| LAND AND WATER RESOURCES CONSERVATION ENGINEERING (IPCC) | | | |
|---|---|---|---|
| *Course Code* | **1MCWL201** | *Scheme* | *2026* |
| *Type of Course* | *Integrated Professional Core Courses (IPCC)* | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *70 (3:0:2 )* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *120 (42:0:28:50)* | *SEE Marks* | *50* |
| *Credits* | *4* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE, and Lab- CIE only.* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Understand the principles of land and water resources conservation, watershed concepts, and resource degradation processes.*
2. *CO2 (L3): Apply hydrological principles and engineering methods for assessment of soil erosion and runoff processes.*
3. *CO3 (L3): Apply land and water conservation techniques for planning and design of conservation structures.*
4. *CO4 (L4): Analyze watershed characteristics and evaluate soil and water conservation measures under varying field conditions.*
5. *CO5 (L4): Analyze integrated watershed management strategies and sustainable resource utilization approaches.*
6. *CO6 (L5): Evaluate conservation engineering solutions through case studies and project-based applications.*

**Module-1**

**Fundamentals of Land and Water Resources Conservation (more contents on LW conservations)**

- *Importance and scope of land and water resources conservation engineering*
- *Soil and water resources: availability, utilization, and challenges*
- *Causes and effects of land degradation and water resource deterioration*
- *Concepts of watershed and watershed characteristics*
- *Principles of sustainable resource management*
- *Engineering approaches for conservation planning*
- *Conservation engineering in rural and urban environments*
- *Role in disaster risk reduction (droughts, floods, landslides, and soil erosion)*
- *Climate-smart land and water management practices*

**Linked COs: CO1, CO2** **Number of Hours: 14**

**Module-2**

**Hydrological principles and Soil Erosion Processes (Sequentail arrengaments)**

- *Definition, scope, and importance of hydrology, hydrological cycle and watershed hydrology concepts*
- *Rainfall characteristics and runoff estimation*
- *Soil erosion: causes, types, and factors affecting erosion*
- *Estimation of soil loss using empirical methods and erosion models*
- *Sediment transport and sediment yield assessment*

**Linked COs: CO1, CO2** **Number of Hours: 14**

**Module-3**

**Soil and Water Conservation Measures (more spects on conservation measurements)**

- *Introduction to Soil and Water Conservation, Objectives and principles of soil and water conservation, Land capability-based conservation planning, Integrated approach to soil and water conservation.*

- *Selection of suitable conservation measures based on topography, soil, rainfall, and land use*
- *Agronomic measures: contour farming, strip cropping, crop rotation, mulching*
- *Mechanical Soil Conservation Measures, Principles and objectives of mechanical conservation, Land leveling and grading, Farm roads and drainage planning*
- *Waterways for safe disposal of runoff*
- *Gully control structures and stream bank stabilization*
- *Water harvesting techniques and conservation practices*
- *Design considerations for soil and water conservation structures*

**Linked COs: CO2, CO3** **Number of Hours: 14**

**Module-4**

**Watershed Management and Conservation Planning**

- *Watershed characterization and delineation*
- *Conservation planning*
- *Watershed management principles and approaches*
- *Planning and implementation of watershed development programs*
- *Groundwater recharge and water conservation strategies*
- *Impact assessment of watershed management practices*

**Linked COs: CO3, CO4** **Number of Hours: 14**

**Module-5**

**Advanced Conservation Engineering and Applications**

- *Remote sensing and GIS applications in watershed management*
- *GIS and Remote Sensing for conservation planning*
- *UAV/Drone-based monitoring, GPS-based field survey*
- *Artificial Intelligence (AI) and Machine Learning applications related water and land conservation*
- *Internet of Things (IoT)-based soil moisture monitoring*
- *Decision Support Systems (DSS)*
- *Integrated land and water resources management approaches*
- *Decision support systems for conservation planning*
- *Case studies on watershed development and sustainable resource management*

**Linked COs: CO4, CO5, CO6** **Number of Hours: 14**

**PRACTICAL COMPONENTS OF IPCC**

**SET OF EXPERIMENTS** **LI: 28 hrs**

*Students shall perform practical 6-8 exercises related to:*

1. *Determine soil texture and classify soils using standard methods.*
2. *Determine bulk density, moisture content, and infiltration characteristics of soil samples.*
3. *Estimate runoff from a watershed using hydrological methods and rainfall data.*
4. *Carry out contour mapping and prepare contour layouts for conservation planning.*
5. *Design and prepare contour bund and graded bund layouts for a given area.*
6. *Estimate soil loss using empirical equations such as Universal Soil Loss Equation (USLE).*

7. *Perform watershed delineation and drainage network analysis using maps/GIS tools.*
8. *Design and evaluate water harvesting structures for small watersheds.*
9. *Study sediment yield and erosion characteristics in experimental watershed conditions.*
10. *Compile a soil and water conservation engineering portfolio.*

**Suggested Learning Resources**

**Text Books**

1. *R. Suresh — Soil and Water Conservation Engineering — Standard Publishers Distributors, New Delhi.*
2. *G.O. Schwab, D.D. Fangmeier, W.J. Elliot and R.K. Frevert — Soil and Water Conservation Engineering — John Wiley & Sons.*
3. *D.K. Majumdar — Irrigation Water Management: Principles and Practice — Prentice Hall of India.*
4. *V.V.N. Murthy — Land and Water Management Engineering — Kalyani Publishers.*
5. *S.K. Garg — Soil, Water and Water Resources Engineering — Khanna Publishers.*

**Reference Books / Manuals**

1. *R.K. Frevert, G.O. Schwab, T.W. Edminster and K.K. Barnes — Soil and Water Conservation Engineering — Wiley Eastern Limited.*
2. *C.V. Madramootoo and V.K. Singh — Land and Water Management Engineering — Springer Publications.*
3. *R.S. Varshney — Watershed Management and Applications — New Age International Publishers.*
4. *V.P. Singh and D.K. Frevert — Watershed Models — CRC Press.*
5. *Glenn O. Schwab, Delmar D. Fangmeier and William J. Elliot — Engineering for Soil and Water Conservation — McGraw-Hill Publications.*
6. *R.K. Suresh — Watershed Hydrology and Management — Standard Publishers.*

**Web links and Video Lectures (e-Resources) & Software tools**

1. *NPTEL – Soil and Water Conservation Engineering*
2. *SWAYAM Learning Portal*
3. *FAO Water Resources Portal*
4. *USDA Natural Resources Conservation Service*
5. *Central Water Commission (India)*
6. *ISRO Bhuvan Geoportal*

**Core software tools:**

- *QGIS or ArcGIS for watershed and spatial analysis*
- *SWAT (Soil and Water Assessment Tool) for watershed modeling*
- *HEC–HMS for hydrological analysis and runoff estimation*
- *Excel / LibreOffice Calc for calculations and reporting*
- *Google Earth Pro for terrain visualization and watershed reconnaissance*
- *Python or R for data analysis and modeling.*

**Teaching-Learning Process (Innovative Delivery Methods):**

*The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):*

- *Flipped Classroom*
- *Problem-Based Learning (PBL)*
- *Case-Based Teaching*
- *Simulation and Virtual Labs*
- *Partial Delivery of course by Industry expert/ industrial visits*
- *ICT-Enabled Teaching*
- *Role Play*

*Assessment Structure (both CIE and SEE)*
*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.*
*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

*Continuous Internal Evaluation:*
*(i)Theory component*
*The CIE marks of 25 shall be earmarked for two tests.*
*The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.*
*Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.*
*(ii) Laboratory component*
*Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.*
*The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table – ICs/IPCCs 1.*
*To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.*

*Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component*

| *Component* | *Description* | *Marks* |
|---|---|---|
| *Allotment of marks for regular classwork* | | |
| *Ability in Conducting Experiments* | *Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.* | *5 marks* |
| *Laboratory Record / Journal* | *Regular and neat maintenance of lab record, accuracy of results, and timely submission.* | *10 marks* |
| *Subtotal* | | *15* |
| *Allotment of marks for CIE practical test* | | |
| *Laboratory Test / Experiment Performance* | *Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.* | *5 marks* |
| *Viva-Voce* | *Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.* | *5 marks* |
| *Subtotal* | | *10* |
| *Total* | | *25* |

**Term work and Self Learning:**
*Students' activities for TW/SL under NCrF: As per National credit framework (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also design learning activities based on course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Transport base map preparation:** *Prepare a georeferenced base map of an urban or regional transport study area showing roads, junctions, transit stops, land use, and important landmarks. Include coordinate system, scale, legend, north arrow, and source details.* | *25* |
| *2* | **Transport corridor mapping** | *25* |

| | | |
|---|---|---|
| | *Use GIS to digitize a road corridor or transit route and prepare layers for carriageway, intersections, bus stops, railway stations, and activity centers. Add a short note on corridor characteristics and connectivity.* | |
| *3* | **Route suitability analysis**<br>*Prepare a simple suitability map for a proposed road or transit alignment using factors such as slope, land use, built-up area, water bodies, and constraints. Assign weights and explain the selection logic* | *25* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | **QGIS / ArcGIS self-study**<br>*Learn layer management, symbology, georeferencing, digitization, buffer analysis, and map composition using a sample transport dataset.* | *25* |
| *2* | **Google Earth Engine basics**<br>*Explore how time-series imagery can support corridor growth analysis, built-up mapping, or transport-related land-use studies.* | *25* |
| *3* | **Case study review**<br>*Prepare a one-page review of a published transport GIS case study, such as congestion mapping, transit accessibility, or road expansion analysis.* | *25* |
| *4* | **Data quality and ethics**<br>*Study privacy issues in mobility data, uncertainty in spatial layers, and responsible use of transport data in planning.* | *25* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Concept understanding* | *Demonstrates clear understanding of the transport GIS problem, objectives, and workflow.* | *Shows good understanding with minor gaps.* | *Basic understanding with limited clarity.* | *Understanding is weak or incorrect.* |
| *Task completion* | *Activity is completed fully, correctly, and on time.* | *Activity is mostly complete with minor omissions.* | *Activity is partially complete.* | *Activity is incomplete or missing.* |
| *Technical accuracy* | *GIS layers, maps, or analysis are correct, properly processed, and well justified.* | *Mostly correct with few technical errors.* | *Contains noticeable errors but shows partial correctness.* | *Major technical errors or no meaningful attempt.* |
| *Data handling and workflow* | *Uses data systematically, follows proper workflow, and* | *Workflow is clear with minor gaps.* | *Workflow is incomplete or inconsistently followed.* | *Poor workflow and weak data handling.* |

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| | *maintains good map/database structure.* | | | |
| *Interpretation and analysis* | *Provides strong interpretation of spatial results and transport implications.* | *Gives reasonable interpretation with some analysis.* | *Interpretation is brief and descriptive.* | *Interpretation is minimal or absent.* |
| *Presentation and documentation* | *Work is neat, well structured, and easy to follow with proper maps, legends, and notes.* | *Organized well with minor formatting issues.* | *Acceptable presentation with several issues.* | *Poorly organized or difficult to read.* |

**Sample rubrics for Self-Learning activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Concept understanding* | *Demonstrates clear and accurate understanding of the assigned concept.* | *Shows good understanding with minor gaps.* | *Basic understanding with limited detail.* | *Understanding is weak or incorrect.* |
| *Independent learning* | *Explores beyond the minimum requirement and shows initiative in learning.* | *Shows good initiative with some additional effort.* | *Completes the assigned task with limited exploration.* | *Relies heavily on guidance or shows little effort.* |
| *Task completion* | *Activity is completed fully, correctly, and on time.* | *Activity is mostly complete with minor omissions.* | *Activity is partially complete.* | *Activity is incomplete or missing.* |
| *Technical accuracy* | *Workflow, tool use, or analysis is correct and well justified.* | *Mostly correct with few technical errors.* | *Contains noticeable errors but shows partial correctness.* | *Major technical errors or no meaningful attempt.* |
| *Reflection and analysis* | *Provides strong reflection, interpretation, and learning outcomes.* | *Gives reasonable reflection with some analysis.* | *Reflection is brief and descriptive.* | *Reflection is minimal or absent.* |
| *Presentation and organization* | *Work is neat, well structured, and easy to follow.* | *Organized well with minor formatting issues.* | *Acceptable presentation with several issues.* | *Poorly organized or difficult to read.* |

**Suggested rubrics for Practical continuous assessment:**

| *Performance Indicators* | *Excellent* | *Very Good* | *Good* | *Satisfactory* |
|---|---|---|---|---|
| *Fundamental Knowledge (4) (PO1)* | *The student has well depth knowledge of construction planning, BIM-enabled 4D/5D workflows, project controls and site logistics. (4)* | *Student has good knowledge of some topics related to construction planning and BIM workflows. (3)* | *Student is capable of narrating the answer but not capable to show in depth knowledge. (2)* | *Student has not understood the concepts clearly. (1)* |
| *Design Of Experiment (5) (PO2 & PO3)* | *Student is capable of discussing more than one planning workflow/design for the problem statement and selecting the best suitable approach with proper reason. (5)* | *Student is capable of discussing a few workflows but not fully capable of selecting the best. (4)* | *Student is capable of discussing a single planning workflow with merits and demerits. (3)* | *Student can explain the planning/design approach only partly. (1-2)* |
| *Implementation (8) (PO3 & PO8)* | *Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)* | *Student is capable of implementing the workflow and explaining it with minor gaps. (5-6)* | *Student is capable of implementing the workflow with partial explanation. (3-4)* | *Student can implement only limited parts of the workflow. (1-2)* |
| *Result &Analysis (5) (PO4)* | *Student is able to run the workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis. (5)* | *Student will be able to run the workflow for all the cases. (4)* | *Student will be able to run the workflow for a few cases and analyze the output. (3)* | *Student will be able to run the workflow but not able to analyze the output. (1-2)* |
| *Demonstration (8) (PO9)* | *The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet, issue log, results and conclusion. (7-8)* | *The lab record/portfolio is organized, with clear sections, but some sections are not well-defined. (5-6)* | *The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)* | *The lab record is poorly organized, with missing or unclear sections. (1-2)* |

| WATERSHED DEVELOPMENT, SOIL EROSION & LAND RECLAMATION | | | |
|---|---|---|---|
| *Course Code* | **1MCWL202** | *Scheme* | *2026* |
| *Type of Course* | **Professional Core Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE only.* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Explain the principles, concepts and significance of watershed development, hydrological processes and watershed characteristics.*
2. *CO2 (L4): Analyze the causes, processes and types of soil erosion and assess erosion hazards using conventional and geospatial techniques.*
3. *CO3 (L3): Apply soil and water conservation measures for agricultural and watershed management under different land conditions.*
4. *CO4 (L5): Evaluate watershed planning, development and management strategies using Remote Sensing, GIS and Decision Support Systems.*
5. *CO5 (L6): Design suitable land reclamation measures for degraded lands including saline, sodic, waterlogged, ravine and mined areas.*
6. *CO6 (L6): Develop sustainable watershed management plans integrating climate resilience, community participation and environmental conservation.*

**Module-1**

**Introduction to Watershed Development:**

- *Definition, concept, and objectives of watershed development , Importance and scope of watershed management*
- *Watershed characteristics and classification. Watershed delineation using topographic maps and DEM, delineation, classification and hydrologic cycle.*
- *Drainage patterns and stream ordering and surface runoff and groundwater interaction*
- *Watershed planning principles and participatory watershed management*
- *Integrated watershed development approach*
- *Watershed development programmes in India, Integrated Watershed Management Programme (IWMP), PMKSY.*

**Linked COs: CO1** **Number of Hours: 8**

**Module-2**

**Soil Erosion Processes and Assessment:**

- *Soil erosion definition, causes,*
- *Factors affecting erosion, splash, sheet, rill, gully, stream bank and wind erosion andSoil loss estimation methods.*
- *Universal Soil Loss Equation (USLE), RUSLE, erosion hazard mapping, sediment yield estimation, GIS-based erosion assessment.*
- *Sediment yield and sediment transport*
- *Soil conservation principles*
- *Mechanical conservation measures and biological conservation measures*

**Linked COs: CO2** **Number of Hours: 8 hrs**

**Module-3**

**Soil and Water Conservation Engineering**

- *Watershed planning and prioritization and Resource inventory and watershed assessment*

- *Land capability and land suitability classification and Participatory Rural Appraisal (PRA)*
- *Soil moisture conservation techniques and different rainwater harvesting methods*
- *Contour trenches and Gully control structures*
- *Groundwater recharge techniques using various methods*
- *Afforestation and agroforestry, Integrated Farming Systems (IFS)*
- *Monitoring and evaluation of watershed development projects*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Watershed Planning and Management**

- *Watershed prioritization, participatory watershed management.*
- *Land degradation: Definition and causes and soil degradation processes*
- *Waterlogging and drainage management and Saline and sodic soils*
- *Digital Elevation Model (DEM) for water resource planning and management.*
- *Morphometric analysis, watershed modelling, SWAT model, climate change impacts.*
- *Decision Support Systems (DSS), monitoring and evaluation.*
- *Sustainable land management and ecological restoration*

**Linked COs: CO4** **Number of Hours: 9 hrs**

**Module-5**

**Remote Sensing, GIS and Advanced Applications in Watershed Management:**

- *Introduction to Remote Sensing and GIS and GPS applications in watershed management*
- *Digital Elevation Models (DEM), Watershed delineation using GIS*
- *Drainage network extraction and Slope, aspect, and contour analysis*
- *Flow direction and flow accumulation analysis and Land Use/Land Cover (LULC) mapping*
- *Soil and geomorphology mapping, Hydrological modelling (SWAT, HEC-HMS)*
- *Decision Support Systems (DSS)*
- *Artificial Intelligence and Machine Learning applications*
- *Drone and UAV applications in watershed studies*

**Linked COs: CO5, CO6** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**

1. *Murthy, V.V.N., Land and Water Management Engineering, Kalyani Publishers, New Delhi.*
2. *Schwab, G.O., Fangmeier, D.D., Elliot, W.J., and Frevert, R.K., Soil and Water Conservation Engineering, John Wiley & Sons.*
3. *Michael, A.M., Irrigation: Theory and Practice, Vikas Publishing House.*
4. *Tideman, E.M., Watershed Management: Guidelines for Indian Conditions, Omega Scientific Publishers.*
5. *Morgan, R.P.C., Soil Erosion and Conservation, Wiley-Blackwell.*

**Reference Books**

1. *Singh, G., Watershed Planning and Management, CBS Publishers.*
2. *Reddy, S.R., Watershed Management, Kalyani Publishers.*
3. *Brooks, K.N., Ffolliott, P.F., Gregersen, H.M., and DeBano, L.F., Hydrology and the Management of Watersheds, Wiley.*
4. *Arora, K.R., Soil Conservation and Water Resources Engineering, Standard Publishers.*
5. *Lal, R., Soil Erosion Research Methods, CRC Press.*

**Web links and Video Lectures (e-Resources)**

1. *National Remote Sensing Centre (NRSC): https://www.nrsc.gov.in*
2. *Indian Space Research Organisation (ISRO): https://www.isro.gov.in*
3. *Central Ground Water Board (CGWB): https://cgwb.gov.in*

4. *Ministry of Jal Shakti: https://jalshakti-dowr.gov.in*

**Teaching-Learning Process (Innovative Delivery Methods):**

*The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):*

- *Flipped Classroom*
- *Problem-Based Learning (PBL)*
- *Case-Based Teaching*
- *Simulation and Virtual Labs*
- *Partial Delivery of course by Industry expert/ industrial visits*
- *ICT-Enabled Teaching*
- *Role Play*

**Assessment Structure (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]*

*A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

**Students' activities for TW/SL under NCrF: Samples only**

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Watershed Delineation and Morphometric Analysis:** *Delineate a watershed using Survey of India topo sheets or DEM data and compute watershed characteristics such as drainage density, stream order, bifurcation ratio and basin shape.* | *24* |
| *2* | **Soil Erosion Assessment:** *Conduct a field survey to identify different types of soil erosion (sheet, rill, gully and stream bank erosion), estimate erosion severity and suggest suitable conservation measures.* | *24* |
| *3* | **Watershed Management Case Study:** *Prepare a case study on a successful watershed development project in India highlighting planning, implementation, community participation and environmental benefits.* | *24* |
| *4* | **Land Reclamation and Conservation Project:** *Develop a reclamation and soil-water conservation plan for a degraded land (saline, sodic, waterlogged, ravine or mined area) using* | *24* |

| | | |
|---|---|---|
| | *appropriate engineering and biological measures.* | |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | *Read selected IPCC summary sections and prepare a reflective note.* | *24* |
| *2* | *Develop a concept map on risk, vulnerability, and resilience.* | *24* |
| *3* | *Complete a MOOC module on climate change or disaster risk reduction.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| GEOSPATIAL TECHNIQUES FOR LAND AND WATER GOVERENANCE | | | |
|---|---|---|---|
| *Course Code* | **1MCWL203** | *Scheme* | *2026* |
| *Type of Course* | **Professional Core Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE only* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Explain the principles of Geospatial Technologies, including Remote Sensing, GIS, GPS, and their applications in land and water governance.*
2. *CO2 (L4): Analyze spatial and non-spatial data to prepare thematic maps for land resource assessment and water resource management.*
3. *CO3 (L3): Apply GIS and Remote Sensing techniques for watershed delineation, land use/land cover mapping, groundwater potential assessment, and environmental monitoring*
4. *CO4 (L5): Evaluate geospatial models and decision-support tools for sustainable land and water resource planning and governance.*
5. *CO5 (L6): Develop geospatial databases and perform spatial analysis using GIS software for resource management and policy implementation.*
6. *CO6 (L5): Assess emerging technologies such as UAVs, Artificial Intelligence, Machine Learning, IoT, and cloud-based GIS for smart land and water governance*

**Module-1**

**Fundamentals of Geospatial Technologies**

- *Introduction to Geospatial Technologies and Earth observation systems*
- *Principles of Remote Sensing, Electromagnetic Radiation (EMR)*
- *Energy interactions with atmosphere and earth surface*
- *Different Remote sensing platforms and its applications*
- *Types of satellites and its applications in different sectors, Satellite sensors and resolutions*
- *Satellite imageries and it Image characteristics*
- *GPS and GNSS fundamentals and coordinate systems and map projections*
- *Introduction to GIS and different Components of GIS*
- *Spatial and attribute data, Data models (Raster and Vector)*
- *Geospatial data standards and Applications in Land & Water Governance*

**Linked COs: CO1** **Number of Hours: 8**

**Module-2**

**Spatial Data Acquisition and Mapping**

- *Different sources of spatial data, Satellite imagery*
- *Topographical maps and its applications in various fields.*
- *Digital Elevation Models (DEM) and it Applications*
- *LiDAR data, Drone/UAV data and applications*
- *Ground survey methods and GPS field survey*
- *Spatial database development and data process*
- *Georeferencing and Image enhancement*
- *Image interpretation and Digital image classification using different methods*
- *Land Use/Land Cover (LULC) Mapping*
- *Soil mapping, Geology, slope, drainage and geomorphology mapping*
- *Thematic map preparation*

**Linked COs: CO2** **Number of Hours: 8 hrs**

**Module-3**

**Geospatial Applications in Land and Water Resources**

- *Watershed delineation and morphometric analysis*
- *Groundwater potential mapping using GIS techniques*
- *Aquifer mapping and surface water resource mapping*
- *Flood hazard zonation and Drought monitoring using Geospatial Techniques*
- *Irrigation management and agricultural land suitability analysis*
- *Soil erosion mapping and Land degradation assessment*
- *Wetland mapping and Water quality monitoring*
- *Environmental Impact Assessment (EIA)*
- *Integrated watershed management using Geospatial Techniques*
- *Case studies*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Spatial Analysis and Decision Support Systems**

- *Spatial analysis techniques and overlay analysis its applications*
- *Buffer analysis, Network analysis*
- *Terrain analysis and Hydrological modelling*
- *Multi-Criteria Decision Analysis (MCDA) and Analytical Hierarchy Process (AHP)*
- *Weighted Overlay Analysis and its suitability modelling*
- *Spatial statistics, Geostatistics and Decision Support Systems (DSS)*
- *Spatial database management and web GIS*
- *Geospatial governance policies and National Geospatial Policy*
- *Land information systems*

**Linked COs: CO4, CO5** **Number of Hours: 9 hrs**

**Module-5**

**Emerging Technologies in Land & Water Governance**

- *Integration of Artificial Intelligence in GIS*
- *Machine Learning for spatial analysis*
- *Deep Learning in Remote Sensing for different sectors and UAV and Drone applications*
- *Internet of Things (IoT) and Smart sensors*
- *Cloud GIS, Google Earth Engine and Big Data Analytics*
- *Digital Twin concepts*
- *Climate change modelling and Disaster risk management using Geospatial Techniques*
- *Urban planning and Smart water management using Geospatial Techniques*
- *SDGs and geospatial technologies*
- *National and international case studies*

**Linked COs: CO6** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**

1. *Kang-tsung Chang, Introduction to Geographic Information Systems, McGraw-Hill Education.*
2. *Lillesand, T. M., Kiefer, R. W., and Chipman, J. W., Remote Sensing and Image Interpretation, Wiley.*
3. *Lo, C. P. and Yeung, A. K. W., Concepts and Techniques of Geographic Information Systems, Pearson.*
4. *Burrough, P. A. and McDonnell, R. A., Principles of Geographical Information Systems, Oxford University Press.*

5. *Michael N. DeMers, Fundamentals of Geographic Information Systems, Wiley.*

**Reference Books**

1. *Jensen, J. R., Introductory Digital Image Processing, Pearson.*
2. *Sabins, F. F., Remote Sensing: Principles and Interpretation, Waveland Press.*
3. *Longley, P. A., Goodchild, M. F., Maguire, D. J., and Rhind, D. W., Geographic Information Science and Systems, Wiley.*
4. *Campbell, J. B. and Wynne, R. H., Introduction to Remote Sensing, Guilford Press.*
5. *NRSC, ISRO, Remote Sensing Applications Manual.*
6. *FAO, Land Resources Planning for Sustainable Land Management.*
7. *National Remote Sensing Centre (NRSC), GIS and Remote Sensing Applications Manuals.*

**Web links and Video Lectures (e-Resources)**

1. *ISRO – Indian Space Research Organisation: https://www.isro.gov.in*
2. *NRSC – National Remote Sensing Centre: https://www.nrsc.gov.in*
3. *Bhuvan Geoportal (ISRO): https://bhuvan.nrsc.gov.in*
4. *National Informatics Centre (GIS): https://www.nic.in*
5. *Survey of India: https://www.surveyofindia.gov.in*
6. *USGS Earth Explorer: https://earthexplorer.usgs.gov*

**Teaching-Learning Process (Innovative Delivery Methods):**

*The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):*

- *Flipped Classroom*
- *Problem-Based Learning (PBL)*
- *Case-Based Teaching*
- *Simulation and Virtual Labs*
- *Partial Delivery of course by Industry expert/ industrial visits*
- *ICT-Enabled Teaching*
- *Role Play*

**Assessment Structure (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]*

*A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

**Students' activities for TW/SL under NCrF: Samples only**

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Land Use/Land Cover Mapping:** *Prepare a Land Use/Land Cover (LULC) map of a selected study area using satellite imagery (Sentinel/Landsat) and GIS software. Analyze temporal land use changes and their impact on land and water resources.* | *24* |
| *2* | **Watershed Delineation and Terrain Analysis:** *Delineate a watershed using Digital Elevation Model (DEM) data and generate slope, drainage, flow direction, flow accumulation, and watershed boundary maps using GIS tools.* | *24* |
| *3* | **Groundwater Potential and Flood Susceptibility Mapping:** *Develop thematic maps for groundwater potential or flood hazard zonation using GIS-based Multi-Criteria Decision Analysis (MCDA) by integrating geology, soil, slope, rainfall, drainage density, and land use data.* | *24* |
| *4* | **Geospatial Governance Case Study:** *Prepare a case study on the application of Remote Sensing, GIS, GPS, UAVs, or AI in land administration, watershed management, disaster management, urban planning, or water resource governance. Present the findings with maps and spatial analysis* | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | *Read selected PCC summary sections and prepare a reflective note.* | *24* |
| *2* | *Develop a concept map on Integrated watershed management* | *24* |
| *3* | *Complete a MOOC module on Spatial analysis techniques and overlay analysis its applications* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-* | *Relevant with minor* | *Generic recommendations.* | *Incomplete or unrealistic.* |

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| | *specific.* | *limitations.* | | |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| AGRICULTURAL WATER MANAGEMENT & CROP WATER MODELLING | | | |
|---|---|---|---|
| *Course Code* | **1MCWL204** | *Scheme* | *2026* |
| *Type of Course* | **Professional Core Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE only.* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Explain the principles of agricultural water management, crop water requirements, and soil–plant–atmosphere relationships.*
2. *CO2 (L3): Calculate crop water requirements, evapotranspiration, irrigation scheduling, and irrigation efficiency using standard methods.*
3. *CO3 (L4): Analyze soil moisture movement, irrigation methods, and drainage systems for efficient agricultural water management.*
4. *CO4 (L5): Evaluate crop growth, water productivity, and climate impacts using crop water models and decision support systems.*
5. *CO5 (L6): Develop crop water balance models and irrigation management plans using simulation software and geospatial tools.*
6. *CO6 (L5): Assess the applications of Remote Sensing, GIS, IoT, Artificial Intelligence, and precision agriculture for sustainable water management.*

**Module-1**

**Fundamentals of Agricultural Water Management:**

- *Introduction to agricultural water management and its importance of water in agriculture*
- *Global and Indian water resources for agriculture, Soil–Plant–Atmosphere Continuum (SPAC)*
- *Soil physical properties affecting water movement and Soil moisture concepts andForms of soil water*
- *Field capacity, permanent wilting point, available water, Crop growth stages, Crop water requirement.*
- *Consumptive use of water and Water balance concept*
- *Factors affecting crop water requirement and Climate and weather influences on irrigation*
- *Principles of sustainable agricultural water management*

**Linked COs: CO1** **Number of Hours: 8**

**Module-2**

**Crop Water Requirements and Irrigation Scheduling**

- *Concept of Evaporation and evapotranspiration and Reference evapotranspiration (ETo)*
- *Crop coefficient (Kc) and its Estimation of crop water requirement*
- *FAO Penman–Monteith method and Blaney–Criddle method*
- *Pan evaporation method*
- *Effective rainfall estimation*
- *Net and gross irrigation requirement*
- *Different Irrigation scheduling methods and its frequency and interval*
- *Irrigation efficiencies, Deficit irrigation conjunctive use of surface and groundwater*
- *Water-saving irrigation techniques*

**Linked COs: CO2** **Number of Hours: 8 hrs**

**Module-3**

**Irrigation Systems and Drainage Management**

- *Various methods of Surface irrigation (ie Border irrigation, Furrow irrigation, Basin irrigation, Sprinkler*

*irrigation, Drip irrigation and Micro-irrigation systems).*

- *Fertigation concepts*
- *Precision irrigation and Irrigation water quality*
- *Salinity and sodicity management and Agricultural drainage systems*
- *Surface drainage and Subsurface drainage*
- *Waterlogging control and reclamation*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Crop Water Modelling and Decision Support Systems**

- *Introduction to crop water modelling, Crop growth simulation models and water balance models*
- *FAO Aqua Crop model, CROPWAT model, DSSAT model, SWAT model, APSIM model*
- *Irrigation scheduling using models and calibration and validation of models*
- *Sensitivity analysis and water productivity assessment*
- *Climate change impacts on crop water use*
- *Decision Support Systems (DSS) and case studies on crop water modelling*

**Linked COs: CO4, CO5** **Number of Hours: 9 hrs**

**Module-5**

**Geospatial Technologies and Smart Agricultural Water Management**

- *Concept of Remote Sensing and its applications in agriculture*
- *GIS applications in irrigation management and GPS and GNSS for precision agriculture*
- *Satellite-based crop monitoring, Soil moisture mapping and Evapotranspiration mapping*
- *Drought monitoring, Water stress assessment, UAV/Drone applications*
- *Internet of Things (IoT) in irrigation and Smart irrigation systems*
- *Artificial Intelligence and Machine Learning applications and cloud-based agricultural decision support systems*
- *Climate-smart agriculture and sustainable water management for food security*

**Linked COs: CO6** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**

1. *Michael, A. M., Irrigation: Theory and Practice, Vikas Publishing House.*
2. *Allen, R. G., Pereira, L. S., Raes, D., and Smith, M., Crop Evapotranspiration – FAO Irrigation and Drainage Paper 56, FAO.*
3. *Suresh, R., Soil and Water Conservation Engineering, Standard Publishers.*
4. *Brouwer, C., Prins, K., Kay, M., and Heibloem, M., Irrigation Water Management Training Manual, FAO.*
5. *James, L. G., Principles of Farm Irrigation System Design, Wiley.*

**Reference Books**

1. *Jensen, M. E., Design and Operation of Farm Irrigation Systems, ASABE.*
2. *Pereira, L. S., Cordery, I., and Iacovides, I., Coping with Water Scarcity, Springer.*
3. *Doorenbos, J. and Pruitt, W. O., Crop Water Requirements, FAO Irrigation and Drainage Paper 24.*
4. *Howell, T. A., Irrigation Efficiency, ASCE Publications.*
5. *Hillel, D., Introduction to Environmental Soil Physics, Elsevier.*
6. *Raes, D., AquaCrop Training Manual, FAO.*

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**Web links and Video Lectures (e-Resources)**

1. *Food and Agriculture Organization (FAO): https://www.fao.org*
2. *FAO AquaCrop: https://www.fao.org/aquacrop*
3. *FAO CROPWAT: https://www.fao.org/land-water/databases-and-software/cropwat*

4. *International Water Management Institute (IWMI): https://www.iwmi.cgiar.org*
5. *Indian Council of Agricultural Research (ICAR): https://icar.org.in*
6. *Central Water Commission (CWC): https://cwc.gov.in*

**Teaching-Learning Process (Innovative Delivery Methods):**

*The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):*

- *Flipped Classroom*
- *Problem-Based Learning (PBL)*
- *Case-Based Teaching*
- *Simulation and Virtual Labs*
- *Partial Delivery of course by Industry expert/ industrial visits*
- *ICT-Enabled Teaching*
- *Role Play*

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*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

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*Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]*

*A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

**Students' activities for TW/SL under NCrF: Samples only**

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| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Crop Water Requirement and Irrigation Scheduling:** *Estimate crop water requirement and prepare an irrigation schedule for a selected crop using FAO CROPWAT or AquaCrop software based on local climatic and soil data.* | *24* |
| *2* | **Soil Moisture and Irrigation Efficiency Assessment:** *Conduct field measurements of soil moisture before and after irrigation using suitable methods, evaluate irrigation efficiency, and recommend water-saving irrigation practices.* | *24* |
| *3* | **Crop Water Modelling Project:** *Develop a crop water balance model for a selected crop using AquaCrop, DSSAT, APSIM, or CROPWAT software. Analyze the effects of rainfall, irrigation, and climate variability on crop yield and water productivity.* | *24* |
| *4* | **Precision Irrigation and Geospatial Analysis:** *Prepare* | *24* |

| | | |
|---|---|---|
| | *thematic maps (soil moisture, evapotranspiration, irrigation suitability, or drought severity) using Remote Sensing and GIS. Evaluate the role of precision agriculture technologies (GPS, UAVs, IoT) in efficient agricultural water management.* | |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | *Read selected IPCC summary sections and prepare a reflective note.* | *24* |
| *2* | *Develop a concept map on risk, vulnerability, and resilience.* | *24* |
| *3* | *Complete a MOOC module on climate change or disaster risk reduction.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
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| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| INTEGRATED LAND USE PLANNING AND SDG-15 | | | |
|---|---|---|---|
| *Course Code* | 1MWL205A | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE only.* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Explain the principles of integrated land use planning, sustainable land management, and the objectives of SDG-15 (Life on Land).*
2. *CO2 (L4): Analyze land resources, land capability, land suitability, and land use changes using geospatial techniques for sustainable planning.*
3. *CO3 (L3): Apply land evaluation methods and spatial planning tools for land allocation, watershed management, and ecosystem conservation*
4. *CO4 (L5): Evaluate the impacts of land degradation, urbanization, climate change, and biodiversity loss on sustainable land governance.*
5. *CO5 (L6): Develop integrated land use plans using GIS, Remote Sensing, Multi-Criteria Decision Analysis (MCDA), and Decision Support Systems (DSS).*
6. *CO6 (L5): Assess national and international policies, SDG-15 indicators, and emerging technologies for sustainable land resource management and ecological restoration.*

**Module-1**

**Fundamentals of Integrated Land Use Planning and SDG-15**

- *Introduction to land resources and land use planning and concepts and principles of integrated land use planning.*
- *Land resource inventory and classification.*
- *Importance of sustainable land management and land governance and policy framework.*
- *Sustainable Development Goals (SDGs): Overview and SDG-15: Life on Land – Goals, targets, and indicators.*
- *Ecosystem services and natural capital and Land ethics and environmental stewardship.*
- *Land administration systems, Land tenure and ownership.*
- *Stakeholder participation in land use planning, National Land Use Policy of India and Integrated landscape approach.*
- *Challenges and opportunities in sustainable land management.*
- **Linked COs: CO1** **Number of Hours: 8**

**Module-2**

**Land Resource Assessment and Geospatial Techniques**

- *Land resource assessment, Land capability classification, and Land suitability analysis using Geospatial Techniques.*
- *Soil survey and land evaluation, Land Information System (LIS)*
- *Remote Sensing for land resource mapping and GIS applications in land use planning.*
- *GPS and GNSS applications, Digital Elevation Model (DEM).*
- *Land Use/Land Cover (LULC) mapping.*
- *Change detection analysis and Geology and geomorphology mapping.*
- *Soil and drainage mapping, Terrain analysis and Spatial database development.*
- *Preparation of thematic maps*

**Linked COs: CO2** **Number of Hours: 8 hrs**

**Module-3**

**Integrated Land Use Planning and Resource Management**

- *Land use planning process, Spatial planning principles and Watershed-based land use planning*
- *Agricultural land use planning, Urban and peri-urban land management and Forest and biodiversity conservation planning*
- *Wetland and coastal zone management, Agroforestry and social forestry and Soil and water conservation planning*
- *Climate-resilient land use planning, Multi-functional landscapes and Ecosystem restoration*
- *Participatory Rural Appraisal (PRA) and Integrated Natural Resource Management (INRM)*
- *Case studies on integrated land use planning*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Land Degradation, Climate Change and Decision Support Systems**

- *Land degradation: Causes and impacts, Desertification and drought and Soil erosion and conservation*
- *Salinity, sodicity, and waterlogging, Mining and industrial land degradation and Urban expansion and land fragmentation*
- *Climate change impacts on land resources, Carbon sequestration and land management*
- *Ecological restoration techniques, Multi-Criteria Decision Analysis (MCDA) and Analytical Hierarchy Process (AHP)*
- *Decision Support Systems (DSS), Spatial modelling for land suitability and Land use optimization*
- *Preparation of integrated land use plans*

**Linked COs: CO4, CO5** **Number of Hours: 9 hrs**

**Module-5**

**Emerging Technologies, Policies and policies**

- *Artificial Intelligence in land use planning, Machine Learning for LULC classification and Deep Learning in Remote Sensing.*
- *UAV and Drone applications and Internet of Things (IoT) in land monitoring.*
- *Google Earth Engine applications and Big Data and Cloud GIS.*
- *Digital Twin technology, National Geospatial Policy and Forest Conservation Act and Environmental Protection Act.*
- *National Action Plan on Climate Change (NAPCC) and Land Degradation Neutrality (LDN)*
- *Monitoring and reporting and National and international case studies (SDG-15)*
- *Future trends in sustainable land governance.*

**Linked COs: CO6** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**

1. *Steiner, F. R., The Living Landscape: An Ecological Approach to Landscape Planning, McGraw-Hill.*
2. *FAO, Guidelines for Land Use Planning, Food and Agriculture Organization.*
3. *Burrough, P. A. and McDonnell, R. A., Principles of Geographical Information Systems, Oxford University Press.*
4. *Lillesand, T. M., Kiefer, R. W., and Chipman, J. W., Remote Sensing and Image Interpretation, Wiley.*
5. *Reddy, M. A., Textbook of Remote Sensing and Geographic Information Systems, BS Publications.*

**Reference Books**

1. *Dent, D. and Dalal-Clayton, B., Sustainable Land Management.*
2. *FAO, Planning for Sustainable Use of Land Resources.*
3. *Longley, P. A., Goodchild, M. F., Maguire, D. J., and Rhind, D. W., Geographic Information Science and*

*Systems, Wiley.*
4. *Campbell, J. B. and Wynne, R. H., Introduction to Remote Sensing, Guilford Press.*
5. *United Nations, Transforming Our World: The 2030 Agenda for Sustainable Development.*
6. *ISRO–NRSC, Remote Sensing Applications Manuals.*

**Web links and Video Lectures (e-Resources)**

1. *United Nations – Sustainable Development Goals: https://sdgs.un.org/goals*
2. *UN SDG-15 (Life on Land): https://sdgs.un.org/goals/goal15*
3. *Food and Agriculture Organization (FAO): https://www.fao.org*
4. *UNCCD (United Nations Convention to Combat Desertification): https://www.unccd.int*
5. *ISRO: https://www.isro.gov.in*
6. *National Remote Sensing Centre (NRSC): https://www.nrsc.gov.in*
7. *Bhuvan Geoportal: https://bhuvan.nrsc.gov.in*
8. *Survey of India: https://www.surveyofindia.gov.in*

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| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Land Use/Land Capability Assessment:** *Conduct a land capability and land suitability assessment for a selected watershed or administrative area using soil, slope, land use, and climatic data. Prepare suitable land use recommendations using GIS techniques.* | *24* |

| | | |
|---|---|---|
| *2* | **Land Use/Land Cover Change Analysis:** *Prepare Land Use/Land Cover (LULC) maps of a selected area using satellite imagery (Sentinel/Landsat) for two different years. Analyze land use changes, urban expansion, agricultural land conversion, and their environmental impacts using GIS software.* | *24* |
| *3* | **Integrated Land Use Planning Project:** *Develop an integrated land use plan for a village, watershed, or urban fringe by considering agriculture, forestry, water resources, biodiversity conservation, infrastructure, and environmental sustainability. Apply GIS-based Multi-Criteria Decision Analysis (MCDA) for land allocation.* | *24* |
| *4* | **SDG-15 Assessment and Ecosystem Restoration Case Study:** *Prepare a case study on the implementation of SDG-15 (Life on Land) by assessing land degradation, biodiversity conservation, afforestation, wetland restoration, or ecosystem rehabilitation in a selected region. Present the findings using maps, geospatial analysis, and sustainability indicators.* | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | *Read selected PEC summary sections and prepare a reflective note.* | *24* |
| *2* | *Prepare a technical report highlighting strategies for land degradation neutrality and ecosystem restoration.* | *24* |
| *3* | *Complete a MOOC module on integrated land use planning, biodiversity conservation, watershed management, or climate-resilient land governance.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| SOIL HYDRAULICS & INFILTRATION MODELLING | | | |
|---|---|---|---|
| *Course Code* | **1MWL205B** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE only.* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Explain the principles of soil hydraulics, soil water movement, and infiltration processes in saturated and unsaturated soils.*
2. *CO2 (L3): Apply soil hydraulic properties and infiltration theories to estimate infiltration rates and soil water storage under different field conditions.*
3. *CO3 (L4): Analyze soil moisture dynamics, groundwater recharge, and surface runoff using infiltration models and hydraulic principles.*
4. *CO4 (L5): Evaluate different infiltration models, field measurement techniques, and numerical methods for soil water movement.*
5. *CO5 (L6): Develop soil water balance and infiltration models using computational and geospatial tools for sustainable land and water management.*
6. *CO6 (L5): Assess the applications of Remote Sensing, GIS, Artificial Intelligence, Machine Learning, and IoT for soil moisture monitoring and infiltration modelling*

**Module-1**

**Fundamentals of Soil Hydraulics**

- *Introduction to soil hydraulics, Soil formation and soil profile, Soil texture, structure and Soil physical properties*
- *Soil porosity and bulk density, Soil water: forms and occurrence, Soil water potential*
- *Soil moisture constants, Soil-water-plant relationship*
- *Saturated and unsaturated flow, Hydraulic head and hydraulic gradient*
- *Darcy's Law and Hydraulic conductivity*
- *Soil water retention characteristics*
- *Applications of soil hydraulics in water resources engineering*

**Linked COs: CO1** **Number of Hours: 8**

**Module-2**

**Infiltration Processes and Measurement Techniques:**

- *Introduction to infiltration, Factors affecting infiltration and Infiltration capacity*
- *Infiltration rate and Cumulative infiltration*
- *Soil moisture movement, Percolation process and Capillary action*
- *Double-ring infiltrometer, Automated infiltrometer, Rainfall simulator method and Tension infiltrometer*
- *Laboratory infiltration tests and Infiltration indices (φ-index and W-index)*
- *Groundwater recharge estimation*
- *Field applications of infiltration studies*

**Linked COs: CO2** **Number of Hours: 8 hrs**

**Module-3**

**Infiltration Modelling and Soil Water Dynamics :**

- *Concept of infiltration modelling, Horton infiltration model, Green-Ampt infiltration model*

- *Philip infiltration model, Kostiakov infiltration model and Modified Kostiakov model*
- *Richards equation, Soil water balance concept and Surface runoff generation*
- *Groundwater recharge modelling, Vadose zone hydrology and Preferential flow*
- *Macropore flow, Infiltration under different land uses and Climate change impacts on infiltration*
- *Case studies on infiltration modelling*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Numerical Modelling and Decision Support Systems**

- *Numerical methods for soil water movement and Finite Difference Method (FDM)*
- *Finite Element Method (FEM) and Soil water simulation models*
- *HYDRUS-1D and HYDRUS-2D/3D*
- *SWAP model, MIKE SHE and MODFLOW recharge estimation*
- *Calibration and validation of models and Sensitivity analysis, Decision Support Systems (DSS)*
- *Water balance modelling and Model uncertainty analysis. Applications in irrigation and watershed management*

**Linked COs: CO4, CO5** **Number of Hours: 9 hrs**

**Module-5**

**Geospatial Technologies and Smart Soil Water Management**

- *Remote Sensing for soil moisture estimation and GIS applications in infiltration mapping*
- *Digital Elevation Model (DEM) analysis and Land Use/Land Cover impact on infiltration*
- *Soil moisture mapping, Groundwater recharge zonation, Satellite-based soil moisture products (SMAP, Sentinel, Landsat)*
- *UAV applications in soil studies and Internet of Things (IoT) for soil moisture monitoring*
- *Wireless sensor networks and Artificial Intelligence in infiltration prediction*
- *Machine Learning models for soil hydraulic properties and Google Earth Engine applications*
- *Climate-smart soil water management*
- *Sustainable groundwater recharge planning*

**Linked COs: CO6** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**

1. *Hillel, D., Introduction to Environmental Soil Physics, Elsevier.*
2. *Hillel, D., Environmental Soil Physics, Academic Press.*
3. *Bear, J., Dynamics of Fluids in Porous Media, Dover Publications.*
4. *Michael, A. M., Irrigation: Theory and Practice, Vikas Publishing House.*
5. *Suresh, R., Soil and Water Conservation Engineering, Standard Publishers..*

**Reference Books**

1. *Philip, J. R., Theory of Infiltration.*
2. *Richards, L. A., Capillary Conduction of Liquids through Porous Medium.*
3. *Kirkham, D. and Powers, W. L., Advanced Soil Physics.*
4. *Freeze, R. A. and Cherry, J. A., Groundwater, Prentice Hall.*
5. *Dingman, S. L., Physical Hydrology, Waveland Press.*
6. *Jury, W. A. and Horton, R., Soil Physics, Wiley.*

**Web links and Video Lectures (e-Resources)**

1. *AO – Water Resources: https://www.fao.org*
2. *USDA Natural Resources Conservation Service (NRCS): https://www.nrcs.usda.gov*

3. *USGS Water Resources: https://www.usgs.gov*
4. *ISRO: https://www.isro.gov.in*
5. *National Remote Sensing Centre (NRSC): https://www.nrsc.gov.in*
6. *Bhuvan Geoportal: https://bhuvan.nrsc.gov.in*
7. *Google Earth Engine: https://earthengine.google.com*
8. *NASA SMAP Mission: https://smap.jpl.nasa.gov*

**Teaching-Learning Process (Innovative Delivery Methods):**

*The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):*

- *Flipped Classroom*
- *Problem-Based Learning (PBL)*
- *Case-Based Teaching*
- *Simulation and Virtual Labs*
- *Partial Delivery of course by Industry expert/ industrial visits*
- *ICT-Enabled Teaching.*
- *Role Play.*

**Assessment Structure (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]*

*A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

**Students' activities for TW/SL under NCrF: Samples only**

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Soil Hydraulic Properties Assessment:** *Conduct laboratory and field investigations to determine soil texture, bulk density, porosity, field capacity, permanent wilting point, hydraulic conductivity, and soil moisture characteristics. Analyze the influence of these properties on water movement in soils.* | *24* |
| *2* | **Infiltration Measurement and Analysis:** *Measure infiltration rates using a Double-Ring Infiltrometer or suitable field method. Analyze infiltration characteristics, estimate infiltration indices (φ-index and W-index), and compare results under different soil and land use conditions.* | *24* |
| *3* | **Infiltration Modelling Project:** *Develop infiltration models using Horton, Green-Ampt, Philip, or Kostiakov equations based on field or* | *24* |

| | | |
|---|---|---|
| | *laboratory data. Compare model performance and evaluate their suitability for groundwater recharge and runoff estimation.* | |
| *4* | **Soil Moisture Mapping and Groundwater Recharge Assessment:** *Prepare thematic maps of soil moisture, infiltration potential, groundwater recharge zones, or runoff potential using Remote Sensing, GIS, and Digital Elevation Models (DEM). Interpret the results for sustainable watershed and irrigation management.* | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | *Read selected PEC summary sections and prepare a reflective note.* | *24* |
| *2* | *Prepare a technical report Climate-smart soil water management.* | *24* |
| *3* | *Complete a MOOC module on Groundwater recharge estimation.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| WATERSHED ECONOMICS & BENEFIT-COST ANALYSIS | | | |
|---|---|---|---|
| *Course Code* | **1MWL205C** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE only.* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Explain the principles of watershed economics, environmental valuation, and economic aspects of watershed development projects.*
2. *CO2 (L3): Apply economic analysis techniques to estimate project costs, benefits, and financial feasibility of watershed management interventions.*
3. *CO3 (L4): Analyze economic indicators, water resource investments, and livelihood impacts for sustainable watershed planning.*
4. *CO4 (L5): Evaluate watershed development projects using benefit–cost analysis, cost-effectiveness analysis, and economic decision-making tools.*
5. *CO5 (L6): Develop economic models and investment plans for watershed development using financial, statistical, and geospatial tools.*
6. *CO6 (L5): Assess the role of geospatial technologies, Decision Support Systems (DSS), Artificial Intelligence (AI), and climate-resilient economic policies in watershed governance.*

**Module-1**

**Fundamentals of Watershed Economics**

- *Introduction to watershed economics and Principles of environmental and natural resource economics.*
- *Economic importance of watersheds, Watershed ecosystem services and Goods and services provided by watersheds.*
- *Sustainable development and green economy, Resource valuation concepts and Market and non-market valuation*
- *Public goods and common property resources, Externalities in watershed development and water as an economic resource.*
- *Socio-economic aspects of watershed management and livelihood and poverty alleviation through watershed development.*
- *Economic principles of sustainable resource management and National watershed development programmes and funding mechanisms*

**Linked COs: CO1** **Number of Hours: 8**

**Module-2**

**Cost Estimation and Economic Evaluation of Watershed Projects**

- *Introduction to cost estimation and economic evaluation, components of cost estimation.*
- *Economic evaluation and types of costs (Capital and operational costs)*
- *Direct and indirect costs and Tangible and intangible benefits*
- *Economic and financial analysis, Time value of money and discounting techniques*
- *Net Present Value (NPV), Benefit–Cost Ratio (BCR), Internal Rate of Return (IRR)*
- *Payback period and Cost-effectiveness analysis*
- *Break-even analysis and Risk and uncertainty analysis*
- *Project feasibility studies*

**Linked COs: CO2** **Number of Hours: 8 hrs**

**Module-3**

**Watershed Investment Planning and Socio-Economic Analysis**

- *Concept of infiltration modelling, Horton infiltration model, Green-Ampt infiltration model*
- *Philip infiltration model, Kostiakov infiltration model and Modified Kostiakov model*
- *Richards equation, Soil water balance concept and Surface runoff generation*
- *Groundwater recharge modelling, Vadose zone hydrology and Preferential flow*
- *Macropore flow, Infiltration under different land uses and Climate change impacts on infiltration*
- *Case studies on infiltration modelling*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Benefit–Cost Analysis and Decision Support Systems:**

- *Benefit–Cost Analysis (BCA): Concepts and principles and financial vs Economic Benefit–Cost Analysis*
- *Multi-Criteria Decision Analysis (MCDA),*
- *Types of Analysis Cost Utility Analysis, Cost Benefit Matrix, Sensitivity analysis, Scenario analysis and decision tree analysis*
- *Economic optimization techniques and Project appraisal methods*
- *Decision Support Systems (DSS) and Economic modelling*
- *Spreadsheet-based financial analysis and Watershed investment planning*
- *Preparation of Detailed Project Reports (DPRs)*
- *Case studies*

**Linked COs: CO4, CO5** **Number of Hours: 9 hrs**

**Module-5**

**Emerging Technologies and Sustainable Watershed Governance**

- *Remote Sensing and GIS in watershed economics and Spatial economic analysis*
- *Watershed asset mapping, Artificial Intelligence applications and Machine Learning for economic forecasting*
- *Big Data analytics and Internet of Things (IoT) in water management*
- *Digital dashboards and monitoring systems, Climate change economics and Green accounting*
- *Natural capital accounting, SDGs and watershed economics and National and international watershed policies.*
- *Case studies on successful watershed investments and Future trends in sustainable watershed governance*

**Linked COs: CO6** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**


1. *Kerr, J., Pangare, G., and Pangare, V. L., Watershed Development Projects in India: An Evaluation, International Food Policy Research Institute (IFPRI).*
2. *Dixon, J. A. and Hufschmidt, M. M., Economic Valuation Techniques for the Environment, Johns Hopkins University Press.*
3. *Gittinger, J. P., Economic Analysis of Agricultural Projects, World Bank Publications.*
4. *Dasgupta, P., Economics of the Environment, Oxford University Press.*
5. *Hanley, N., Shogren, J. F., and White, B., Environmental Economics in Theory and Practice, Palgrave Macmillan.*


**Reference Books**


1. *Boardman, A. E., Greenberg, D. H., Vining, A. R., and Weimer, D. L., Cost–Benefit Analysis: Concepts and Practice, Cambridge University Press.*
2. *Mishan, E. J. and Quah, E., Cost–Benefit Analysis, Routledge.*
3. *Pearce, D., Turner, R. K., and Bateman, I., Environmental Economics, Harvester Wheatsheaf.*
4. *FAO, Watershed Management Field Manual.*
5. *World Bank, Economic Analysis of Investment Operations.*

6. *Planning Commission (NITI Aayog), Guidelines for Watershed Development Projects.*

**Web links and Video Lectures (e-Resources)**

1. *NITI Aayog: https://www.niti.gov.in*
2. *Department of Land Resources (DoLR): https://dolr.gov.in*
3. *Ministry of Jal Shakti: https://jalshakti-dowr.gov.in*
4. *Food and Agriculture Organization (FAO): https://www.fao.org*
5. *World Bank: https://www.worldbank.org*
6. *International Water Management Institute (IWMI): https://www.iwmi.cgiar.org*
7. *ISRO Bhuvan: https://bhuvan.nrsc.gov.in*
8. *Google Earth Engine: https://earthengine.google.com*

**Teaching-Learning Process (Innovative Delivery Methods):**

*The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):*

- *Flipped Classroom*
- *Problem-Based Learning (PBL)*
- *Case-Based Teaching*
- *Simulation and Virtual Labs*
- *Partial Delivery of course by Industry expert/ industrial visits*
- *ICT-Enabled Teaching.*
- *Role Play.*

**Assessment Structure (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]*

*A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

**Students' activities for TW/SL under NCrF: Samples only**

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Economic Assessment of a Watershed Project:** *Conduct an economic assessment of a selected watershed development project by estimating capital costs, operation and maintenance costs, direct and indirect benefits, and socio-economic impacts.* | *24* |
| *2* | **Benefit–Cost Analysis of Soil and Water Conservation Measures:** *Perform a Benefit–Cost Analysis (BCA) for selected watershed interventions such as check dams, farm ponds, contour bunds, percolation tanks, or afforestation* | *24* |

| | | |
|---|---|---|
| | *using economic indicators like NPV, BCR, IRR, and Payback Period.* | |
| *3* | **Watershed Investment Planning Project:** *Prepare an investment plan for a watershed development programme by prioritizing interventions based on technical, economic, environmental, and social criteria using GIS-based Multi-Criteria Decision Analysis (MCDA) or spreadsheet tools.* | *24* |
| *4* | **Socio-Economic Impact Assessment and Geospatial Analysis:** *Conduct a case study on a watershed development programme to evaluate improvements in agricultural productivity, groundwater recharge, livelihoods, and ecosystem services. Present findings using statistical analysis, thematic maps, and geospatial visualization.* | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | *Read selected PEC summary sections and prepare a reflective note.* | *24* |
| *2* | *Prepare a technical report Prepare an investment plan for a watershed development programme based on technical, economic, environmental, and social.* | *24* |
| *3* | *Complete a MOOC module on economic assessment of a selected watershed development project.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| WATER–ENERGY–FOOD NEXUS | | | |
|---|---|---|---|
| *Course Code* | **1MWL205D** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE only.* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Explain the concepts, principles, and interrelationships of the Water–Energy–Food (WEF) Nexus and its role in sustainable development.*
2. *CO2 (L4): Analyze water, energy, and food resource interactions using resource assessment and nexus approaches for sustainable planning.*
3. *CO3 (L3): Apply integrated resource management techniques to improve water, energy, and food security under changing climatic conditions.*
4. *CO4 (L5): Evaluate policies, governance frameworks, and decision-support systems for sustainable Water–Energy–Food Nexus management.*
5. *CO5 (L6): Develop integrated Water–Energy–Food Nexus models using geospatial technologies, simulation tools, and optimization techniques.*
6. *CO6 (L5): Assess emerging technologies such as Remote Sensing, GIS, Artificial Intelligence to achieve the Sustainable Development Goals (SDGs.*

**Module-1**

**Fundamentals of Water–Energy–Food Nexus**

- *Introduction to the Water–Energy–Food (WEF) Nexus and Evolution and importance of the Nexus approach.*
- *Components of the WEF Nexus, Interdependence of water, energy, and food systems*
- *Global water, energy, and food challenges and Population growth and resource demand*
- *WEF Nexus and Climate change impacts on water, energy, and food.*
- *Principles of integrated resource management and Nexus thinking and systems approach*
- *Resource efficiency and circular economy and Environmental sustainability*
- *Ecosystem services and WEF Nexus indicators*
- *National and Global case studies*

**Linked COs: CO1** **Number of Hours: 8**

**Module-2**

**Water, Energy, and Food Resource Assessment**

- *Water resource assessment, Surface water and groundwater resources and Agricultural water demand*
- *Urban and industrial water demand, Energy resources (renewable and non-renewable)*
- *Energy use in agriculture and Energy efficiency in irrigation systems*
- *Food production systems and Crop water productivity*
- *Water footprint, Energy footprint and Carbon footprint*
- *Life Cycle Assessment (LCA) and Resource accounting*
- *Nexus indicators and sustainability assessment*

**Linked COs: CO2** **Number of Hours: 8 hrs**

**Module-3**

**Integrated Management of Water–Energy–Food Systems**

- *Concept of Integrated Water Resources Management (IWRM) and Sustainable agricultural water management.*

- *Types of irrigation system and Precision irrigation systems.*
- *Renewable energy in agriculture and Solar-powered irrigation systems*
- *Bioenergy and biomass utilization, Wastewater reuse in agriculture and Rainwater harvesting*
- *Groundwater recharge, Climate-smart agriculture and Circular economy approaches*
- *Resource conservation technologies and Risk and resilience assessment*
- *What are different role of community participation and Case stxudies on integrated WEF management*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Governance, Policy and Decision Support Systems**

- *Governance principles in the WEF Nexus and Water governance frameworks*
- *Different types of policies like Energy policies, Food security policies, National Water Policy and National Energy Policy*
- *National Food Security Mission, Integrated policy approaches and Multi-Criteria Decision Analysis (MCDA).*
- *Decision Support Systems (DSS) and Resource optimization techniques*
- *Scenario analysis and System dynamics modelling*
- *Stakeholder engagement and WEF Nexus planning and management*

**Linked COs: CO4, CO5** **Number of Hours: 9 hrs**

**Module-5**

**Emerging Technologies and Future Perspectives**

- *Desalination process for sustainable prospective.*
- *Remote Sensing concept and its applications in WEF management, GIS for resource mapping and Digital Elevation Models (DEM)*
- *Internet of Things (IoT) for smart agriculture and Smart water management systems*
- *Artificial Intelligence applications and Machine Learning for resource prediction*
- *Digital Twin technology, Big Data Analytics and Cloud computing for resource management*
- *Google Earth Engine applications, Precision agriculture and Climate adaptation strategies*
- *Sustainable cities and resilient communities*
- *Future trends in Water–Energy–Food Nexus*

**Linked COs: CO6** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**

1. *Hoff, H., Understanding the Nexus: Background Paper for the Bonn 2011 Nexus Conference, Stockholm Environment Institute.*
2. *Bazilian, M., et al., Considering the Energy, Water and Food Nexus, Current Opinion in Environmental Sustainability.*
3. *Ringler, C., Bhaduri, A., and Lawford, R., The Nexus Across Water, Energy, Land and Food (WELF): Potential for Improved Resource Use Efficiency?, Current Opinion in Environmental Sustainability.*
4. *Michael, A. M., Irrigation: Theory and Practice, Vikas Publishing House.*
5. *Pereira, L. S., Cordery, I., and Iacovides, I., Improved Indicators of Water Use Performance and Productivity, Springer.*

**Reference Books**

1. *FAO, The Water–Energy–Food Nexus – A New Approach in Support of Food Security and Sustainable Agriculture.*
2. *International Water Management Institute (IWMI), Water-Energy-Food Nexus Reports.*
3. *United Nations, Transforming Our World: The 2030 Agenda for Sustainable Development.*
4. *UNESCO, World Water Development Report.*
5. *World Bank, High and Dry: Climate Change, Water, and the Economy.*

6. *IPCC Assessment Reports (Latest Edition).*

**Web links and Video Lectures (e-Resources)**

1. *Food and Agriculture Organization (FAO): https://www.fao.org*
2. *International Water Management Institute (IWMI): https://www.iwmi.cgiar.org*
3. *United Nations Sustainable Development Goals: https://sdgs.un.org*
4. *UNESCO World Water Assessment Programme: https://www.unesco.org*
5. *International Energy Agency (IEA): https://www.iea.org*
6. *World Bank – Water Resources: https://www.worldbank.org*
7. *ISRO: https://www.isro.gov.in*
8. *Bhuvan Geoportal: https://bhuvan.nrsc.gov.in*

**Teaching-Learning Process (Innovative Delivery Methods):**

*The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):*

- *Flipped Classroom*
- *Problem-Based Learning (PBL)*
- *Case-Based Teaching*
- *Simulation and Virtual Labs*
- *Partial Delivery of course by Industry expert/ industrial visits*
- *ICT-Enabled Teaching.*
- *Role Play.*

**Assessment Structure (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]*

*A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

**Students' activities for TW/SL under NCrF: Samples only**

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Water–Energy–Food Resource Assessment:** *Conduct an assessment of water, energy, and food resources for a selected watershed, village, or district. Analyze the interdependencies among the three sectors and identify key sustainability challenges using available data and resource indicators.* | *24* |
| *2* | **Water and Energy Audit in Agriculture:** *Perform a water and energy audit for a selected irrigation system or agricultural farm by estimating irrigation water use, pumping energy consumption, water-use efficiency, and energy efficiency. Recommend suitable resource conservation measures.* | *12* |

| | | |
|---|---|---|
| *3* | **Integrated Water–Energy–Food Nexus Planning Project:** *Develop an integrated WEF Nexus management plan for a selected study area by incorporating water conservation, renewable energy, sustainable agriculture, and climate-resilient practices. Apply GIS-based Multi-Criteria Decision Analysis (MCDA) or simulation tools for resource optimization.* | *24* |
| *4* | **WEF Nexus Case Study and Geospatial Analysis:** *Prepare a case study on the implementation of Water–Energy–Food Nexus principles in a watershed, irrigation command area, smart agriculture project, or rural development programme. Present the findings using statistical analysis, thematic maps, and geospatial visualization.* | *24* |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | *Read selected PEC summary sections and prepare a reflective note.* | *24* |
| *2* | *Prepare a technical report Prepare an estimating irrigation water use, pumping energy consumption, water-use efficiency, and energy efficiency.* | *24* |
| *3* | *Complete a MOOC module on Sustainable Natural Resources* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| GEOMORPHOLOGY AND TERRAIN ANALYSIS | | | |
|---|---|---|---|
| *Course Code* | **1MCWL206A** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE only.* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Explain the principles of geomorphology, geomorphic processes, landform evolution, and terrain characteristics.*
2. *CO2 (L4): Analyze geomorphic features, drainage systems, and terrain attributes using geospatial techniques.*
3. *CO3 (L3): Apply terrain analysis methods for watershed management, land capability assessment, natural hazard mapping, and engineering site investigations*
4. *CO4 (L5): Evaluate geomorphological processes, erosion, sediment transport, slope instability, and landscape evolution for sustainable land management.*
5. *CO5 (L6): Develop terrain models and geomorphological maps using GIS, Remote Sensing, DEMs, and spatial analysis techniques..*
6. *CO6 (L5): Assess the applications of Artificial Intelligence (AI), Machine Learning (ML), UAVs, LiDAR, and Geospatial technologies.*

**Module-1**

**Fundamentals of Geomorphology**

- *Introduction to Geomorphology , scope and significance of Geomorphology*
- *Earth structure and tectonic processes and Endogenic and exogenic geomorphic processes*
- *Weathering: Physical, chemical, and biological, Mass wasting and slope processes*
- *Fluvial geomorphology, Aeolian geomorphology and Glacial geomorphology*
- *Coastal geomorphology, Karst geomorphology and Structural landforms*
- *Landform evolution theories and Geomorphic cycles*
- *Applications of geomorphology in engineering and environmental studies*

**Linked COs: CO1** **Number of Hours: 8**

**Module-2**

**Terrain Analysis and Geospatial Data**

- *Concept of Terrain analysis and terrain analysis uses. Topographic maps and contour interpretation*
- *Types of models like Digital Elevation Models (DEMs), Digital Terrain Models (DTMs) and Digital Surface Models (DSMs)*
- *Terrain parameters, Slope analysis, Aspect analysis and Curvature analysis*
- *Hillshade and relief mapping, Drainage network extraction and Watershed delineation*
- *Morphometric analysis and Geospatial data sources (LiDAR, UAV, Satellite imagery)*
- *Different Terrain visualization techniques.*

**Linked COs: CO2** **Number of Hours: 8 hrs**

**Module-3**

**Geomorphological Mapping and Applications**

- *Geomorphological mapping principles and Landform classification*
- *Geological and geomorphological mapping and its Soil–landform relationship*
- *River basin analysis and Watershed characterization*
- *Land capability assessment, Groundwater potential mapping and Floodplain mapping*

- *Landslide susceptibility mapping, Soil erosion assessment and Land degradation mapping*
- *Environmental Impact Assessment (EIA) and Engineering geological investigations*
- *Case studies in terrain analysis*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Geomorphic Processes, Hazards and Modelling**

- *River morphology and channel dynamics, Sediment transport processes and River erosion and deposition*
- *Coastal erosion and its types and Desertification*
- *Landscape evolution modelling, Slope stability analysis and Landslide mechanisms*
- *Rockfall and debris flow, Flood hazard assessment and Geomorphic hazard zonation*
- *Terrain suitability analysis, Multi-Criteria Decision Analysis (MCDA) and Geomorphic modelling using GIS.*
- *Sustainable terrain management.*

**Linked COs: CO4, CO5** **Number of Hours: 9 hrs**

**Module-5**

**Advanced Geospatial Technologies in Terrain Analysis**

- *Concept of Remote Sensing and different applications in Geomorphology*
- *GIS-based terrain analysis, LiDAR applications and UAV/Drone-based terrain mapping InSAR applications*
- *Google Earth Engine, Artificial Intelligence in terrain classification and Machine Learning for landform mapping*
- *Deep Learning for geomorphic feature extraction , Cloud GIS and Digital Twin concepts*
- *Big Data analytics in geomorphology and Climate change and landscape evolution*
- *Smart terrain monitoring systems and Future trends in geomorphological investigations*

**Linked COs: CO6** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**


1. *Bloom, A. L., Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, Prentice Hall.*
2. *Summerfield, M. A., Global Geomorphology, Pearson Education.*
3. *Thornbury, W. D., Principles of Geomorphology, Wiley.*
4. *Verstappen, H. T., Applied Geomorphology, Elsevier.*
5. *Reddy, M. A., Remote Sensing and Geographic Information Systems, BS Publications.*


**Reference Books**


1. *Huggett, R. J., Fundamentals of Geomorphology, Routledge.*
2. *Knighton, D., Fluvial Forms and Processes, Arnold Publishers.*
3. *Selby, M. J., Hillslope Materials and Processes, Oxford University Press.*
4. *Lillesand, T. M., Kiefer, R. W., and Chipman, J. W., Remote Sensing and Image Interpretation, Wiley.*
5. *Burrough, P. A. and McDonnell, R. A., Principles of Geographical Information Systems, Oxford University Press.*
6. *Chow, V. T., Maidment, D. R., and Mays, L. W., Applied Hydrology, McGraw-Hill.*
7. *ISRO–NRSC, Remote Sensing Applications Manuals.*


**Web links and Video Lectures (e-Resources)**

1. *ISRO: https://www.isro.gov.in*
2. *National Remote Sensing Centre (NRSC): https://www.nrsc.gov.in*
3. *Bhuvan Geoportal: https://bhuvan.nrsc.gov.in*
4. *Survey of India: https://www.surveyofindia.gov.in*
5. *USGS Earth Explorer: https://earthexplorer.usgs.gov*
6. *NASA Earth Observatory: https://earthobservatory.nasa.gov*
7. *Google Earth Engine: https://earthengine.google.com*
8. *OpenTopography: https://opentopography.org*

9. *Copernicus Data Space Ecosystem: https://dataspace.copernicus.eu*

**Teaching-Learning Process (Innovative Delivery Methods):**

*The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):*

- *Flipped Classroom*
- *Problem-Based Learning (PBL)*
- *Case-Based Teaching*
- *Simulation and Virtual Labs*
- *Partial Delivery of course by Industry expert/ industrial visits*
- *ICT-Enabled Teaching.*
- *Role Play.*

**Assessment Structure (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]*

*A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

**Students' activities for TW/SL under NCrF: Samples only**

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Terrain Analysis and Morphometric Assessment:** *Delineate a watershed using Digital Elevation Model (DEM) or Survey of India Topographic Maps. Generate terrain attributes such as slope, aspect, contour, hillshade, drainage network, relief, and morphometric parameters using GIS software.* | *24* |
| *2* | **Geomorphological Mapping Project:** *Prepare a geomorphological map of a selected study area using satellite imagery, DEM, geological maps, and field observations. Identify major landforms, geomorphic processes, and terrain characteristics influencing engineering and environmental planning.* | *24* |
| *3* | **Natural Hazard and Terrain Suitability Analysis:** *Develop landslide susceptibility, soil erosion, flood hazard, or terrain suitability maps using GIS-based Multi-Criteria Decision Analysis (MCDA). Evaluate the influence of slope, geology, land use, rainfall, and drainage on terrain stability.* | *24* |
| *4* | **Geomorphology Case Study and Geospatial Analysis:** *Conduct a case study on river basin evolution, watershed geomorphology, land degradation, coastal erosion, or terrain change using Remote Sensing, GIS,* | *12* |

| | | |
|---|---|---|
| | *UAV, or LiDAR data. Present the findings using thematic maps, statistical analysis, and geospatial visualization.* | |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | *Read selected PEC summary sections and prepare a reflective note.* | *24* |
| *2* | *Prepare a technical report on the application of Digital Elevation Models (DEM), Remote Sensing, GIS, LiDAR, UAVs, or Artificial Intelligence in geomorphological mapping, terrain analysis,* | *24* |
| *3* | *Complete a MOOC module on Geomorphology, Terrain Analysis, Remote Sensing, GIS, Engineering Geology, Hydrology, or Natural Hazard Assessment (NPTEL/SWAYAM/ISRO-IIRS) and submit a learning report highlighting practical applications.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
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| AGRI GIS AND SMART FARMING TECHNOLOGIES | | | |
|---|---|---|---|
| *Course Code* | **1MCWL206B** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE only.* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Explain the principles of Geographic Information Systems (GIS), Remote Sensing, GPS, and smart farming technologies for modern agriculture.*
2. *CO2 (L4): Analyze spatial and temporal agricultural data using GIS, Remote Sensing, and Global Navigation Satellite Systems (GNSS) for crop and resource management.*
3. *CO3 (L3): Apply geospatial technologies for crop monitoring, soil mapping, irrigation planning, precision agriculture, and agricultural decision-making.*
4. *CO4 (L5): Evaluate precision farming techniques, sensor-based technologies, crop health assessment, and smart irrigation systems for sustainable agriculture.*
5. *CO5 (L6): Develop GIS-based agricultural databases, thematic maps, and precision farming models using geospatial and decision support tools*
6. *CO6 (L5): Assess the applications of Artificial Intelligence (AI), Machine Learning (ML), Internet of Things (IoT), UAVs, cloud computing, and digital agriculture technologies in smart farming systems.*

**Module-1**

**Fundamentals of Agri-GIS and Smart Farming**

- *Introduction to Agri-GIS and Smart Farming and Evolution of precision agriculture*
- *Principles of Geographic Information Systems (GIS)*
- *Components of GIS and Types of data like Spatial and attribute data*
- *Remote Sensing principles and Electromagnetic spectrum and satellite sensors*
- *GPS and GNSS technologies and different Coordinate systems and map projections*
- *Agricultural information systems*
- *Digital agriculture concepts and Precision farming principles*
- *Smart farming technologies, Sustainable agriculture and SDGs and different applications of GIS in agriculture*

**Linked COs: CO1** **Number of Hours: 8**

**Module-2**

**Spatial Data Acquisition and Agricultural Mapping**

- *Types and source of data acquisition and sources of agricultural spatial data*
- *Satellite imagery (Landsat, Sentinel) and Drone/UAV data acquisition*
- *Soil survey and soil mapping, Land Use/Land Cover (LULC) mapping and Crop acreage estimation*
- *Crop classification techniques, Digital Elevation Models (DEM) and Terrain analysis for agriculture*
- *Vegetation indices (NDVI, SAVI, EVI), Crop health monitoring and Soil moisture mapping*
- *Spatial database development and Geospatial data integration*
- *Various Thematic map preparation for different crop analysis with season wise data analysis.*

**Linked COs: CO2** **Number of Hours: 8 hrs**

**Module-3**

**Precision Agriculture and Smart Farming Applications**

- *Concept of Precision agriculture and Site-specific crop management*
- *Variable Rate Technology (VRT), Precision irrigation and smart fertigation systems*

- *Crop water requirement mapping, Soil fertility mapping and also Yield monitoring*
- *Crop growth monitoring, Pest and disease mapping and Precision nutrient management*
- *Agricultural decision support systems and Farm management information systems*
- *Climate-smart agriculture and Case studies in precision farming.*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Sensor Technologies and Decision Support Systems**

- *Fundamentals of sensors, type of sensors for Agricultural, smart devices and Soil moisture sensors and weather stations*
- *IoT applications in agriculture, Wireless sensor networks and different smart irrigation systems*
- *Artificial Intelligence in agriculture and Machine Learning for crop prediction*
- *Deep Learning for crop disease detection and Big Data analytics*
- *Cloud-based farm management, Decision Support Systems (DSS)*
- *Agricultural resource optimization, Precision farm planning and Smart agriculture case studies*

**Linked COs: CO4, CO5** **Number of Hours: 9 hrs**

**Module-5**

**Emerging Technologies in Digital Agriculture**

- *UAV and drone applications and Drone-based crop monitoring and LiDAR applications in agriculture.*
- *Google Earth Engine, Digital Twin technology and automation in agriculture*
- *Autonomous farm machinery, Blockchain in agriculture and Smart supply chain management*
- *Carbon farming and Climate resilience and adaptation*
- *Sustainable agricultural resource management and agricultural policy and digital governance*
- *Future trends in smart farming.*
- *National and international case studies.*

**Linked COs: CO6** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**

1. *Zhang, Q., Precision Agriculture Technology for Crop Farming, CRC Press.*
2. *Robert, P. C., Rust, R. H., and Larson, W. E., Precision Agriculture, ASA-CSSA-SSSA.*
3. *Lillesand, T. M., Kiefer, R. W., and Chipman, J. W., Remote Sensing and Image Interpretation, Wiley.*
4. *Kang-tsung Chang, Introduction to Geographic Information Systems, McGraw-Hill.*
5. *M. A. Reddy, Remote Sensing and Geographic Information Systems, BS Publications.*

**Reference Books**

1. *Pierce, F. J. and Nowak, P., Aspects of Precision Agriculture, Advances in Agronomy.*
2. *Burrough, P. A. and McDonnell, R. A., Principles of Geographical Information Systems, Oxford University Press.*
3. *Jensen, J. R., Remote Sensing of the Environment, Pearson.*
4. *FAO, Precision Agriculture for Smallholder Farmers.*
5. *ICAR, Precision Farming and Digital Agriculture Manuals.*
6. *ISRO–NRSC, Remote Sensing Applications in Agriculture.*

**Web links and Video Lectures (e-Resources)**

1. *Indian Council of Agricultural Research (ICAR): https://icar.org.in*
2. *ISRO: https://www.isro.gov.in*
3. *National Remote Sensing Centre (NRSC): https://www.nrsc.gov.in*
4. *Bhuvan Geoportal: https://bhuvan.nrsc.gov.in*
5. *Google Earth Engine: https://earthengine.google.com*
6. *USGS Earth Explorer: https://earthexplorer.usgs.gov*
7. *Copernicus Data Space Ecosystem: https://dataspace.copernicus.eu*
8. *Food and Agriculture Organization (FAO): https://www.fao.org*

**Teaching-Learning Process (Innovative Delivery Methods):**

*The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):*

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- *ICT-Enabled Teaching.*
- *Role Play.*

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*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]*

*A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

**Students' activities for TW/SL under NCrF: Samples only**

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Crop Mapping and Agricultural Resource Assessment***: Prepare Land Use/Land Cover (LULC), crop acreage, soil, and vegetation maps of a selected agricultural area using Sentinel/Landsat satellite imagery and GIS software. Analyze crop distribution, land suitability, and agricultural resource availability.* | *24* |
| *2* | **Precision Agriculture and Smart Irrigation Analysis***: Develop thematic maps for soil moisture, crop health (NDVI), irrigation suitability, evapotranspiration, or drought severity using Remote Sensing and GIS. Evaluate precision irrigation practices for improving water-use efficiency.* | *24* |
| *3* | **Smart Farming Technology Project:** *Design a smart farming system for a selected farm by integrating GIS, GPS, UAVs, IoT sensors, Artificial Intelligence (AI), and Decision Support Systems (DSS) for crop monitoring, precision nutrient management, irrigation scheduling, and yield prediction..* | *24* |
| *4* | **Agri-GIS Case Study and Geospatial Analysis:** *Conduct a case study on the application of Remote Sensing, GIS, GPS, UAVs, AI, or Machine Learning in precision agriculture, crop monitoring, soil fertility assessment, climate-smart agriculture, or digital farming. Present the findings using thematic maps, statistical analysis, and geospatial visualization.* | *24* |

| SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc. | | |
|---|---|---|
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | *Read selected chapters from ICAR, FAO, ISRO, or Precision Agriculture manuals and prepare a reflective note on the role of GIS, Remote Sensing, and smart farming technologies in sustainable agriculture.* | *24* |
| *2* | *Prepare a technical report on the application of GIS, Remote Sensing, UAVs, IoT, Artificial Intelligence, Machine Learning, or Google Earth Engine in crop monitoring, precision farming, irrigation management, soil fertility assessment, or agricultural resource management.* | *24* |
| *3* | *Complete a MOOC module on Precision Agriculture, Remote Sensing, GIS, Smart Farming, Digital Agriculture, Artificial Intelligence, or Internet of Things (IoT) (NPTEL/SWAYAM/ISRO-IIRS/FAO).* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| PARTICIPATORY IRRIGATION MANAGEMENT | | | |
|---|---|---|---|
| *Course Code* | **1MCWL206C** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE only.* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Explain the principles, objectives, and institutional framework of Participatory Irrigation Management (PIM) and Water Users' Associations (WUAs).*
2. *CO2 (L4): Analyze irrigation systems, water distribution practices, and stakeholder participation in irrigation management..*
3. *CO3 (L3): Apply participatory approaches for irrigation scheduling, operation and maintenance, conflict resolution, and water allocation.*
4. *CO4 (L5): Evaluate the performance of irrigation projects, WUAs, and participatory management strategies using technical, economic, and social indicators.*
5. *CO5 (L6): Develop participatory irrigation management plans integrating water budgeting, irrigation efficiency, and decision-support tools.*
6. *CO6 (L5): Assess the applications of GIS, Remote Sensing, IoT, Artificial Intelligence, and digital platforms in modern participatory irrigation management and governance.*

**Module-1**

**Fundamentals of Participatory Irrigation Management**

- *Introduction to irrigation management and Evolution of Participatory Irrigation Management (PIM).*
- *Concept, objectives, and principles of PIM and Irrigation management transfer*
- *Water Users' Associations (WUAs) and organizational structure of WUAs*
- *Roles and responsibilities of stakeholders, Legal and institutional framework and PIM policies in India*
- *Irrigation governance, Community participation and Gender and social inclusion*
- *Capacity building and training, Benefits and challenges of PIM*
- *National and international case studies*

**Linked COs: CO1** **Number of Hours: 8**

**Module-2**

**Irrigation Systems and Water Distribution**

- *Different types of irrigation systems, Canal irrigation systems, Tank irrigation systems and Groundwater irrigation*
- *Command area development and Irrigation scheduling principles*
- *Different water allocation methods and Rotational water distribution (Warabandi)*
- *Canal operation and regulation, water measurement techniques and conveyance, distribution, and application losses*
- *Irrigation efficiencies and maintenance of irrigation infrastructure*
- *Stakeholder analysis in irrigation systems and Performance indicators of irrigation systems.*

**Linked COs: CO2** **Number of Hours: 8 hrs**

**Module-3**

**Participatory Approaches in Irrigation Management**

- *Participatory Rural Appraisal (PRA) Social mobilization and Formation and strengthening of WUAs.*
- *Participatory irrigation scheduling, Water budgeting and equitable water distribution.*
- *Operation and maintenance planning, conflict management and resolution and financial management of*

*WUAs.*

- *Cost recovery and water charges and farmer participation in decision making*
- *Participatory monitoring and climate-resilient irrigation practices*
- *Conjunctive use of water resources and successful PIM models*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Irrigation Performance Evaluation and Planning**

- *Irrigation performance assessment, Technical performance indicators and economic performance indicators*
- *Social performance indicators, Environmental performance indicators and benchmarking of irrigation systems*
- *Water productivity assessment, Irrigation auditing and Participatory evaluation techniques*
- *Decision Support Systems (DSS), Multi-Criteria Decision Analysis (MCDA)*
- *Irrigation modernization, Preparation of PIM plans and risk and resilience assessment*
- *Sustainable irrigation management planning*

**Linked COs: CO4, CO5** **Number of Hours: 9 hrs**

**Module-5**

**Geospatial and Smart Technologies in PIM**

- *Remote Sensing for irrigation monitoring and GIS applications in command area management*
- *GPS and GNSS in irrigation surveys, Digital Elevation Models (DEM) and Crop water requirement mapping.*
- *Soil moisture mapping, Irrigation suitability analysis and UAV and drone applications*
- *Internet of Things (IoT) for irrigation.*
- *Smart irrigation systems, Artificial Intelligence and Machine Learning*
- *Mobile and web-based irrigation platforms and Digital water governance*
- *Climate-smart irrigation management*
- *Future trends in participatory irrigation management.*

**Linked COs: CO6** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**

1. *Michael, A. M., Irrigation: Theory and Practice, Vikas Publishing House.*
2. *Chambers, R., Managing Canal Irrigation, Oxford & IBH.*
3. *FAO, Participatory Irrigation Management Training Manuals.*
4. *Suresh, R., Soil and Water Conservation Engineering, Standard Publishers.*

**Reference Books**

1. *Vermillion, D. L., Irrigation Management Transfer.*
2. *Groenfeldt, D., Participatory Irrigation Management.*
3. *IWMI, Participatory Irrigation Management Guidelines.*
4. *Pereira, L. S., Cordery, I., and Iacovides, I., Coping with Water Scarcity, Springer.*
5. *Chow, V. T., Maidment, D. R., and Mays, L. W., Applied Hydrology, McGraw-Hill.*

**Web links and Video Lectures (e-Resources)**

1. *Food and Agriculture Organization (FAO): https://www.fao.org*
2. *International Water Management Institute (IWMI): https://www.iwmi.cgiar.org*
3. *Central Water Commission (CWC): https://cwc.gov.in*
4. *Ministry of Jal Shakti: https://jalshakti-dowr.gov.in*
5. *ICID – International Commission on Irrigation and Drainage: https://www.icid.org*
6. *ISRO: https://www.isro.gov.in*
7. *Bhuvan Geoportal: https://bhuvan.nrsc.gov.in*
8. *Google Earth Engine: https://earthengine.google.com*

9. *USGS Earth Explorer:*

**Teaching-Learning Process (Innovative Delivery Methods):**

*The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):*

- *Flipped Classroom*
- *Problem-Based Learning (PBL)*
- *Case-Based Teaching*
- *Simulation and Virtual Labs*
- *Partial Delivery of course by Industry expert/ industrial visits*
- *ICT-Enabled Teaching.*
- *Role Play.*

**Assessment Structure (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]*

*A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

**Students' activities for TW/SL under NCrF: Samples only**

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Water Users' Association (WUA) Assessment:** *Conduct a field study of a Water Users' Association (WUA) in a selected irrigation command area. Assess its organizational structure, water allocation practices, operation and maintenance activities, financial management, stakeholder participation, and institutional challenges. Prepare recommendations for improving participatory irrigation management.* | *12* |
| *2* | **Irrigation System Performance and Water Distribution Analysis:** *Evaluate the performance of a canal, tank, or lift irrigation system by estimating conveyance efficiency, distribution efficiency, application efficiency, water productivity, and irrigation scheduling. Suggest suitable measures for improving water-use efficiency.* | *12* |
| *3* | **Participatory Irrigation Management Planning Project:** *Develop a Participatory Irrigation Management (PIM) plan for a selected irrigation command area by integrating water budgeting, irrigation scheduling, Water Users' Associations (WUAs), conflict resolution strategies, and GIS-based Decision Support Systems (DSS) for equitable water distribution.* | *12* |
| *4* | **Participatory Irrigation Management Case Study and Geospatial** | *12* |

| | | |
|---|---|---|
| | **Analysis:** *Conduct a case study on the implementation of Participatory Irrigation Management in a canal command area, watershed, or irrigation project. Analyze institutional performance, socio-economic benefits, irrigation efficiency and groundwater recharge.* | |
| **SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.** | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| *1* | *Read selected chapters from FAO, ICID, CWC, Ministry of Jal Shakti, or Water Users' Association (WUA) manuals and prepare a reflective note on the role of community participation in sustainable irrigation management and water governance.* | |
| *2* | *Prepare a technical report on the application of GIS, Remote Sensing, IoT, Artificial Intelligence (AI), Decision Support Systems (DSS), or Smart Irrigation Technologies in irrigation scheduling, canal operation.* | |
| *3* | *Complete a MOOC module on Participatory Irrigation Management, Irrigation Engineering, Water Resources Management, Remote Sensing and GIS, Smart Irrigation, Water Governance, or Sustainable Agriculture (NPTEL/SWAYAM/ISRO-IIRS/FAO/IWMI)* | |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| SOIL CARBON & CLIMATE ADAPTATION | | | |
|---|---|---|---|
| *Course Code* | **1MCWL206D** | *Scheme* | *2026* |
| *Type of Course* | **Professional Elective Course** | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *42(3:0:0)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL* | *90 (42:0:0:48)* | *SEE Marks* | *50* |
| *Credits* | *3* | *Total Marks* | *100* |
| *Type of Examination (IPCC):* | *Theory- CIE +SEE only.* | *Exam Hours* | *03* |

**Course outcome (Course Skill Set):**

*At the end of the course, the student will be able to:*

1. *CO1 (L2): Explain the concepts of soil carbon, carbon cycling, climate change, and their significance in sustainable land management.*
2. *CO2 (L4): Analyze soil carbon dynamics, greenhouse gas emissions, and the influence of land use and agricultural practices on soil carbon sequestration.*
3. *CO3 (L3): Apply soil carbon assessment methods and climate-smart agricultural practices for improving soil health and climate resilience.*
4. *CO4 (L5): Evaluate carbon sequestration strategies, ecosystem restoration approaches, and climate adaptation measures for sustainable land and water management.*
5. *CO5 (L6): Develop soil carbon management plans using geospatial technologies, carbon accounting methods, and decision-support tools.*
6. *CO6 (L5): Assess the applications of Remote Sensing, GIS, Artificial Intelligence (AI), Machine Learning (ML), IoT, and carbon modelling tools for monitoring soil carbon and climate adaptation.*

## Module-1

**Fundamentals of Soil Carbon and Climate Change**

- *Introduction to soil carbon, Global carbon cycle and Soil organic carbon (SOC) and inorganic carbon*
- *Carbon pools and carbon stocks, Soil health and soil quality and Carbon dynamics in terrestrial ecosystems*
- *Greenhouse gases ($CO_2$, $CH_4$, $N_2O$), Climate change and global warming and Soil–plant–atmosphere interactions*
- *Carbon balance and carbon budgeting, Sustainable Development Goals (SDGs) and climate action and IPCC guidelines and climate policies*
- *Land degradation and desertification and Importance of soil carbon in sustainable agriculture.*
- *National and global case studies*

**Linked COs: CO1** **Number of Hours: 8**

## Module-2

**Soil Carbon Dynamics and Assessment**

- *Soil carbon formation and decomposition and Factors affecting soil carbon storage*
- *Soil microbial activity, Carbon mineralization and Carbon sequestration processes*
- *Soil sampling techniques and Laboratory analysis of soil organic carbon*
- *Soil carbon stock estimation, Greenhouse gas emission measurement and Carbon footprint assessment*
- *Land Use/Land Cover (LULC) impacts on soil carbon and Climate variability and soil carbon*
- *Carbon accounting methods and Soil carbon indicators.*
- *Case studies on carbon assessment*

**Linked COs: CO2** **Number of Hours: 8 hrs**

## Module-3

**Climate-Smart Agriculture and Soil Carbon Management**

- *Climate-smart agriculture (CSA), Conservation agriculture and No-till and minimum tillage*
- *Cover crops and purpose of crop rotation, Organic farming and Integrated nutrient management*

- *Agroforestry systems and Biochar applications*
- *Composting and organic amendments and different water conservation practices*
- *Precision agriculture and Soil moisture conservation*
- *Carbon farming, Sustainable land management*
- *Best management practices for carbon sequestration*

**Linked COs: CO3** **Number of Hours: 9 hrs**

**Module-4**

**Carbon Sequestration, Ecosystem Restoration and Climate Adaptation**

- *Carbon sequestration in agricultural soils and Forest and grassland carbon storage*
- *Wetland restoration, Ecosystem restoration techniques and Nature-based solutions (NbS)*
- *Climate adaptation strategies, Land degradation neutrality and Drought resilience*
- *Sustainable watershed management and Carbon credit mechanisms*
- *Carbon markets and Environmental Impact Assessment (EIA)*
- *Multi-Criteria Decision Analysis (MCDA) and Decision Support Systems (DSS)*
- *Soil carbon management planning*

**Linked COs: CO4, CO5** **Number of Hours: 9 hrs**

**Module-5**

**Geospatial Technologies and Digital Soil Carbon Monitoring**

- *Remote Sensing for soil carbon assessment and GIS-based soil carbon mapping*
- *Digital soil mapping, Digital Elevation Models (DEM) and UAV applications in agriculture*
- *LiDAR applications and Satellite-based carbon monitoring*
- *Google Earth Engine, Artificial Intelligence in soil carbon prediction and Machine Learning for carbon modelling*
- *Internet of Things (IoT) for soil monitoring and Big Data analytics*
- *Carbon modelling software and Climate risk mapping*
- *Future trends in digital soil carbon management*

**Linked COs: CO6** **Number of Hours: 8 hrs**

**Suggested Learning Resources**

**Textbooks**

1. *Michael, A. M., Irrigation: Theory and Practice, Vikas Publishing House.*
2. *Chambers, R., Managing Canal Irrigation, Oxford & IBH.*
3. *FAO, Participatory Irrigation Management Training Manuals.*
4. *Suresh, R., Soil and Water Conservation Engineering, Standard Publishers.*

**Reference Books**

1. *FAO, Soil Organic Carbon: The Hidden Potential.*
2. *Lal, R., Soil Carbon Dynamics and Global Change.*
3. *IPCC, Guidelines for National Greenhouse Gas Inventories.*
4. *USDA, Soil Health and Carbon Management Manuals.*
5. *UNEP, Global Environment Outlook.*
6. *UNCCD, Land Degradation Neutrality Guidelines.*

**Web links and Video Lectures (e-Resources)**

1. *Food and Agriculture Organization (FAO): https://www.fao.org*
2. *Intergovernmental Panel on Climate Change (IPCC): https://www.ipcc.ch*
3. *United Nations Framework Convention on Climate Change (UNFCCC): https://unfccc.int*
4. *Indian Council of Agricultural Research (ICAR): https://icar.org.in*
5. *ISRO: https://www.isro.gov.in*
6. *National Remote Sensing Centre (NRSC): https://www.nrsc.gov.in*
7. *Google Earth Engine: https://earthengine.google.com*

**Teaching-Learning Process (Innovative Delivery Methods):**

*The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):*

- *Flipped Classroom*
- *Problem-Based Learning (PBL)*
- *Case-Based Teaching*
- *Simulation and Virtual Labs*
- *Partial Delivery of course by Industry expert/ industrial visits*
- *ICT-Enabled Teaching.*
- *Role Play.*

**Assessment Structure (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation:**

*Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]*

*A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.*

*In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks*

**Students' activities for TW/SL under NCrF: Samples only**

*As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.*

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | **Soil Carbon Assessment and Mapping:** *Collect soil samples from a selected agricultural field or watershed and estimate Soil Organic Carbon (SOC). Prepare soil carbon distribution maps using GIS and analyze the effects of land use, vegetation, and soil properties on carbon storage.* | *24* |
| *2* | **Climate-Smart Agriculture and Carbon Sequestration Assessment:** *Evaluate the effectiveness of conservation agriculture, agroforestry, cover crops, organic farming, biochar application, or conservation tillage in improving soil carbon sequestration, soil health, and climate resilience.* | *24* |
| *3* | **Soil Carbon Management and Climate Adaptation Project:** *Develop a climate adaptation and soil carbon management plan for a selected watershed or agricultural area by integrating sustainable land management practices, carbon sequestration strategies, climate-smart agriculture, and GIS-based Decision Support Systems (DSS).* | *24* |
| *4* | **Climate Change Case Study and Geospatial Analysis:** *Conduct a case study on the impacts of climate change on soil carbon, land degradation, agricultural productivity, or ecosystem restoration. Analyze spatial variations using Remote Sensing, GIS, UAVs, or Digital Elevation Models (DEM) and present the findings using thematic maps and statistical analysis.* | *24*<br>*24* |

**SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.**

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|
| *1* | *Read selected chapters from IPCC Assessment Reports, FAO Soil Organic Carbon Manuals, ICAR publications, or USDA Soil Health Guides and prepare a reflective note on the role of soil carbon in climate change mitigation, sustainable agriculture, and ecosystem resilience.* | *24* |
| *2* | *Prepare a technical report on the application of Remote Sensing, GIS, Artificial Intelligence (AI), Machine Learning (ML), Digital Soil Mapping, Google Earth Engine, or Carbon Modelling Tools for soil carbon assessment, carbon sequestration, climate adaptation, and sustainable land management.* | *24* |
| *3* | *Complete a MOOC module on Soil Science, Climate Change, Climate-Smart Agriculture, Soil Carbon Sequestration, Remote Sensing and GIS, Sustainable Land Management, or Environmental Sustainability (NPTEL/SWAYAM /FAO/ISRO-IIRS/IPCC) and submit a learning report highlighting practical applications.* | *24* |

**Sample rubrics for TW activities:**

| *Criteria* | *4 - Excellent* | *3 - Good* | *2 - Satisfactory* | *1 - Needs Improvement* |
|---|---|---|---|---|
| *Problem understanding* | *Clear problem framing with strong justification.* | *Mostly clear with minor gaps.* | *Basic attempt with limited clarity.* | *Poorly defined problem.* |
| *Data and method* | *Appropriate data and sound methodology.* | *Mostly appropriate with minor issues.* | *Limited data or partial method.* | *Inadequate or incorrect method.* |
| *Analysis* | *Robust interpretation and valid results.* | *Generally sound with minor errors.* | *Partial analysis with gaps.* | *Weak or incorrect analysis.* |
| *Recommendations* | *Strong, feasible, and context-specific.* | *Relevant with minor limitations.* | *Generic recommendations.* | *Incomplete or unrealistic.* |
| *Presentation* | *Well organized and professional.* | *Good organization with minor issues.* | *Acceptable but uneven.* | *Poorly presented.* |

| LAND AND WATER ANALYTICS LAB | | | |
|---|---|---|---|
| *Course Code* | **1MWLL207** | *Scheme* | *2026* |
| *Type of course* | *Professional Core Course Lab* | *Semester* | *II* |
| *Teaching Hours/Week (L:T:P)* | *2(0: 0: 2)* | *CIE Marks* | *50* |
| *Total Hours of Pedagogy L:T:P:SL:TW* | *30(0: 0:28:2)* | *SEE Marks* | *50* |
| *Credits* | *1* | *Total Marks* | *100* |
| *Type of Examination* | **Practical** | *Exam Hours* | *3* |

**Course outcome (Course Skill Set)**

*At the end of the course, the student will be able to:*

1. *CO1 -- L3 Apply GIS, Remote Sensing, GPS, and spatial data processing techniques for land and water resources analysis.*
2. *CO2 -- L4 Analyze terrain, watershed, soil, and hydrological characteristics using geospatial datasets and analytical tools.*
3. *CO3 -- L4 Develop thematic maps and spatial databases for land use planning, watershed management, groundwater assessment, and environmental monitoring.*
4. *CO4 -- L3 Evaluate land and water resource problems using geospatial analysis, statistical methods, and decision-support techniques.*
5. *CO5 -- L6 Design integrated geospatial solutions for sustainable land and water resources management using modern software tools and field observations.*

**Note:**

1. *The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.*
2. *Both PART-A and PART-B are considered for CIE and SEE.*
3. *Students have answer 1(one) question from PART-A and 1(one) question from PART-B.*
   a. *The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for* **80 marks** *out of the maximum 100 marks.*
   b. *The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for* **20 marks.**

*For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from* **Part-B**, *along with other similar questions designed to enhance the students' skills.*

**LIST OF EXPERIMENTS**

2. *Introduction to Preparation of Land Use/Land Cover (LULC) map using Sentinel/Landsat satellite imagery and GIS software. (CO1, CO2)*
3. *Delineation of a watershed using Digital Elevation Model (DEM) and generation of slope, aspect, contour, drainage network, flow direction, and flow accumulation maps. (CO2, CO3)*
4. *Morphometric analysis of a watershed by computing stream order, drainage density, bifurcation ratio, elongation ratio, form factor, and relief characteristics. (CO2, CO4)*
5. *Preparation of groundwater potential, soil suitability, or flood susceptibility maps using GIS-based Multi-Criteria Decision Analysis (MCDA). (CO3, CO4)*
6. *Estimation of Normalized Difference Vegetation Index (NDVI), land surface temperature (LST), evapotranspiration, or drought indices using Remote Sensing data. . (CO1, CO4)*
7. *Develop a Flood Hazard or Drought Vulnerability Assessment using Remote Sensing, GIS, rainfall, DEM, drainage, soil, and land use data.*
8. *Develop a GIS-based Integrated Watershed Management Plan by preparing thematic maps such as LULC, soil, slope, drainage, geomorphology, groundwater potential, erosion risk, and conservation measures. ( CO2, CO4, CO5)*
9. *Prepare an Integrated Land and Water Resources Database using GPS field data, satellite imagery, and GIS for sustainable planning and decision-making. (CO1, CO3, CO5).*

10. *Prepare a Land Capability and Land Suitability Assessment for a selected watershed or village using GIS-based Multi-Criteria Decision Analysis (MCDA). (CO3, CO5)*
11. *Design and analyze an irregular building frame and identify critical displacement and force response zones. (CO3, CO4, CO5)*
12. *Design a Smart Land and Water Management Decision Support System (DSS) by integrating GIS, Remote Sensing, IoT data, and AI-based analytical tools. (CO3, CO4, CO5).*

**Textbooks:**

1. *Kang-tsung Chang, Introduction to Geographic Information Systems, McGraw-Hill Education.*
2. *Lillesand, T. M., Kiefer, R. W., & Chipman, J. W., Remote Sensing and Image Interpretation, Wiley.*
3. *Burrough, P. A., & McDonnell, R. A., Principles of Geographical Information Systems, Oxford University Press.*
4. *M. Anji Reddy, Remote Sensing and Geographic Information Systems, BS Publications.*
5. *R. Suresh, Soil and Water Conservation Engineering, Standard Publishers.*

**Reference books / Manuals:**

1. *Jensen, J. R., Remote Sensing of the Environment, Pearson.*
2. *Maidment, D. R., Handbook of Hydrology, McGraw-Hill.*
3. *FAO, GIS Applications in Agriculture and Water Resources.*
4. *ISRO–NRSC, Remote Sensing Applications for Natural Resources Management.*
5. *ESRI, ArcGIS Pro Tutorials.*
6. *QGIS Documentation and User Guide*

**Web links and Video Lectures (e-Resources):**

1. *ISRO: https://www.isro.gov.in*
2. *National Remote Sensing Centre (NRSC): https://www.nrsc.gov.in*
3. *Bhuvan Geoportal: https://bhuvan.nrsc.gov.in*
4. *Google Earth Engine: https://earthengine.google.com*
5. *USGS Earth Explorer: https://earthexplorer.usgs.gov*
6. *Copernicus Data Space Ecosystem: https://dataspace.copernicus.eu*
7. *QGIS: https://qgis.org*

**Software Tools:**

- *Commercial GIS software: ArcGIS Pro, ArcMap, GRASS GIS and SAGA GIS*
- *Open-source software: QGIS, Google Earth Engine*

**Assessment Structure (both CIE and SEE)**

*The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.*

*A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.*

**Continuous Internal Evaluation (CIE):**

*For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."*

*Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)*

*Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.*

*The remaining 15 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table 1.*

*The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.*

| **Table – 1 Distribution of marks corresponding to laboratory component** | | |
|---|---|---|
| **Component** | **Description** | **Marks** |
| **Allotment of marks for regular classwork** | | |
| *Ability in Conducting Experiments* | *Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.* | *10 marks* |
| *Laboratory Record / Journal* | *Regular and neat maintenance of lab record, accuracy of results, and timely submission.* | *15 marks* |
| | **Subtotal** | **25** |
| **Allotment of marks for CIE practical test** | | |
| *Laboratory Test / Experiment Performance* | *Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.* | *5 marks* |
| *Viva-Voce* | *Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.* | *10marks* |
| | **Subtotal** | **15** |
| | **Total** | **40** |

| **Table 2 Distribution of marks corresponding to PART -B of the laboratory component** | | | | |
|---|---|---|---|---|
| **Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10** | | | | |
| **Criteria and Guiding factors** | **Students' Level and Rubrics** | | | |
| | **Excellent: E, Good: G, Fair: F Needs Improvements: NI** | | | |
| | **E** | **G** | **F** | **NI** |
| **(1)** *Problem Understanding*<br>**Criteria:** *Is the problem understood correctly and framed appropriately?*<br>*(i)Clarity in interpreting the given problem.*<br>*(ii)Identification of relevant concepts and constraints.*<br>*(iii) Ability to rephrase or model the problem logically.* | *2.0* | *1.5* | *1.0* | *0.5* |
| **(2)** *Conceptual Knowledge*<br>**Criteria***: Are the chosen methods or concepts valid for this type of problem?*<br>*(i)Application of appropriate theories, principles, or laws.*<br>*(ii)Integration of multiple concepts where necessary.*<br>*(iii)Accuracy in stating relevant equations or models.* | *2.0* | *1.5* | *1.0* | *0.5* |
| **(3)** *Approach and Strategy*<br>**Criteria***: Is the approach well thought out and methodical?*<br>*(i)Logical structure and progression.*<br>*(ii)Use of diagrams, sketches, or flowcharts if applicable.*<br>*(iii)Identification of assumptions and boundary conditions.* | *2.0* | *1.5* | *1.0* | *0.5* |
| **(4)** *Execution and Accuracy*<br>**Criteria***: Are the calculations correct? Is the final solution reasonable?*<br>*(i) Correct application of formulas/methods.*<br>*(ii)Accuracy of calculations or simulations (if any).* | *2.0* | *1.5* | *1.0* | *0.5* |

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| *(iii)Unit consistency and result verification.* | | | | |
| **(5)** *Innovation or Depth*<br>**Criteria***: Has the student shown original thinking or alternative methods?*<br>*(i)Novel or efficient solutions.*<br>*(ii)Consideration of alternate approaches.*<br>*(iii)Interdisciplinary integration or practical extensions.* | *1* | *0.75* | *0.5* | *0.25* |
| **(6)** *Presentation and Clarity*<br>**Criteria***: Is the answer easy to follow and professionally written?*<br>*(i)Organization and neatness.*<br>*(ii)Clarity of explanation, labelling, and steps.*<br>*(iii) Use of proper technical terminology.* | *1* | *0.75* | *0.5* | *0.25* |
| *Total* | *10* | *7.5* | *5.0* | *2.5* |

**Note:**
*(i)The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work.*
*(ii)If the total score results in a fraction, it should be rounded off to the next higher integer.*
*(iii)The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.*
*(iv)To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.*

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