DEPARTMENT OF CIVIL ENGINEERING
ANNA UNIVERSITY, CHENNAI

OUR VISION

Department of Civil Engineering, Anna University, shall strive hard to develop and impart technical knowledge and professional skills required for Civil Engineering practice through excellence in teaching, research and consultancy to address sustainable infrastructure development needs at local, national and International levels.

OUR MISSION

Department of Civil Engineering, Anna University shall contribute to technological and social development by
1. Providing a firm scientific and technological base in Civil Engineering to achieve self-reliance.
2. Providing quality education through innovation in teaching practices at par with global standards.
3. Nurturing leadership and entrepreneurship qualities with ethical values.
4. Developing and disseminating latest knowledge and technologies in emerging areas of Civil Engineering.
5. Sharing intellectual resources and infrastructure facilities through collaborative partnership.
6. Ensuring supporting conditions for enhancing the employability skills.
ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS 2023
CHOICE BASED CREDIT SYSTEM
M.E. IRRIGATION WATER MANAGEMENT (FULL-TIME)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):
Graduates of the Programme M E Irrigation Water Management will

PEO1 Gain knowledge and skills in Water Resources engineering which will enable them
to have a career and professional accomplishment in the public or private sector
organizations
PEO2 Become consultants in Water Resources Engineering and solve complex real life
issues related to analysis, design and maintenance of structures under various
environmental conditions
PEO3 Contribute to the enhancement of knowledge in Water Resources Engineering by
performing quality research in institutions of international repute or in Research
organizations or Academia.
PEO4 Practice their profession with good communication, leadership, ethics and social
responsibility and formulate solutions that are technically sound, economically
feasible, and socially acceptable.
PEO5 Graduates will function in multi-disciplinary teams and adapt to evolving
technologies through life-long learning and innovation

PROGRAMME OUTCOMES (POs):
After going through the two years of study, our Irrigation Water Management Graduates will exhibit
ability to:

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<th>PO</th>
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<tr>
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<td>Research Aptitude</td>
<td>An ability to independently carry out research/investigation and development work to solve practical problems</td>
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<td>Technical Documentations</td>
<td>An ability to write and present a substantial technical report/document</td>
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<td>Technical Competence</td>
<td>Students should be able to demonstrate a degree of mastery over the area as per the specialization of the programme. The mastery should be at a level higher than the requirements in the appropriate bachelor programme.</td>
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<td>Handle Complex Problems</td>
<td>Use research based knowledge, resources, methods, appropriate techniques and tools to solve water resources engineering complex issues with an understanding of limitations.</td>
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<td>5</td>
<td>Environmental Sustainability and Societal Ethics</td>
<td>Ensure development of socially relevant and eco-friendly hydrological, hydraulics and environmental projects by applying technical knowledge, ethical principles and sustainable engineering practices</td>
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<td>6</td>
<td>Life-long Learning</td>
<td>Recognize the need for independent, life-long learning and adapt to emerging technologies in water resources and solutions to novel problems.</td>
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PEO/PO Mapping:

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1-Low, 2-Medium, 3-High
## MAPPING OF COURSE OUTCOME AND PROGRAMME OUTCOME

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# Semester I

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**PRACTICALS**

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**TOTAL CREDITS** 34
## PROFESSIONAL ELECTIVE COURSES (PEC)

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**RESEARCH METHODOLOGY AND IPR COURSES (RMC)**

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**TOTAL CREDITS** 3

## EMPLOYABILITY ENHANCEMENT COURSES (EEC)

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**TOTAL CREDIT** 21 21 19 12 73
UNIT I  ESTIMATION THEORY  
12  

UNIT II  TESTING OF HYPOTHESIS  
12  
Tests based on Normal, t, χ² and F distributions for testing of means, variance and proportions – Analysis of r x c tables – Goodness of fit.

UNIT III  CORRELATION AND REGRESSION  
12  
Multiple and Partial Correlation - Method of Least Squares- Plane of Regression - Properties of Residuals - Coefficient of Multiple Correlation - Coefficient of Partial Correlation - Multiple Correlation with total and partial correlations - Regression and Partial correlations in terms of lower order coefficients.

UNIT IV  DESIGN OF EXPERIMENTS  
12  
Analysis of variance – One-way and two-way classifications – Completely randomized design – Randomized block design – Latin square design.

UNIT V  MULTIVARIATE ANALYSIS  
12  

TOTAL: 60 PERIODS

COURSE OUTCOMES:
At the end of the course, students will be able to
CO1: Obtain the value of the point estimators using the method of moments and method of maximum likelihood.
CO2: Use various test statistics in hypothesis testing for mean and variances of large and small samples.
CO3: Determine the regression line using the method of least square and also to calculate the partial and multiple correlation coefficient for the given set of data points.
CO4: Test the hypothesis for several means using one way, two way or three way classifications.
CO5: Get exposure to the principal component analysis of random vectors and matrices.

REFERENCES:
CO-PO MAPPING

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* 1-low, 2-medium, 3-high

IW3101 ADVANCED IRRIGATION ENGINEERING AND MANAGEMENT L T P C
3 0 4 5

UNIT I DEVELOPMENT OF IRRIGATION

UNIT II SOIL WATER PLANT RELATIONSHIP
Soil physical properties influencing - Soil-water relationship - Forms and occurrence of Soil Water-Classification of Soil Water - Soil Water Constants- Energy concept of Soil Water - Forces acting on Soil Water- Soil Water Potential concept- Soil Water retention - Soil Moisture Measurement.- soil water plant relationship – soil water availability to plants.

UNIT III CROP WATER REQUIREMENT
Water requirement of crops - Evapotranspiration and Consumptive use- Methods of estimating Evapotranspiration - Effective Rainfall- Irrigation Requirement – Duty of Water-Irrigation Efficiency-Irrigation Scheduling - Irrigation measurement – Introduction to Cropwat / AQUACROP.

UNIT IV IRRIGATION METHODS

UNIT V IRRIGATION MANAGEMENT

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS
1. Determination of Agro-meteorological parameters.
2. Determination of Bulk density and Specific gravity of Soil
3. Determination of Textural classification of Soil
4. Determination of field capacity and permanent wilting coefficient
5. Estimation of Soil Moisture for Irrigation Scheduling by Tensiometer
6. Measurement of Infiltration rate in Soil
7. Demonstration on measurement of Transpiration in plants
8. Determination of Leaf Area Index

Attested

[Signature]

DIRECTOR

Centre for Academic Courses
Anna University, Chennai-600 025
9. Flow measurement in open channels through flumes and notches
10. Evaluation of Surface irrigation system.
11. Evaluation of Drip irrigation system
12. Evaluation of Sprinkler irrigation system
13. Study on soil moisture wetting pattern
14. Demonstration on automation of Micro-irrigation systems

TOTAL: 45+60=105 PERIODS

COURSE OUTCOMES
On completion of the course, the student is expected to be able to

CO1 Explain the importance of irrigation in the development of the nation and national water policy and its relevance. To observe and record weather data, analyze and plot them

CO2 Apply knowledge of science and engineering to Soil - Water - Plant relationship and estimation of soil moisture. To understand the concept of infiltration, evapotranspiration and soil moisture measurement

CO3 Apply knowledge of science and engineering in estimating the water requirement of crops and designing water network. To analyze and interpret soil physical properties for irrigation

CO4 Analyse and evaluate irrigation methods and identify suitable methods. To understand the flow measurement in pipes and channels

CO5 Identify the performance of the irrigation systems for better management. To evaluate the performance of irrigation methods

REFERENCES:
UNIT II  WATER ECONOMICS  9
Economic view of water issues - Economic characteristics of water good and services - Non-revenue waters (NRW) - Metering water uses - Non-market monetary valuation methods Water management through economic instruments – Private sector partnership in water resources management: PPP objectives, PPP models, PPP processes, PPP experiences through case studies.

UNIT III  LEGAL AND REGULATORY SETTINGS  9

UNIT IV  WATER AND HEALTH WITHIN THE IWRM CONTEXT  9
Links between water and health: options to include water management interventions for health – Health protection and promotion in the context of IWRM – Global burden of Diseases - Health impact assessment of water resources development projects – Case studies.

UNIT V  GLOBAL ISSUES IN THE CONTEXT OF IWRM  9
Water for food production: ‘blue’ versus ‘green’ water debate — Water foot print - Virtual water trade for achieving global water and food security - Urban water security – Climate change: Key challenges and impacts and adaptation in the context of IWRM – International Water management Institute Models and Software for water management - Case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES
- On completion of the course, the student is expected to be able to
CO1 Describe the concepts and principles of IWRM and its advantages over the conventional water management practices to attain the SDGs.
CO2 Analyze the various economic instruments for water management and to interpret the pros and cons of PPP.
CO3 Appraise the legal framework for water management and the application of game theory on dispute resolution.
CO4 Discuss the linkages between water and health and develop HIA framework.
CO5 Value the importance of IWRM for global issues such as urban water security, food security and climate change and understand the applications of models and software in water management.

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* 1-low, 2-medium, 3-high

IW3103 SURFACE AND GROUND WATER HYDROLOGY L T P C 3 0 0 3

UNIT I HYDROLOGICAL CYCLE AND PRECIPITATION 9
Hydrological cycle, Hydrological budget – Hydro meteorological observation - Precipitation, Types and Forms - Measurement - Radar Measurement - Processing of precipitation data - Spatial analysis using GIS

UNIT II HYDROLOGICAL PROCESSES OF ABSTRACTION 9
Water losses – Initial abstraction – interception and Depression storage - Evaporation, Evapotranspiration and infiltration – Field Measurement – Estimation by empirical formulae - - Infiltration Indices

UNIT III RUNOFF PROCESS 9

UNIT IV GROUNDWATER 9

UNIT V WELL HYDRAULICS 9
General flow equation, Steady and unsteady flow, well flow near aquifer boundaries, partially penetrating wells, characteristics of well losses, specific capacity – Safe yield - Image well theory - Ground Water Recharge – GEC norms for Groundwater Assessment – Managed Aquifer Recharge.

TOTAL: 45 PERIODS
COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

**CO1** The students describe the various processes of hydrologic cycle and hydro meteorological Measurements

**CO2** The students quantify various abstractions by selecting appropriate field measurements and empirical equation.

**CO3** The students apply their knowledge on runoff processes to assess the water balance and runoff potential

**CO4** The students identify and describe the various features of ground water system.

**CO5** The students apply their knowledge on well hydraulics to estimate the safe yield and ground water potential.

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* 1-low, 2-medium, 3-high

**IW3104 IRRIGATION STRUCTURES AND DRAINAGE ENGINEERING**

**UNIT I IRRIGATION CANAL STRUCTURES**

Irrigation channels- Weirs and Barrage -Components of diversion head works – selection of the suitable site for the headwork –Cross drainage structures: aqueduct, siphon, super-passage, level crossing, inlet/outlet - fall or drop structures - necessity and location- Regulation and control structures: silt ejectors, gates, division boxes - Canal outlets - Canal escapes-types of escapes.

**UNIT II DESIGN OF IRRIGATION CHANNEL**

Types of canals - canal alignment-types of irrigation channels-design Parameters-Regime theory-Kennedy's silt theory - Lacey's silt theory - Design of canals using the above theories – comparison of kennedy's and laceys’s theory - canal maintenance.

**UNIT III SURFACE DRAINAGE SYSTEM AND DESIGN**

UNIT IV
SUBSURFACE DRAINAGE SYSTEM AND DESIGN
Sub-surface drainage system-types of sub-surface drainage system recharge condition-Horizontal flow through layers of soil- Design of sub-surface drainage system: The Hooghought’s equation-derivation, Importance of equivalent depth: The Ernst’s equations- derivation, horizontal, vertical and radial – Conditions for two layered soil Profile-Unsteady flow to drains: Glover-Dumm equation, De Zeeuw-Hellinga Equation – comparisons between steady state and unsteady state-- drainage materials.

UNIT V
NON-CONVENTIONAL DRAINAGE AND SALT CONTROL
Special drainage systems: vertical drainage, bio-drainage, mole drains and pump drainage their adaptability-Characteristics of salt affected soils-formation of salt affected soils-problems of salt affected soils-identification and reclamation of salt affected soils- soil chemical analysis and estimation of lime and gypsum requirement (GR) - Quantity of amendments to be added.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
- On completion of the course, the student is expected to be able to
  CO1 knowledge about various types of irrigation canal hydraulic structures.
  CO2 have the knowledge for designing irrigation canals.
  CO3 acquire knowledge to estimate surface runoff in the agricultural land.
  CO4 understand usefulness and design consideration under steady and unsteady state subsurface drainage.
  CO5 know the types of non-conventional drainage structures and understand the salt problems in agricultural soils.

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RM3151 RESEARCH METHODOLOGY AND IPR  L T P C
2 1 0 3

UNIT I
RESEARCH PROBLEM FORMULATION
Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap
UNIT II  RESEARCH DESIGN AND DATA COLLECTION  9
Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III  DATA ANALYSIS, INTERPRETATION AND REPORTING  9
Sampling, sampling error, measures of central tendency and variation.; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV  INTELLECTUAL PROPERTY RIGHTS  9
Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V  PATENTS  9
Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon completion of the course, the student can
CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

REFERENCES:
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,

IW3201  SOIL SCIENCE AND AGRONOMY  L T P C
3 0 0 3

UNIT I  SOILS AND THEIR CLASSIFICATION  8
Importance of soil- soil genesis- weathering of rocks and minerals–soil profile- soil forming processes-Important soil physical properties and its importance; Soil texture, structure, density, porosity, colour, organic matter– Major soils of India and Tamil Nadu, U.S. system of soil taxonomic orders and characterisation –collection of soil samples, techniques and procedure.

17
UNIT II  SOIL NUTRIENTS AND PRODUCTIVITY  8

Plant nutrients- essential plant nutrients-based on mobility in plants-their function, deficiency symptoms-methods of control and toxicity-nutrient deficiency symptoms- soil pH and scale- effects of pH on nutrient availability –life in the soil – soil fertility and productivity - fertility vs productivity.

UNIT III  PRINCIPLES OF AGRONOMY AND TILLAGE  10


UNIT IV  NUTRIENT AND WEED MANAGEMENT  10

Classification of manures, commercial fertilizers- Role of manures and fertilizers- Methods of fertilizers application - Integrated nutrient management (INM): concept, advantage and components of INM-weed management: physical, cultural, chemical, biological methods -Harmful effects of weeds- Integrated Pest Management (IPM): tools and components of IPM.

UNIT V  CROP PRODUCTION OF FIELD CROPS  9

Classification and distribution of field crops- cropping systems- Introduction of major field crops:cereals, millets, minor millets, pulses, oil seeds crops and cash crops.

TOTAL: 45 PERIODS

COURSE OUTCOME:

- On completion of the course, the student is expected to be able to

CO1 understand the various physical properties and classification of soils types required for an agricultural field.

CO2 Learn about plant nutrients and their functions, deficiency, and symptoms of nutrients in plants. To know the influence of soil reaction on availability of plant nutrients..

CO3 understanding the basic concepts and theory of agronomy and will know the different tillage practices in the crop field.

CO4 Knowledge of different types of manure and fertilizer and also management of crop pest through integrated Pest Management approach without side effect on plant, animal and environment health.

CO5 learn about the crop classification and cultivation practices of field crops.

REFERENCES:


CO - PO Mapping

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* 1-low, 2-medium, 3-high
UNIT I  INTRODUCTION TO MICRO-IRRIGATION

UNIT II  DRIP IRRIGATION SYSTEM DESIGN AND LAYOUT
Drip irrigation – advantages and disadvantages – types – suitable crops – planning and layout of drip system – components. Principles and hydraulics for design of drip system - Darcy Weishbach equation - Hazen Williams equation – factors to be considered for the design of drip system – design procedure – design of emitters, laterals, sub mains and main lines – head works. Installation- O & M – trouble shooting - Dripper types - Wetting pattern- Chemigation - sub-surface drip system - Subsidy calculation.

UNIT III  SPRINKLER IRRIGATION SYSTEM DESIGN AND LAYOUT

UNIT IV  FILTRATION, CHEMIGATION, CARE & MAINTENANCE OF MICRO IRRIGATION

UNIT V  AUTOMATION IN MICRO IRRIGATION AND ITS COMPATIBILITIES

TOTAL: 45 PERIODS

COURSE OUTCOMES:
- On completion of the course, the student is expected to be able to
  CO1 Understand the fundamental concepts of micro irrigation.
  CO2 Design drip irrigation system, install, operate and maintain.
  CO3 Design sprinkler irrigation system, install, operate and maintain.
  CO4 Understand filtration & chemigation in micro irrigation and their care and maintenance.
  CO5 Understand automation in micro irrigation and its compatibilities.

REFERENCES:
Participatory Field Research Methodology

**UNIT I**
- **RESEARCH**
- Meaning – Purpose – Types of Research – Stages of Research

**UNIT II**
- **PARTICIPATORY AND FIELD RESEARCH**
- Types of Participation-Participatory meaning-Importance of Peoples Knowledge
- Emergence of Participatory Research-Participatory Research Approaches in Science and Technology-Participatory Research and Development.

**UNIT III**
- **TECHNIQUES IN FIELD RESEARCH**
- Primary data collection- Qualitative and Quantitative Survey– Observation-Semi Structured Interview Questionnaire Schedule and Field Trials–Analysis and Evaluation.

**UNIT IV**
- **METHODS OF FIELD RESEARCH**
- Research Methods: Rapid Rural Appraisal (RRA), Participatory Rural Appraisal(PRA), Participatory Learning and Action(PLA)–Diagramming and Mapping – Field Observation and Field Trials Analysis and Evaluating Participatory Research and Development: Some Key Elements.

**UNIT V**
- **PARTICIPATORY TOOLS**
- Situation Query Problem and Response (SPQR)–Statistical Analysis-case studies.

**LIST OF EXPERIMENTS**

1. Transect Walk 2
2. Social Mapping 2
3. Resource Mapping 2
4. Focus Group Discussion 2
5. Time Line Charting 2
6. Time Trend Analysis 2
7. Cause and Effect Mapping 2
8. Seasonal Calendar 2
9. Daily Calendar 2
10. Matrix Ranking 2
11. Pair-wise Ranking 2
12. Key Informant Interview 2
13. Situation, Problems, Query and Response(SPQR) 6

**TOTAL: 45 PERIODS**
COURSE OUTCOMES:
- On completion of the course, the student is expected to be able to
CO1 Gain comprehensive understanding of particular research area.
CO2 Capture roles and responsibilities in social context.
CO3 Verify the proposed interventions and the real time experiences.
CO4 Discover both internal and external agents and their influence.
CO5 Facilitate students to understand problem solving or solution based approach.

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1-low, 2-medium, 3-high

HW3251 REMOTE SENSING AND GIS FOR WATER RESOURCES

UNIT I BASICS OF REMOTE SENSING
Physics of remote sensing, Types of Remote sensing, electromagnetic radiation (EMR), Interaction of EMR with atmosphere, earth surface, soil, water and vegetation; Swath, Nadir, resolutions, image referencing system; Monitoring atmosphere, land and water resources - Indian Space Programme, Sensor characteristics LANDSAT, SPOT, ERS, IKONOS, IRS and others - Principles of LiDAR Remote Sensing - LiDAR Data Processing- LiDAR applications.

UNIT II INTERPRETATION AND ANALYSIS

UNIT III GEOGRAPHIC INFORMATION SYSTEM

UNIT IV GEOSPATIAL ANALYSIS

UNIT V WATER RESOURCES APPLICATIONS

LIST OF EXPERIMENTS
Image processing
1. Satellite data products: commercial and open source
2. Land use land cover classification
   1. Unsupervised
   2. Supervised
   3. Accuracy assessment
3. Vegetation indices for vegetative cover analysis
4. Reservoir volume estimation using temporal satellite imageries

Geographical Information System
5. Georeferencing of toposheet and creating vector layers, attribute tables and layout preparation
6. GPS Survey, data transformation into GIS, analysis of data and creation of maps using Google earth maps.
7. Use of D8 pointer algorithm for deriving flow direction, flow accumulation and watershed delineation.
8. Interpolation of point data to create Spatial Maps.
   1. Theissen polygon method
   2. Natural Neibourhood method
   3. Triangular irregular network
   4. Kriging method
   1. Identifying suitable artificial recharge areas
   2. Identification of ground water potential zones
   3. Estimation of sedimentation yield using RUSLE method
10. Join and Relate tables, File conversion from .kml to.shp
11. Open source GIS –Demo

TOTAL: (45+60) = 105 PERIODS

COURSE OUTCOMES
On completion of the course, the student is expected to
CO1 Describe the principles of remote sensing and distinguish the sensors and satellite's characteristics for different applications Demonstrate the methodology for image classification and interpretation using remote sensing
CO2 choose the appropriate data products and techniques for image analysis Illustrate the basics of map preparation, watershed delineation and geospatial data analysis techniques in GIS attribute creation
CO3 Illustrate the basics of map preparation in GIS Formulate the methodology using remote sensing and GIS tools for various applications in water resources engineering
CO4 Demonstrate the geospatial data analysis techniques
CO5 Formulate the methodology using remote sensing and GIS tools for various applications in water resources engineering
REFERENCES

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3 – High, 2 – Medium, 1 – Low

IW3301 WATER QUALITY L T P C 3 0 4 5

UNIT I WATER QUALITY MONITORING
Physical, chemical and biological characteristic of water-suspended and dissolved solids–EC and pH-major ions-water quality investigation-sampling design- samplers and automatic samplers- field kits- water quality data storage, analysis and inference-Methods of illustration -outline of global hydrochemical software: AQUACHEM.

UNIT II IRRIGATION WATER QUALITY

UNIT III GROUNDWATER QUALITY

UNIT IV WATER QUALITY POLLUTION
Sources and types of water pollution -organic and inorganic pollutants- BOD-DO-relationships-impact on water Resources-NPS pollution and its control-eutrophication control –water -packed water quality.

UNIT V WATER QUALITY MANAGEMENT

TOTAL: 45 PERIODS
LIST OF EXPERIMENTS

1. Introduction to the analytical laboratory. Good Laboratory Practices and Quality Control
2. Determination of physical parameters of the water
   - Measurement of pH, turbidity, solids and electrical conductivity
3. Determination of Chemical parameters of water
   - Major ions - Sodium, potassium, chloride, fluoride, hardness, alkalinity
   - Calculation of Sodium Absorption Ratio
4. Determination of nutrients
   - Nitrate and phosphate
5. Demonstration of multi-parameter water quality probes
6. Demonstration of BOD and COD estimations

TOTAL: 45+60=105 PERIODS

COURSE OUTCOME:

- On completion of the course, the student is expected to be able to

  CO1 describe the water quality parameters, its sampling design and methodology for data analysis.
  Analyse the physical, chemical and nutrients parameters through the analytical procedures

  CO2 Describe the water quality standards for irrigation and the methods to assess irrigation water quality. Examine the physical, chemical and nutrients parameters in respect to the standards

  CO3 understand the groundwater quality and effects the groundwater quality in coastal aquifer
  Demonstrate the usage of multiparameter probes, field kits and sondes for measuring water quality parameters

  CO4 Relate water quality and its dependence on sources of water pollution.

  CO5 Understand, formulate and interpret water quality data for beneficial uses and water quality models.

REFERENCES:

7. IS 10500 : 2012 - Indian Standard DRINKING WATER — SPECIFICATION ( Second Revision ), BUREAU OF INDIAN STANDARDS 2012

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* 1-low, 2-medium, 3-high
IW3311 PRACTICAL TRAINING (4 WEEKS) LTPC 0 0 0 2

SYLLABUS: The students individually undertake training in reputed institutions doing Irrigation Water Management with a special focus on Irrigation Water Management during the summer vacation for a specified duration of four weeks. At the end of the training, a detailed report on the work done. The students will be evaluated through a viva-voce examination by a three-member committee.

COURSE OUTCOME:
- On completion of the course, the student is expected to be able to
  CO1 Get expose to the real-world problems
  CO2 Describe the challenges in the management of irrigation water.
  CO3 Develop skills for solving the problem
  CO4 Present the work carried out during the practical training

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• 1-low, 2-medium, 3-high

IW3312 PROJECT WORK I LTPC 0 0 1 2 6

SYLLABUS: The student individually works on a specific topic approved by faculty member who is familiar in the area of interest. The student can select any topic which is relevant to his/her specialization. The topic may be experimental or analytical or case studies. At the end of the semester, a detailed report on the work done should be submitted, which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voce examination by a panel of examiners including one external examiner.

COURSE OUTCOME:
- On completion of the course, the student is expected to be able to
  CO1 apply the knowledge gain from the theoretical and practical courses to the real-world problems.
  CO2 identify the gap in research by doing extensive literature survey.
  CO3 formulate the methodology for arriving at the solution.
  CO4 Interpret and present the findings of the research work carried out
  CO5 Synthesize the conclusion of the research
  CO6 Present the research work carried out during project work I

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TOTAL: 180 PERIODS

[Signature]
DIPLOMA
Centre for Academic Courses
Anna University, Chennai-600 025

Attested
DIRECTOR
SYLLABUS:
The student should continue the Project work I on the selected topic as per the formulated methodology. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report and the viva-voce examination conducted by a panel of examiners including one external examiner.

TOTAL: 360 PERIODS

COURSE OUTCOME:
- On completion of the course, the student is expected to be able to
  CO1 apply the knowledge gain from the theoretical and practical courses to the real-world problems.
  CO2 identify the gap in research by doing extensive literature survey.
  CO3 formulate the methodology for arriving at the solution.
  CO4 Interpret and present the findings of the research work carried out
  CO5 Synthesize the conclusion of the research
  CO6 Present the research work carried out during project work II

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PROFESSIONAL ELECTIVE COURSES

IW3051 WATERSHED CONSERVATION AND MANAGEMENT LT P C 3 0 0 3

UNIT I WATERSHED CONCEPTS

UNIT II SOIL CONSERVATION MEASURES

UNIT III WATER HARVESTING AND CONSERVATION

UNIT IV GIS FOR WATERSHED MANAGEMENT
UNITV  WATERSHED MANAGEMENT  

TOTAL: 45 PERIODS

COURSE OUTCOME:
- On completion of the course, the student is expected to be able to
  
CO1 Recognize and interpret the morphological features of a watershed and describe the principles of watershed management.
  
CO2 State, design and sketch the soil conservation structures.
  
CO3 Describe the micro catchment and apply the concepts to design the small water harvesting structures.
  
CO4 Illustratetheapplicationofmoderntoolsandtechnologyinthewatershedmanagement.
  
CO5 Classify the management activities and to develop an integrated watershed development plan.

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IW3001  IRRIGATION ECONOMICS  

UNIT I  SCOPE OF ECONOMICS  
Scope of irrigation economics – Role of irrigation in economic development – Performance of agriculture in Indian economy: pre independent, post independent and post liberalisation scenario.

UNIT II  CONSUMPTION ECONOMICS  

UNIT III  PRODUCTION ECONOMICS  
Production economics – Conventional approach – Non-conventional approach – Cobb Douglas, Spillman and other types of production functions – Data analysis for production function estimation - Cost, revenue, production and profit maximization approach.

UNIT IV  FARM ECONOMICS  
Concept of farm management – Farm records and budgeting – Whole farm and partial budgeting – Risk and uncertainty in farming – Case studies.
UNIT V  FINANCIAL ANALYSIS
Role of financial analysis – Central and State financing – Economic instruments: water charges, cess, taxes, subsidies and compensation - Irrigation water pricing - Concept and methods of irrigation water pricing - Discounting factors and techniques – Applications of discounting techniques for irrigation project viability.

TOTAL: 45 PERIODS

COURSE OUTCOME:
- On completion of the course, the student is expected to be able to
  CO1 Understand the meaning and scope of economics applied to agriculture and irrigation and economic development from past to present.
  CO2 Analyse the tools of economics and its application to behavioural pattern of market dynamics.
  CO3 Impart knowledge into concepts of production economics by understanding the principle and types of production functions.
  CO4 Discuss the importance of farm management and expose to preparation of farm records and budgeting.
  CO5 Analyse the financial aspects, water pricing and identify the justifiable irrigation project among different alternatives.

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HW3051  ENVIRONMENTAL IMPACT ASSESSMENT FOR WATER RESOURCES  L T P C

UNIT I  ENVIRONMENTAL ISSUES
Water resources development and environmental issues – Environment in water resources project planning – Environmental regulations and requirements – EIA notification - Role of EIA

UNIT II  EIA FUNDAMENTALS
Environmental Impact Assessment (EIA) – EIA in Project Cycle – Legal and Regulatory aspects in India according to Ministry of Environment and Forests – Types and limitations of EIA – Cross sectoral issues and terms of reference in EIA – Public hearing - Merits and Demerits of EIA
UNIT III  ENVIRONMENTAL BASELINE AND IMPACT STUDIES

UNIT IV  EIA REPORT
EIA team formation - Environmental management plan – Mitigation and rehabilitation plans – Policy and Guidelines for planning and monitoring programmes – Post project audit – Documentation of EIA findings – Ethical and quality aspects of EIA

UNIT V  EIA CASE STUDIES
EIA of water resources projects – Case studies – Hydropower projects – Command area problems - Role of NGOs - Digital EIA

TOTAL:  45 PERIODS

COURSE OUTCOMES:
• On completion of the course, the student is expected to be able to
  CO1 Understand the complex socio-ecological issues in developmental projects.
  CO2 Analyse the tools of environmental impact in both the qualitative and quantitative terms
  CO3 Apply the domain knowledge and legal principles, access to information, public participation.
  CO4 Communicate research findings effectively through written, media materials and colloquial in public hearing for project based EIA.
  CO5 Analyse and evaluate the evidences, arguments, claims, beliefs on the basis of empirical evidence

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UNIT I  
**RAINFED AGRICULTURE**
9  
Rainfed agriculture – introduction and importance - Types of Rainfed farming systems - Past trends, problems and prospects of rainfed agriculture in India - Soil and climatic conditions prevalent in rainfed areas - Drought: introduction, classification – effects of drought – moisture stress - Impact of climate change on rainfed agriculture

UNIT II  
**SUSTAINABLE DEVELOPMENT AND MANAGEMENT STRATEGIES IN RAINFED AREAS**
10  
Contingent crop planning for aberrant weather conditions - Crops and cropping practices in rainfed areas - land development for soil moisture conservation - Improvement of tillage and soil management - Soil and moisture conservation for rainfed lands - Water harvesting - micro catchments - Farm Ponds, percolation tanks - Fertility management in dryland farming – drought management strategies - Increasing crop productivity and water use efficiency - Integrated farm management practices - Case studies.

UNIT III  
**TANK IRRIGATION**
8  
Concept of tank irrigation – Status of tank irrigation in Tamil Nadu - Classification - Components of tank irrigation - Terms used in tank system - Water distribution network - Cascade of tanks - Degradation of Tank Irrigation Systems - Causes and Remedy.

UNIT III  
**TANK CONSTRUCTION & DESIGN OF TANK COMPONENTS**
10  

UNIT V  
**FARMERS’ PARTICIPATION IN TANK IRRIGATION SYSTEMS**
8  
On Farm Development – organization, operation and maintenance- Water Users’ Association- People’s participation in tank irrigation system and its maintenance - community based tank irrigation system - Turn over – Traditional Governance of tank system – Water rights (Ancestral rights) – Multiple users of tank water –Methodologies for tank irrigation performance and management

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**
- On completion of the course, the student is expected to be able to
  - **CO1** Interrelate the rainfed agriculture and tank irrigation systems
  - **CO2** Provide sustainable management strategies
  - **CO3** Sketch the components of tank systems and identify the need to upgrade
  - **CO4** Compute capacity of tanks, design components of tanks
  - **CO5** Assess the level of farmer participation in tank management

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IW3056  DROUGHT RISK ASSESSMENT AND MANAGEMENT  L T P C
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UNIT I  UNDERSTANDING DROUGHT  10

UNIT II DROUGHT IMPACTS  8
Environmental, Social and Economical impacts – Impact on Rainfed and Irrigated Agriculture - Drought effects on poverty, unemployment, and food security – Drought induced Migration - Hydropower Production - Drought effects on agribusiness and industrial sector – Case studies on Climate change induced Drought.

UNIT III DROUGHT HAZARD AND RISK ASSESSMENT  9

UNIT IV DROUGHT RELIEF MEASURES  8

UNIT V DROUGHT MITIGATION AND MANAGEMENT  9

COURSE OUTCOMES:
- On completion of the course, the student is expected to
- CO1 Classify the different types and comprehend various definitions of drought and differentiate Drought with water shortage, aridity and desertification
- CO2 Discuss the impacts of drought on various sectors.
- CO3 Evaluate the drought severity, risk and vulnerability and the modern tools of drought monitoring
- CO4 Prepare the drought plan and frame relief measures for the efficient reduction of drought risk.
- CO5 Comprehend the risk and crisis management of drought mitigation and design programs for drought risk management.

TOTAL: 45 PERIODS
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IW3003 PARTICIPATORY IRRIGATION MANAGEMENT L T P C 3 0 0 3

UNIT I FUNDAMENTALS OF SOCIOLOGY AND PARTICIPATORY APPROACH 6
Basic Sociological concepts and Definitions - Objectives – Perspectives- Social stratification–Sociological understanding - Irrigation as a Sociotechnical Process - paradigm shift and Participatory approach

UNIT II UNDERSTANDING FARMERS PARTICIPATION 12

UNIT III ROLE OF STAKEHOLDERS AND THE UNDERLYING ISSUES 12
Multiple use of water – Issues in sectoral Water Allocation - Domestic, Irrigation, Industrial sectors – Woman as a water user –Constraints and Opportunities. Role of Community Organisers – Constraints in Organising farmers Organisation.

UNIT IV IMPROVING AGENCY RELATIONSHIPS AND INSTITUTIONAL REFORMS 10

UNIT V POLICY CONSIDERATIONS AND EMERGING CHALLENGES 5
Water Policy-Irrigation Governance-Building from Below-Non-political Associations-Bureaucratic Reorientation- Policy options and Alternatives and Sustainability.

TOTAL: 45 PERIODS
COURSE OUTCOMES:

- On completion of the course, the student is expected to
  CO1 Capture to fundamental concepts and terms which are to be applied and understood all through the study
  CO2 Acquire a clear insight into the subject matter of participatory ideology with its rudiments under the light of both national and international illustrative cases.
  CO3 Comprehend the roles of different players as stakeholders with the ground reality of the underlying issues in farm community.
  CO4 Articulate as how reforms can help build up institutional and irrigation agencies with the support obtained from the existing farm network in irrigation Management
  CO5 Gain an overarching understanding of recommendation for improved irrigation management with a vision to transform the existing governance and policies with the novel approach of sustainability.

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7. http://irap.india.org/IMTlnIndia-Pa

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IW3004 GENDER AND WATER L T P C 3 0 0 3

UNIT I INTRODUCTION 9
Basic Concepts of Sociology-Definition-Gender–Social Perspectives-Historical Framework Gender and Social Stratification-Roles-Power and authority Equity and Equality Gender Empowerment

UNIT II GENDER IN DEVELOPMENT SECTORS 9
Gender Issues in Agriculture and Irrigation –Gender and Allied and Other Agricultural Activities-Gender in Coastal Region: Salt Production –Gender and Health : A third World outlook

UNIT III GENDER AND INTEGRATED WATER RESOURCES MANAGEMENT 9
UNIT IV GENDER COMPETENCY ISSUES AND POLICY REFORMS


UNIT IV GENDER IN GLOBAL SCENARIO


TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the student is expected

CO1 Understand the necessity of gender participation in water management.

CO2 Comprehend the roles of men and women as stakeholders in various domains.

CO3 Apply IWRM concepts and understand the intensity of women involvement in water resource management.

CO4 Articulate gender and water in water management practices.

CO5 Gain an overarching understanding of the global, regional and local issues of women in water resources management.

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HW3052 LEGAL ASPECTS OF WATER RESOURCES

UNIT I HISTORICAL BACKGROUND AND CURRENT CHALLENGES

UNIT II  WATER LEGISLATION IN INDIA AND TAMILNADU  
9

UNIT III  WATER GOVERNANCE: POLICIES AND LEGAL FRAMEWORKS  
9

UNIT IV  TRANSBOUNDARY WATER ISSUES  
9

UNIT V  WATER CONFLICTS IN INDIA  
9

TOTAL: 45 PERIODS

COURSE OUTCOMES:
- On completion of the course, the student is expected to be able to
  CO1 Discuss the historical background of formation of laws and the types of rights.
  CO2 Explain the legal provisions existing in India and Tamil Nadu.
  CO3 Analyze the policy reforms that have taken place in water management.
  CO4 Illustrate the trans boundary conflicts.
  CO5 Assess the water conflicts based on the rights issue and reveal the gaps that need to be filled up.

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IW3055 WATER, SANITATION AND HEALTH L T P C 3 0 0 3

UNITI FUNDAMENTALS WASH 9
Meanings and Definition: Safe Water- Health, Nexus: Water- Sanitation - Health and Hygiene — Equity issues-Water security - Food Security: Sanitation and Hygiene (WASH) and Integrated Water Resources Management (IWRM)-Need and Importance of WASH.

UNITII MANAGERIAL IMPLICATIONS AND IMPACT 9

UNITIII CHALLENGES IN MANAGEMENT AND DEVELOPMENT 9

UNITIV GOVERNANCE 9
Public health-Community Health Assessment and Improvement Planning (CHA/CHIP)-Infrastructure and Investments on Water,(WASH)-Cost Benefit Analysis— Institutional Intervention-Public Private Partnership –Policy Directives –Social Insurance -Political Will vs Participatory Governance-

UNITV INITIATIVES 9
Management vs Development-Accelerating Development –Development Indicators-Inclusive Development-Global and Local- Millennium Development Goal (MDG) and Targets - Five Year Plans-Implementation- Capacity Building-Case studies on WASH.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
- On completion of the course, the student is expected to be able to
  CO1 Capture fundamental concepts and terms which are to be applied and understood all through out the study.
  CO2 Comprehend the various factors affecting water sanitation and health through the lens of third world scenario.
  CO3 Critically analyse and articulate the underlying common challenges in health care services.
  CO4 Acquire knowledge on the existing policies and its say on water sanitation and health.
  CO5 Gain an overarching in sight in to the aspects of sustainability in health care.

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**IW3054 WASTEWATER TREATMENT AND UTILIZATION**

**UNIT I** INTRODUCTION AND BIOLOGICAL TREATMENT


**UNIT II** DOMESTIC WASTEWATER GENERATION AND TREATMENT PROCESS

Sewerage system- Domestic wastewater characteristics- flow equalization- population equivalent-treatment flow chart- Primary, secondary and tertiary treatment of domestic wastewater- Downstream wastewater treatment for reuse and recycle- Guidelines for wastewater recycling.

**UNIT III** KINETICS OF WASTEWATER TREATMENT


**UNIT IV** ADVANCES IN WASTEWATER TREATMENT

Activated sludge process design for nutrient removal-Process operation - mean cell residence time, oxygen requirement- Biological and chemical phosphorus removal- Sedimentation of activated sludge- Sequencing Batch reactor, Oxidation ditch and membrane bioreactors.

**UNIT V** REUSE OF WASTEWATER


**TOTAL: 45 PERIODS**
COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to
  
  CO1 Understand the characteristics and composition of wastewater and the biological treatment
  
  CO2 Know the different types of domestic wastewater generation and its treatment
  
  CO3 Gain knowledge on the kinetics of wastewater treatment
  
  CO4 Acquire knowledge of advanced wastewater treatment technologies
  
  CO5 Understand the different reuses of wastewater after treatment

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IW3053 CIRCULAR WATER ECONOMY

UNIT I CIRCULAR ECONOMY CONCEPTS

Circular economy; Linear economy - Resource scarcity - Climatic and Non-climatic challenges to cater the linear economy - Techno-economic feasibility - Social acceptance of a circular economy - Application of circular economy principles in the water sector; Resilient and inclusiveness of water systems in the circular economy; The 6 R’s in the circular water economy - Circular Economy in water Conservation: Water efficiency; Reducing water wastage; Water utility-led water conservation

UNIT II DEVELOPING THE CIRCULAR WATER ECONOMY

Reuse and Recycle- Industrial water reuse and recycling; Agricultural reuse; Urban reuse; Sustainable water - management and circular economy in water-energy-food nexus

UNIT III CIRCULAR WATER ECONOMY IN THE ENERGY SECTOR

Recover-Renewable energy generation technologies at wastewater treatment facilities; Traditional renewable energy at water and wastewater treatment facilities; Resource recovery from wastewater

UNIT IV CIRCULAR ECONOMY IN WATER RESOURCES MANAGEMENT

Restore and Reclaim- Restoration of the water sources like groundwater, river water, water in lakes, artificial recharge; Managed Aquifer Recharge; Rejuvenation of water sources; Constructed Wetland (CW) technology; Repurposing the wastewater from residential buildings, industries or agriculture
UNIT V  VIRTUAL WATER

Understanding virtual water and the water footprint - Water footprint categories based on consumption - Perspectives on blue water - Food production and food security - Environmental sustainability - Water pricing – Ownership - Policy implications

TOTAL: 45 PERIODS

COURSE OUTCOMES:
- On completion of the course, the student is expected to be able to
  CO1 Comprehend the circular economy concepts.
  CO2 Demonstrate the methodology for developing water quality models in the Environment of Rivers and streams.
  CO3 Demonstrate the methodology for developing water quality models in the environment of lakes, impoundments and sediments.
  CO4 Illustrate the mechanism of nutrient loading, its control and heat budget for temperature models
  CO5 Comprehend the differences among the numerical modelling methods in water quality modelling and also hands-on practice for water quality analysis.

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IW3052  CLIMATE CHANGE AND WATER RESOURCES  L T P C
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UNITI   GLOBAL CLIMATE SYSTEM
Climate - Drivers of Climate change - Components of Global Climate System: Atmosphere, hydrosphere, Lithosphere, cryosphere and biosphere, atmospheric circulation - redistribution of heat; Global Energy Balance: Green house effect; Hydrological cycle: Reservoirs, flows (or Fluxes), Residence Times, Water Vapor,
UNIT II CLIMATE VARIABILITY AND CHANGE

Climate variability and change: Factors Responsible for Natural Climate Variability and Change: large scale variability- ElNino, LaNina—ENSO, Teleconnections, Sun-Moon-Earth interaction- Factors Responsible for Anthropogenic Climate Change, Detection and Attribution of Climate Change; Global and Indian Scenarios —Observed changes and projected changes of IPCC – Impacts on water resources- IPCC Scenarios

UNIT III CLIMATE MODELS

Need for vulnerability assessment - Approaches for assessment — Types of climate models, History of climate modelling, Sensitivity of climate models, parameterization of climate process, simulation. Box models - Zero-dimensional models - Radiative-convective models - Higher- dimension models - EMICs (Earth-system models of intermediate complexity) - GCMs (global climate models or general circulation models)—Regional Models - Sectoral models – CMIP - Selection of Global Climate Models- Performance Indicators for Evaluating GCMs

UNIT IV ADAPTATION AND MITIGATION

Water-related adaptation to climate change in the fields of Ecosystems and biodiversity, - Agriculture and food security, land use and forestry, Human health, water supply and sanitation, infrastructure and Economy (insurance, tourism, industry and transportation) - Adaptation, vulnerability and sustainable development Sector-specific mitigation - Carbon dioxide capture and storage (CCS), Bio-energy crops, Biomass electricity, Hydropower, Geothermal energy, Energy use in buildings, Land-use change and management, Cropland management, Afforestation and Reforestation.

UNIT V IMPACTS ON WATER RESOURCES

General Circulation Models – downscaling – statistical downscaling – dynamic downscaling Case studies on impacts of climate change on Water resources assessment, water quality, groundwater, irrigation and agriculture

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

  CO1 Describe the earth’s climate system and the interaction among the subsystems of the earth's components.

  CO2 Illustrate the basics of climate variability and change including the observations and projections.

  CO3 Demonstrate the climate models for vulnerability assessment at global and at regional scale.

  CO4 Describe the options available for adaptation and mitigation for different sectors

  CO5 Comprehend the methodology for using appropriate data sets for an impact assessment on Water resources assessment, water quality, groundwater, irrigation and agriculture through case studies.

REFERENCES


6. Inter governmental Panelon Climate Change:https://www.ipcc.ch/

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* 1-low, 2-medium, 3-high

IW3005 REHABILITATION AND MODERNISATION OF IRRIGATION SYSTEMS LT P C

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UNITI IRRIGATION SYSTEMS

Historical evolution of irrigation systems in India – Canal system operation – Conventional operation – Water delivery practices: the Warabandi – Shejpoli block and Satta System – the localized system for paddy area – Irrigation system classification – Nature of system modernization and rehabilitation. Distinction between rehabilitation and modernization; Rehabilitation and modernization objectives – Theory and Practice.

UNITII SYSTEM MAINTENANCE


UNITIII REHABILITATION OF IRRIGATION SYSTEMS


UNITIV MODERNISATION OF IRRIGATION SYSTEMS


UNITV REHABILITATION AND MODERNISATION INITIATIVES

Tank Modernisation Project: Periyar Vaigai Project – Parambikulam – Aliyar project - Water Resources Consolidation Project (WRCP) – DRIP project – RRRofwaterBodiesProject– KudimaramathScheme to restore Water Bodies – IAMWARM Project – Farm Pond Scheme – Government Subsidies – Successful Rehabilitation and Modernisation Projects implemented in Asian Countries

TOTAL: 45 PERIODS

COURSE OUTCOMES

- On completion of the course the student is expected to be able to

CO1 Describe about Indian irrigation systems and discriminate between rehabilitation and modernization.
CO2 Analyse the different types of maintenance problems with respect to technical and social aspects using Different PRA tools

CO3 Carryout diagnostic analysis to identify the constraints in improving the performance of irrigation system

CO4 Illustrate the various types of modern irrigation technologies to attain sustainable irrigated agriculture.

CO5 Explain the rehabilitation and modernization advancements achieved so far through the implemented projects in India and Asian Countries.

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* 1-low, 2-medium, 3-high

HW3053 RADAR METEOROLOGY

UNIT I RADAR PRINCIPLES
Electromagnetic waves (EM): Electric field (EF), Magnetic field (MF), relating EF and MF, Maxwell’s equations; Interaction of EM waves: refraction, reflection, scattering, absorption, Polarization of waves; Radar components: radar beam, pulse, signal processing;

UNIT II RADAR RAY PROPAGATION, REFLECTIVITY FACTOR AND RADIAL VELOCITY
Ray propagation in the idealized atmosphere: factors influencing ray paths, range and height of pulse; Radar equation: solitary target and distributed target, weather radar equation, radar reflectivity factor, the validity of Rayleigh’s approximation; Radial velocity: Doppler effect, measurement, Doppler spectra
UNIT III  PRECIPITATION ESTIMATION WITH RADAR
Measurement of precipitation rate, total precipitation, drop size distribution; instruments, terminal velocities, Radar reflectivity (Z) and Rainfall rate (R), Z-R relationships; Polarimetric Radar Quantitative Precipitation Estimation: Hydrometeor Classification, Polarimetric Radar-Based QPE, Microphysical Retrievals, Precipitation Typology, Precipitation Estimation

UNIT IV  ADVANCED RADAR TECHNOLOGIES FOR QUANTITATIVE PRECIPITATION ESTIMATION
Mobile and Gap-Filling Radars, Space borne Radars: TRMM and GPM, Phased-Array Radar; Surface water radar: Stream flow radar, SAR, Altimetry; Subsurface water: L-band, c band and Ground penetrating radar

UNIT V  RADAR QPE FOR HYDROLOGIC MODELING
Model Classes, Model Parameters, Model State Variables and Data Assimilation, Hydrological Model Evaluation, Hydrological Evaluation of Radar QPE; Flash Flood Forecasting: Lumped flash flood guidance and gridded flash flood guidance. Flash Flood Potential Index, threshold frequency approach

TOTAL: 45 PERIODS

COURSE OUTCOMES
On completion of the course, the student is expected to be able to

CO1 Describe the principles of radar, its components and the interaction of waves with the atmosphere and objects

CO2 Comprehend the radar ray propagation and the parameters that can be measured using radar waves

CO3 Illustrate the methodology for the estimation of precipitation using radar principles

CO4 Demonstrate the advanced techniques for precipitation estimation using mobile and space-borne radars

CO5 Formulate and choose the appropriate model classes and parameters for hydrologic modelling using QP estimated through radar

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UNIT I  BACKGROUND AND INTRODUCTION TO VIRTUAL WATER CONCEPT  6  
Background – Introduction to the concept of virtual water and water footprint - Introduction to water use for crop and livestock products - Water use behind consumer goods - Water for domestic services - Water use for industrial products - Goals and scope of water footprint assessment and accounting - Coherence between different sorts of water footprint accounts.

UNIT II  ASSESSMENT AND ACCOUNTING OF VIRTUAL WATER  10  
Virtual water of a process step – Blue, Green, Grey water footprint and assessment – Calculation of virtual water for a product – Virtual water of a consumer or group of consumers - Water footprint of a business - Analytical framework for the assessment of virtual water content, virtual-water flows, water savings, water footprints, and water dependencies 
Case Analysis: The virtual water of coffee and tea consumption; The virtual water of cotton consumption

UNIT III  SUSTAINABILITY ASSESSMENT – VIRTUAL WATER AND WATER BUDGETING  10  
Water footprint within geographically delineated area - Sustainability of the water footprint within a catchment or river basin - Environmental sustainability criteria for identifying environmental, social, economic hotspots - Sustainability of the water footprint of a process, of a product, of a business and of a consumer 
Case Analysis: Water footprint accounting along the wheat-bread value chain: implications for sustainable and productive water use benchmarks; Evaluating water use for agricultural intensification in Southern Amazonia using the water footprint sustainability assessment

UNIT IV  VIRTUAL WATER TRADE  10  
Virtual water of nations - National water footprint accounting - Water footprint accounting for catchments and river basins – Virtual water flows between nations as a result of trade in agricultural and industrial products - The relation between trade and water scarcity - Water saving through international trade in agricultural products - National water losses – Global water savings – Virtual Water as a new indicator of water use 
Case Analysis: The water footprints of Morocco and the Netherlands; Virtual versus real-water transfers within China

UNIT V  WATER FOOTPRINT A GLOBAL POLICY TOOLS  9  
Water as a geopolitical resource efficient, sustainable, and equitable water use in a globalizorld – Water footprint: A tool towards collective action in water governance - Water footprint response options for producers, consumers and stakeholders –Water footprint-based water policy for local bodies - Limitation and challenges of water footprint assessment 
Case Analysis: Informing national food and water security policy through water footprint assessment: the case of Iran; Simplified direct water footprint model to support urban water management; Water and land footprints and economic productivity as factors in local crop choice: the case of silk in Malawi

TOTAL: 45 PERIODS

COURSE OUTCOMES
On completion of the course the student is expected to be able to
CO1 Explain the concept of Virtual water and identify the scope of water footprint assessment at individual, community, panchayat and national scales
CO2 Apply the tools and techniques in Water footprint assessment and accounting for various products, services, institutions and events for sustainable processes
CO3 Apply knowledge and reflect on the sustainable assessment on products and services and to identify hotspots for sustainable decision making based on virtual water
CO4 Appraise the virtual water trade, its implications with local and global water security and scarcity
CO5 Evolve water norms, policies and regulations based on the water footprint at grassroots to global geographies and integrating with SDGs and National indicators
REFERENCES

Indicative topics for Practical:
- Assessment of Virtual Water for an individual of various socio-economic backgrounds
- Water footprint-based water budgeting at Panchayat or Wards
- Assessment of Blue, Green, Grey Water footprint for a single crops tank-fed, canal fed, aquifers fed and rainfed
- Comparative study on Blue, Green, Grey Water footprint for various crops at a specific agro-climatic zone
- Assessment of virtual water of a single crop across various ecosystems (Hills, plains, coastal, urban and controlled environments)
- Assessment on Virtual water trade of a village Panchayat based on the production, consumption and services
- Deriving Panchayat policies based on Water footprint assessment
- Designing industry, institution and event processes towards sustainable water security based on the Water footprint
- Estimating Virtual water for non-listed local produces using the assessment tools

Indicative Tutorial:
- Case Analysis of recent researches on Water footprint assessment, accounting methods, virtual water trade among nations, regions and counties, various products and services, Water footprint-based policies, regulations and strategies

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