douglas, L, R. James, R. L. (1971). *Economics of Water Resources Planning*. McGraw Hill Book Company.

ADVANCE MATHEMATICS IN HYDROLOGY (03 Credit hrs)

Pre-requisite: GQR-202

Learning outcomes:

- This course will provide an introduction to the Numerical Methods and Problem Solving techniques used in Hydrology & Water resources
- The students will learn about the Fundamentals of MATLAB programming software
- They will have the knowledge about Round off and Truncation Errors
- The students will get used to the phenomena of Roots: Bracketing Methods & Open Methods.
- The students will be equipped with the concept of Optimization & Gauss Elimination method.
- They will become conversant with Linear Algebraic Equations and Matrices.

Contents

Unit-1 Numerical Methods and Problem Solving

1.1. A Simple Mathematical Model
1.2. Conservation Laws in Engineering and Science
1.3. Numerical Methods with Case Study

Unit-2 MATLAB Fundamentals

2.1. The MATLAB Environment
2.2. Mathematical Operations
2.3. Use of Built-In Functions
2.4. Graphics & Other Resources
2.5. Exploratory Data Analysis

Unit-3 Round off and Truncation Errors

3.1. Errors & their types
3.2. Roundoff Errors
3.3. Truncation Errors
3.4. Total Numerical Error
3.5. Blunders, Model Errors, and Data Uncertainty

Unit-4 Roots: Bracketing Methods

4.1. Roots in Engineering and Science
4.2. Graphical Methods
4.3. Bracketing Methods and Initial Guesses
4.4. Bisection
4.5. False Position
4.6. Case Study: Greenhouse Gases and Rainwater

Unit-5 Roots: Open Methods

5.1. Simple Fixed-Point Iteration
5.2. Newton-Raphson
5.3. Secant Methods
5.4. Brent's Method
5.5. MATLAB Function

5.6. Polynomials

Unit-6 Optimization

6.1. Introduction and Background
6.2. One-Dimensional Optimization
6.3. Multidimensional Optimization
6.4. Equilibrium and Minimum Potential Energy

Unit-7 Linear Algebraic Equations and Matrices

7.1. Matrix Algebra Overview
7.2. Solving Linear Algebraic Equations with MATLAB
7.3. Currents and Voltages in Circuits

Unit-8 Gauss Elimination

8.1. Solving Small Numbers of Equations
8.2. Naive Gauss Elimination
8.3. Pivoting
8.4. Tridiagonal Systems
8.5. Model of a Heated Rod

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- attitude and behavior,
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Steven, C. and Canale, R. (2020) *Numerical Methods for Engineers*. 8th ed. McGraw–hill Higher Education, ISBN13: 9781260232073
2. Herbert, E. I. and Keller, B. (2012) *Analysis of Numerical Methods* Dover Publications ISBN-13: 978-0486680293
3. Householder, A. S. (2006) *The Theory of Matrices in Numerical Analysis* Dover Publications ISBN-13: 978-0486449722
4. Esfandiari, R. S. (2017) *Numerical Methods for Engineers and Scientists* Using MATLAB CRC Press ISBN 9781498777421
5. Sastry S.S (2012) *Introductory Methods of Numerical Analysis* Prentice Hall India Learning Private Limited ISBN-13: 978-8120345928

RESEARCH METHODS (03 Credit Hrs)

PRE-REQUISITES: GICT-201

LEARNING OUTCOMES

- Understand research, its major types and methods in Environmental Sciences
- Be aware of the ethical principles of research,
- Identify the components of a literature review process
- Understand synopsis, research design and data acquisition in environmental studies
- Describe quantitative, qualitative and mixed methods approaches to research
- Understand data analysis through statistical and mapping tools
- Understanding research publications and editorial process

CONTENTS

This course will provide an opportunity for participants to establish their basic understanding about research, its types and methods used in environmental studies. Secondly, the participants will be able to learn about developing scientific questions, developing synopsis and applying variety of research designs in environmental studies. Further, the participants will be able handle and analyze data through statistical and mapping tools/software. Further, understanding about writing publications, and editorial process will also be a part of this course. The course introduces the language of research, ethical principles and challenges, and the elements of the research process within quantitative, qualitative, and mixed methods approaches. Participants will use these theoretical underpinnings to begin to critically review literature relevant to their field or interests and determine how research findings are useful in forming their understanding of their work, social, local and global environment.

Unit-1: Fundamentals of Research methods

1.1. Introduction to research and research methods in Environmental Sciences
1.2. Types of research in environmental sciences
1.3. Significance of research in environmental sciences

Unit-2: Research planning

2.1. Identification of research questions
2.2. Introduction to research synopsis
2.3. Literature review process
2.4. Pilot surveys

Unit-3: Research design

3.1. Qualitative and quantitative research
3.2. Deductive and inductive research
3.3. Descriptive, explanatory, predictive, empirical research

Unit-4: Data acquisitions in Environmental studies

4.1. Primary and secondary data
4.2. Environmental survey data
4.3. Experimental designs
4.4. Field sampling for water, dust, soil, air sampling
4.5. Sampling of living organisms
4.6. Ethics in sampling

Unit-5: Data analysis and report writing

5.1. Data input and analysis
5.2. Application of descriptive and inferential statistical tools

5.3. Mapping tools in Environmental studies
5.4. Contents of reports and reports compilations
5.5. Referencing

Unit- 6: Research Publications

1.1. Introduction to Research publication
1.2. Types of research publications
1.3. Preparation of Research publications
1.4. Introduction to Journals, publisher, impact factor, h-index etc.
1.5. Editorial process of research publications

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

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- attendance, assignments and presentation,
- homework
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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Tjora, A. (2018). *Qualitative Research as Stepwise-Deductive Induction.* Routledge Publisher.
2. Alley, M. (2018). *The Craft of Scientific Writing.* Springer-Verlag New York.
3. Bartels, K.P.R. and Wittmayer, J.M. (2018). *Action Research in Policy Analysis: Critical and Relational Approaches to Sustainability Transitions.* Routledge Publisher.
4. Smith, R.L., Nychka, D., Waller, L.A. and Schmidt, A. (2018). *Applied Environmental Statistics.* CRC Press, Taylor and Francis Group.

5. Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
6. Cook, E. R., & Kairiukstis, L. A. (Eds.). (2013). *Methods of dendrochronology: applications in the environmental sciences*. Springer Science & Business Media.
7. Walliman, N. (2010). *Research methods: The basics*. Routledge.
8. Blackwell, J. and Martin, J. (2011). *A Scientific Approach to Scientific Writing.* Springer-Verlag New York.
9. Manly, B.F.J. (2008). *Statistics for Environmental Science and Management.* Chapman and Hall/CRC Press.