ہائیر ایجوکیشن کمیشن
HIGHER EDUCATION COMMISSION

Government of Pakistan, Islamabad
Quality Assurance Division

Deputy Director (QAD)

DD/2025/QAD-NOC/HEC/NUTECH/MS-CC&EI/2018
Dated: June 12, 2025

Subject: **No Objection Certificate to Launch Master of Science (MS) Climate Change and Environmental Informatics at National University of Technology (NUTECH), Islamabad**

Reference your application for NOC received vide email dated 27.03.2025 on the subject matter.

2. I am pleased to inform that HEC has no objection to offer Master of Science (MS) in Climate Change and Environmental Informatics, a Level 7 qualification at National University of Technology (NUTECH), Islamabad with the following relevant faculty members and w.e.f Fall 2025:

S. No.	Name of Faculty & Designation	PhD Degree Title
1.	Dr. Awais Yasin, Professor	PhD (Bionics Engineering)
2.	Dr. Marium Jalal Chaudhry, Associate Professor	PhD (Electrical & Information Engineering)
3.	Dr. Farid Ul Haque, Associate Professor	PhD (Environmental Sciences)

3. The NOC is issued on the basis of information / documents provided by the University. The University shall be responsible for ensuring the faculty members' relevance to the subject degree program and maintaining **supervisor-student ratio** as per **clause 7.1.1** of **HEC Graduate Education Policy (GEP) 2023**. Furthermore, the University is advised to strictly comply with HEC policies prescribed for MS/MPhil/Ph.D. equivalent programs, including minimum standards for department, program duration, credit hours, student-teacher ratio and semester guidelines as notified by HEC.

4. Moreover, in case of a change in faculty; the University shall inform the Quality Assurance Division (QAD) immediately to update the status of NOC in the database. The Higher Education Commission (HEC) reserves the right to withdraw the NOC; if the University is unable to adhere to the minimum HEC criteria/guidelines. Details regarding **HEC GEP 2023** can be read via link at https://www.hec.gov.pk/english/policies/Pages/GEP.aspx

5. Issued with the approval of the Consultant (QAA/QAD) HEC.

(Rehan Jamil)

The Registrar
National University of Technology (NUTECH)
Main I.J.P. Road, Sector H-12, Islamabad

Copy for information to:

- PS to Rector, National University of Technology (NUTECH), Main I.J.P Road, Islamabad
- PS to Consultant (QAD/QAA), Higher Education Commission, Islamabad
- Director (Incharge), QAA, Higher Education Commission, Islamabad
- Office Copy

ہائیر ایجوکیشن کمیشن
HIGHER EDUCATION COMMISSION

Government of Pakistan, Islamabad
Quality Assurance Division

Deputy Director (QAD)

DD/2025/QAD-NOC/HEC/NUTECH/MA-AI-Engg/2019
Dated: June 12, 2025

Subject: No Objection Certificate to Launch Master of Science (MS) Artificial Intelligence Engineering at National University of Technology (NUTECH), Islamabad

Reference your application for NOC received vide email dated 27.03.2025 on the subject matter.

2. I am pleased to inform that HEC has no objection to offer Master of Science (MS) in Artificial Intelligence Engineering, a Level 7 qualification at National University of Technology (NUTECH), Islamabad with the following relevant faculty members and w.e.f Fall 2025:

S. No.	Name of Faculty & Designation	PhD Degree Title
1.	Dr. Ehsan Ullah, Assistant Professor	PhD (Computer Engineering)
2.	Dr. Madiha Arshad, Assistant Professor	PhD (Electrical Engineering)

3. The NOC is issued on the basis of information / documents provided by the University. The University shall be responsible for ensuring the faculty members' relevance to the subject degree program and maintaining **supervisor-student ratio** as per **clause 7.1.1** of **HEC Graduate Education Policy (GEP) 2023**. Furthermore, the University is advised to strictly comply with HEC policies prescribed for MS/MPhil/Ph.D. equivalent programs, including minimum standards for department, program duration, credit hours, student-teacher ratio and semester guidelines as notified by HEC.

4. Moreover, in case of a change in faculty; the University shall inform the Quality Assurance Division (QAD) immediately to update the status of NOC in the database. The Higher Education Commission (HEC) reserves the right to withdraw the NOC; if the University is unable to adhere to the minimum HEC criteria/guidelines. Details regarding **HEC GEP 2023** can be read via link at https://www.hec.gov.pk/english/policies/Pages/GEP.aspx

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Funded by
European Union

"ACTIVE"

The ICT AppliCaTions for sustaInable enVironmental protEction

Grant Agreement No: 101082866

Deliverable D3. 1 (T 3.1 - T 3.2) of Work Package 3

Development of Academic Modules

Of

MS in Climate Change and Environmental Informatics (CCEI)

February 13, 2025

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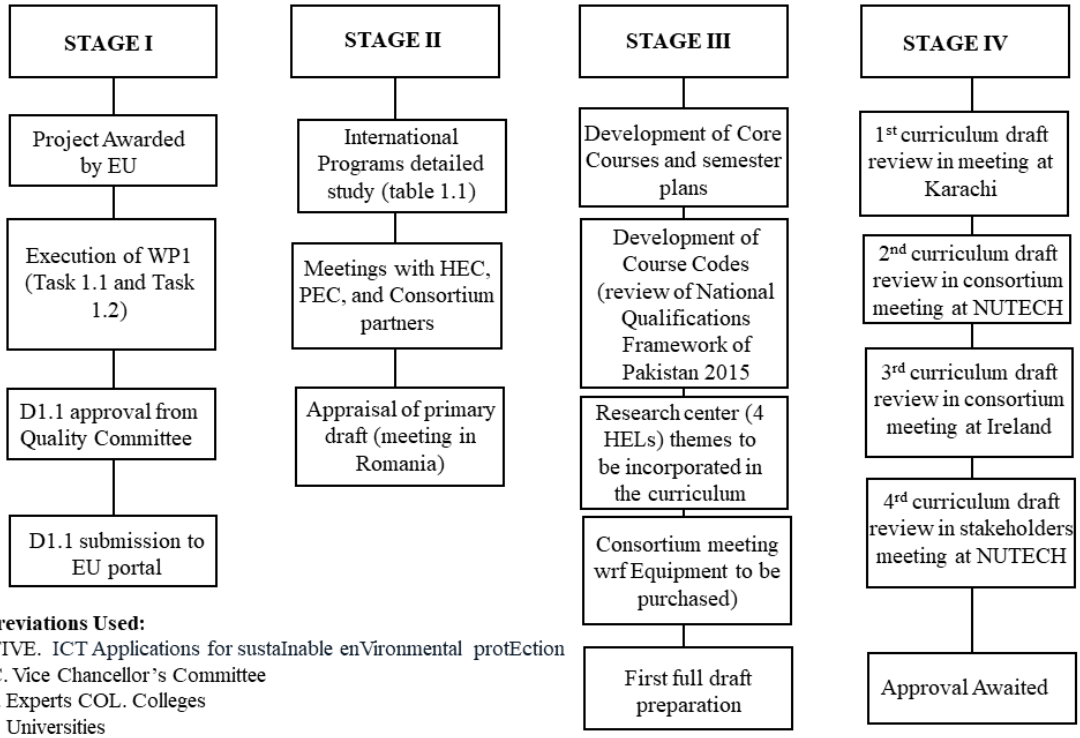
1. Executive Summary

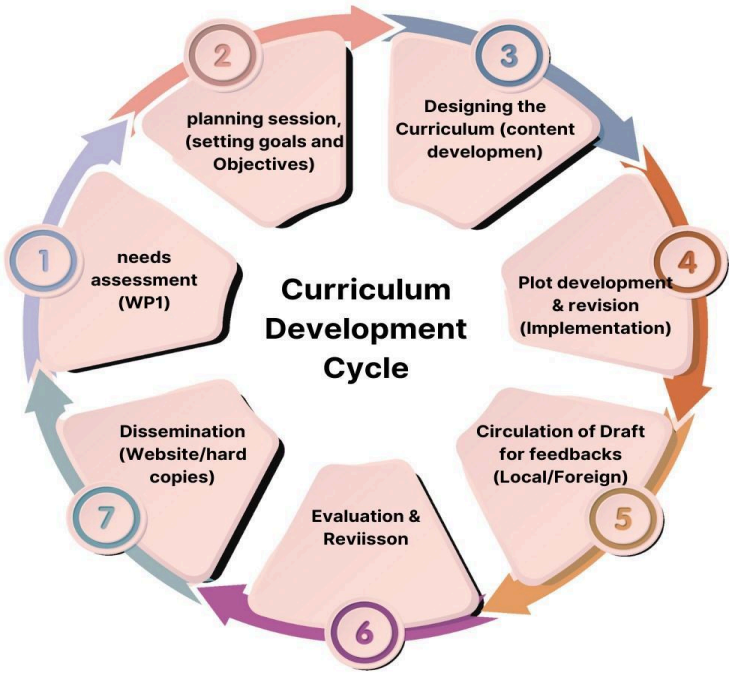
This deliverable illustrates the development of academic modules for the MS program in Climate Change and Environmental Informatics, a critical component of Work Package 3. The primary objective is to construct a comprehensive curriculum addressing key aspects of environmental sustainability and the strategic integration of information and communication technology (ICT)'s applications, covering all the 17 SDGs. The proposed curriculum contains core courses as well as elective courses covering fundamental and specialized topics in Environmental studies, climate science, and Informatics respectively. These courses ensure a strong foundation of environmental informatics, preparing students for efficient solutions for environmental degradation. The curriculum document also underscores practical components including quizzes, assignments, labs, and a specific thesis/project work in order to provide a hands-on knowledge experience. This blended approach trains students with the knowledge as well as skills mandatory to undertake ongoing challenges in the domain of environmental management and conservation, training them for impactful roles in the field.

2. Curriculum Development Stages



Abbreviations Used:
ACTIVE. ICT Applications for sustaInable enVironmental protEction
VCC. Vice Chancellor's Committee
EXP. Experts COL. Colleges
UNI. Universities
PREP. Preparation
LI Learning Innovation
R&D Research & Development Organization

3. Curriculum Development Cycle



4. Work Package 03: Development of Academic Modules

Duration: 6M-24M

Lead Beneficiary: NUTECH, Pakistan

4.1.Introduction

Climate change is a critical challenge faced by the world, with harsh effects such as extreme weather patterns, food insecurity, and rising sea levels. Pakistan, being in the list of top ten climate-affected countries, has been struggling with environmental threats such as flash floods, droughts, and glacial melting and needs urgent attention to develop sustainable solutions. Development of sustainable solutions requires skilled graduates trained with the specific knowledge, innovative technologies, and methods to design schemes for climate mitigation and adaptation.

Given the cruciality of undertaking the issues related to climate change, this Master's degree in Climate Change and Environmental Informatics aims to produce expert graduates in multidisciplinary domains who are also well-versed with Information and Communication Technology (ICT) tools to address environmental and climatic challenges in Pakistan and beyond. ICT is emerging as a transformative force with profound implications for addressing environmental sustainability and climate mitigation challenges. In collaboration with four Pakistani universities and three universities from Spain, Ireland, and Romania, this program combines contemporary technologies such as remote sensing, machine learning, IoT, and the

principles of environmental sciences to devise sustainable development solutions. Anticipating significant impacts on the employment prospects of its participants, the program equips them with the knowledge and skills essential for navigating the complex landscape of environmental sustainability and Informatics successfully. As these critical issues continue to shape our world, the launch of this Master's program marks a significant step toward fostering a cadre of professionals capable of making meaningful contributions to a sustainable and resilient future.

4.2.Activities

Task no.	**Task Name**	**Description**	**Participants**	
			Name	Role
T3.1	Curriculum development and qualification description	In this task, overall structure and modules of program will be developed. Number of semesters, credit hours and course review process will be developed.	All partners	COO, BEN, and AP
T3.2	Developed syllabuses and content materials	Development of courses, learning and teaching tools, delivery processes and platform for student-centered learning of the proposed curriculum	All partners	COO, BEN, and AP
T3.3	Program accreditation	In this task the developed program will first approved from consortium and then it will be accredited from Higher Education Commission.	All partners	COO, BEN, and AP

T3.4	Enrolling 30 master students in partners universities	The program will be advertised in all Pakistan partner Universities and open for enrolment of students at National level.	All partners	COO, BEN, and AP

4.3.Milestones and deliverables

Deliverable No.	**Deliverable Name**	**Lead Beneficiary**	**Type**	**Dissemination Level**	**Due Date**	**Description**
D3.1	One new MS degree program with tentative degree title "MS in Climate Change and Environmental Informatics	NUTECH	R	SEN	20 M	The program will be developed in local Credit Hours System. The document will contain all the detail and quality description regarding the program including the curriculum, syllabus, program modules, load allocation in each semester, project and complex problem and allocation and etc.

4.4.Scope:

The Master's degree program in Climate Change and Environmental Informatics has been proposed and prepared by the EU Center of Excellence for Climate Change with ICT supported by the EU-funded project titled "ICT Applications for Sustainable Environmental Protection (ACTIVE)." The proposed postgraduate program incorporates inputs from all departments of NUETCH School of Engineering and Technology (NUSET) with an aim to tackle climate change and sustainability issues faced by Pakistan and world. Its aim is to produce a skilled workforce equipped with abilities to utilize information and communication technologies (ICT) and innovative tools to resolve complex climate change related problems in urban as well as rural contexts.

The degree program will develop the skills needed to bridge the gap between ICT and environmental field knowledge. It is a visible fact that ICT specialists focus on technology design and development but lack knowledge and expertise in the domain of environmental sciences. Similarly, environmental experts are required to be trained to integrate ICT and innovative tools to tackle climate change-related challenges. The designed curriculum fills this gap by including multidisciplinary courses specifically tailored to addressing the climate change-related challenges. Perspective graduates of this program shall obtain skills in climate adaptation, environmental monitoring, AI-driven climate modeling, and resource management.

With a yearly entry of 30 students, the degree program shall produce graduates for a career in domains such as climate data analysis, and ICT-driven climate adaptation, sustainability consulting and etc. It emphasizes on solutions to native challenges like water shortage, deforestation, air pollution, and disaster management, whilst lining up with the United Nations' Sustainable Development Goals (UN-SDGs). International collaboration with universities from Spain, Ireland, and Romania, environmental organizations, and industry will be helpful in enhancing the students' learning process through funded research projects, secondment, and student exchange opportunities.

This degree program shall help meet the rising demand for applying ICT to develop climate solutions. Graduates of this program will be furnished with the tools required for climate data analytics, sustainable development consultancies, and environmental protection advisory. This program will produce graduates with key skills to tap job opportunities in governmental, non-governmental agencies bodies, and international organizations such as Ministry of Climate Change, departments of disaster management, sustainability advisory agencies, United Nations Environment Program (UNEP), World Bank, climate related research organizations etc. In addition, it will promote entrepreneurship through startups in climate technology by obtaining research and development grants in collaboration with international collaborating universities

and organizations. Furthermore, special consideration is given on including women to participate in sustainability efforts through this degree program.

4.5.Rationale:

The world is faced with pressing challenges caused by the changing climatic conditions with mounting temperatures leading to threats for societies' existence, ecosystems, and the economies. These conditions are causing heightened disasters, food insecurities, and damage to infrastructure, and subsequently ensuing the loss of life on the earth. Sustainable development is considered a complex problem, and in this regard the United Nations stresses the significance of education in fighting the climate change though UN-SDGs.

Pakistan, being one of the most climate change vulnerable countries, has been well acquainted with the negative effects of climate change, and thus, need to prepare its upcoming generations to deal with such serious threats. Problems like unavailability skilled workforce, and insufficient awareness about the same add woes to these challenges even worst. Therefore, it is necessary to encourage interdisciplinary approach to drive innovation through combining Information and Communication Technologies (ICT) and environmental sciences to tackle climate challenges faced by Pakistan. Hence, this degree program aims to prepare graduates with the interdisciplinary skills necessitated to devise effective sustainable development solutions using ICT.

This degree program in Climate Change and Environmental Informatics at NUETCH will develop the skills needed to bridge the gap between ICT and environmental knowledge domain. It will offer students a multilayered understanding of the principles of environmental sciences, and ICT, training them to use innovative technologies like machine learning, remote sensing, IoT, etc. to tackle climate change-related challenges. The designed curriculum is interdisciplinary which combines knowledge of environmental sciences, engineering and technology, policy-making, governance, management and social sciences, producing graduates to work together to solve real-world challenges. This degree program also touches upon the aspects of leadership, ethical responsibility, communication skills, and advanced research, guaranteeing that graduates are fully capable of contributing to sustainability, and environmental protection using state of the art technologies.

4.6.Objective:

The proposed master's degree program in Climate Change and Environmental Informatics at NUETCH aims to:

a. Prepare graduates with a deep understanding of the intersection among climate change, technology, and sustainable development, making them capable to gauge and tackle environmental challenges through application of ICT tools.

b. Develop interdisciplinary capability in climate change science and Information and Communication Technologies (ICT), to devise technology-based solutions for mitigating climate change and contributing to sustainable development.

c. Equip graduates with cutting-edge technologies including but not limited to machine learning, remote sensing, internet-of-things, sensor networks, etc. with an emphasis on their application in tackling climate-induced disasters and environmental degradation, while augmenting their capacity for knowledgeable decision-making in the relevant domain.

d. Produce industry-ready graduates with expertise in climate change related technologies, environmental assessment, sustainability analytics, AI based modeling for environmental parameters, while empowering them to initiate and lead sustainability efforts, guide industries and persuade policymakers, and bring innovation through relevant startups.

4.7.Integrating Sustainable Development Goals (SDGs) into Curriculum Design

In alignment with the United Nations' Sustainable Development Goals (SDGs), the development of this curriculum actively incorporates principles and values that contribute to the achievement of specific goals. The integration of SDGs ensures a holistic and socially responsible approach to education.

The integration of all the 17 SDGs ensures that the curriculum not only prepares students for the challenges of ICT and climate change but also actively contributes to the broader global agenda for sustainable development.

4.8.Innovative Teaching Methodologies (ITMs) to be implemented

This MS program will incorporate innovative teaching methodologies (ITMs) in order to improve the learning experience for students. Here are the approaches that will be executed throughout the degree program:

4.8.1. Flipped Classroom Approach

- Reverse the traditional teaching methods, allowing students to study course material outside of class.
- Class time will be utilized for group projects, problem-solving exercises, and debates.
- Encourage engagement, critical thinking, and deeper understanding through collaborative activities with peers.

4.8.2. Gamification in Education

- Integrate game components such as competition, rewards, and levels into the learning process.
- Boost student participation, motivation, and engagement in class.

4.8.3. Computer-Assisted Instruction (CAI)

- Utilize technology and computers to facilitate the learning process.
- Modernize educational experiences through versatility, interaction, and customized learning pathways.

4.8.4. Microteaching Techniques

- Employ microteaching, a valuable method for teacher development, involving instructing small groups or individual students in a controlled setting.
- Provide teachers with structured feedback for ongoing improvement of instructional techniques.

4.8.5. Experiential Learning

- Emphasize effective involvement and applied learning to build practical expertise.
- Enhance critical thinking, problem-solving skills, and deep understanding of the subject matter for real-world problem-solving.

4.8.6. Team Teaching

- Implement collaborative teaching techniques where teachers share responsibilities for subject planning, designing course outlines, teaching, and student assessment.

4.8.7. Multimedia Learning

- Leverage various media sources, including images, animations, music, text, and videos, to enhance the learning process.
- Utilize multimedia components like PowerPoint presentations, recorded lectures, and digital textbooks to improve the academic process.

4.8.8. Project-Based Learning (PBL)

- Engage students in working on complex, real-world projects to deepen their understanding of academia and develop essential life skills.
- Emphasize practical research applications, teamwork, and skill development through collaborative group projects.

4.9.Program Educational Objectives (PEOs)

Within the realm of higher education, the Program Educational Objectives (PEOs) for the Master of Science (MS) in Climate Change and Environmental Informatics represent a deliberate framework devised to shape graduates into thoughtful professionals. The following PEOs will be intended to be achieved during this MS program:

a. Students will apply their interdisciplinary knowledge to analyze and solve complex challenges and emerge as innovators at the intersection of sustainable environmental development and ICTs.
b. Students will eventually possess effective communication skills, which will allow them to communicate complex concepts related to environmental studies, climate solutions, and ICT-related data to varied audiences.
c. Graduates will maintain high ethical standards in their professional practice, considering the social, environmental, and cultural implications of their work.
d. Graduates will actively engage in making collaborations at local, regional, and global levels to address environmental challenges using technology.

4.10. Program Learning Outcomes (PLOs)

Program Learning Outcomes (PLOs) form the foundational framework of the Master of Science (MS) in Climate Change and Environmental Informatics. The MS in Climate Change and Environmental Informatics will achieve the following PLOs:

a. Apply knowledge of mathematics, science, and fundamentals in identifying, analyzing and solving the complicated problems in the domain of environmental and climate-related challenges considering the health of natural ecosystems.
b. Assess social, health, safety, ethical, legal, as well as cultural issues in the context of environmental sustainability and climate change.
c. Work effectively, as an individual or in a team, on multifaceted and multidisciplinary projects addressing environmental sustainability and climate resilience.

In addition to the stated PLOs, the educational institution may incorporate supplementary outcomes tailored to the evolving needs of the academic landscape and industry demands. Furthermore, the program tries to enhance its internal quality assessment through the Quality Enhancement Cell (QEC).

The objectives of the **ACTIVE Quality Committee (AQC)** encompass:

Continuous Improvement: Regularly assess and enhance the effectiveness of teaching and learning methodologies, curriculum design, and program delivery.

Feedback Integration: Systematically gather and incorporate feedback from stakeholders, including students, faculty, and industry experts, to enhance program quality.

Curriculum Alignment: Ensure the curriculum remains aligned with industry trends, technological advancements, and evolving environmental challenges.

Professional Development: Facilitate opportunities for faculty development to stay abreast of contemporary pedagogical approaches, technological advancements, and industry best practices.

Outcome-Based Education: Emphasize outcome-based education to align the learning outcomes with the expectations of employers, industry partners, and societal needs.

4.11. Input Obtained from Industry/Academia/Stakeholders/Accreditation Bodies

To get expert views on the developed curriculum from different stakeholders, accreditation bodies, and academia, User requirement analysis was carried out for the MS in "Climate Change and Environmental Informatics" program.

a. Input from Academia

Academics strongly agreed with the proposed direction of the curriculum. They said that it focuses on its alignment with the latest research methods and its relevance to current environmental challenges. Their feedback showed the importance of combining theoretical knowledge with practical applications. It is assuring a detailed approach to the program.

b. Input from Industry

Professionals from the industry were keen on the curriculum's focus on real-world applications. They strongly agree with its potential to undertake ongoing as well as emerging challenges. They were hopeful that the curriculum would provide students with major skills that are highly aligned with the needs of today's job market, ultimately making them competitive as well as industry-ready.

c. Input from Accreditation Bodies

Accreditation bodies also voiced strong agreement with the curriculum's development. They also consider its relevance to higher educational standards and alignment with well-recognized standards. Their feedback focused that the program would provide students with a credible and seasoned education, strengthening both academic as well as professional acknowledgement.

- ***Engr. Dr. Nasir Mahmood Khan, Registrar, Pakistan Engineering Council (PEC), Islamabad***

Dr. Khan expressed strong support for the curriculum, noting its alignment with PEC's vision of integrating sustainable practices within engineering and ICT fields. He emphasized that the

curriculum would enhance the competency of future engineers in addressing environmental challenges through technology. It will ultimately foster innovation which is both practical as well as environmentally responsible.

- ***Engr. Niaz Ahmad, Pakistan Engineering Council (PEC), Islamabad***

Engr. Ahmad highlighted the curriculum's value in developing professionals with a strong foundation in sustainable engineering practices aligned with PEC standards. He noted that graduates would be well-equipped to meet the engineering sector's demands for sustainable solutions, making them precious assets in both public and private sectors.

d. Input from other Stakeholders

- ***Dr. Farrukh Bashir, Director, Research & Development Division, Principal Meteorologist and Data Scientist, Pakistan Meteorological Department (PMD), Islamabad***

Dr. Bashir highlighted the importance of the program's focus on ICT integration for environmental sustainability. He appreciated that the curriculum would prepare students with essential skills in data analytics and environmental modeling, which are critical for the initiatives related to climate resilience.

- ***Dr. Bashir Ahmed, Director, Climate, Energy and Water Research Institute (CEWRI), National Agricultural Research Center (NARC), Pakistan Agricultural Research Council (PARC), Islamabad***

Dr. Ahmed supported the program's focus, particularly its emphasis on water resource management and the use of ICT in sustainable water practices. He highlighted that training in ICT-enabled water management systems would equip graduates to handle Pakistan's water scarcity issues. This will ultimately contribute to better water conservation and management at the national level.

- ***Dr. Mohsina Zubair, Pakistan Environmental Protection Agency (EPA)***

Dr. Zubair endorsed the curriculum, highlighting its alignment with current environmental protection policies and the growing need for sustainable ICT applications. She stressed that graduates of this program could play a key role in enforcing environmental standards as well as developing technologies for pollution control, and sustainable resource management.

- ***Dr. Nabeel Amin, Head of Compliance, Ministry of Commerce***

Dr. Amin appreciated the initiative and said that it's an excellent degree program and an innovative idea for the mitigation of environmental challenges through AI and modern tools of data analysis.

- ***Dr. Mirza Habib, Director Research Support, Pakistan Science Foundation (PSF)***

He also appreciated the efforts of the team in making the comprehensive curriculum for this novel initiative. He suggested that the degree must be aligned with market demand. He further stated that the curriculum will prepare the students to address practical challenges towards environmental sustainability.

- ***Dr. Khalid Shafi, Director/ Team Lead Climate Change, Institute of Strategic Studies, Research & Analysis (ISSRA), National Defense University (NDU), Islamabad.***

Dr. Khalid Shafi also endorsed the curriculum, and he emphasized the need to align the degree with national climate policies and strategic frameworks to address emerging environmental challenges.

- ***Dr. Ghani Akbar, Principal Scientific Officer, Integrated Watershed Management Program (IWMP), Climate, Energy and Water Research Institute (CEWRI), Pakistan Agricultural Research Council (PARC)***

Dr. Akbar appreciated the curriculum's potential to address pressing agricultural challenges, particularly in resource management and sustainable agricultural technologies. He remarked that the program would be instrumental in training professionals capable of advancing agricultural productivity while preserving environmental resources, which is crucial for Pakistan's food security.

- ***Dr. Shaukat Ali, Director, National Institute for Genomics and Advanced Biotechnology (NIGAB), NARC, Islamabad***

Dr. Ali endorsed the curriculum, recognizing its potential to address genetic and agricultural challenges through sustainable integration with ICT. He explained that skills in ICT and biotechnology would empower students to improve crop resilience and productivity, making significant contributions to national agricultural research and development.

4.12. Title of the Degree

The tentative title for the master's degree is "MS in Climate Change and Environmental Informatics".

4.13. Eligibility

The MS program requires applicants to have a solid foundation in relevant subjects for effective program commencement and success. Candidates are required to have a bachelor's degree from a university recognized by the Higher Education Commission (HEC) in disciplines like Engineering, Environmental Studies, Computer Science, Information Science, Artificial Intelligence, Life Sciences, Physical Sciences or other relevant disciplines to be eligible, with a minimum CGPA of 2.0.

4.14. Duration

Degree completion time is of minimum 1.5 years as per the requirements of Pakistani Higher Education Commission (HEC). Considering the varying student demands, the HEC permits a maximum completion period of 4 years for flexibility, ensuring students can balance academic excellence with other responsibilities.

4.15. Degree Completion Requirements

Degree completion requires adherence to academic standards as well as successful completion of all components of the program, ensuring credibility as well as maintaining high quality education. To qualify for the conferment of an MS degree, students are required to fulfill the following set of criteria:

1. Cumulative Grade Point Average (CGPA): Achieve a minimum CGPA of 2.5 on a 4.0 scale. This ensures a satisfactory level of academic performance throughout the program.
2. Credit Hours: Choose one of the following options:

a) Prescribed Courses: Successfully complete and pass the designated courses, accumulating a minimum of 30 credit hours.

OR

b) Thesis/Research Work: Complete 24 credit hours from the prescribed course list and successfully undertake 6 credit hours through Thesis/Research Work.

4.16. Course Structure

Degree Requirement: 30 Credit hours including thesis

Course structure	**Number of courses**	**Credit hours**
Deficiency courses (fundamental/introductory courses, 0 semester)	If required	6-9
Core courses	4	12

Elective/specialized courses	4	12
Thesis (third and fourth semesters)	2 Courses OR Thesis	06
Total	10	30

4.17. Proposed timeframe of commencement

Fall 2025

4.18. Layout of courses for MS

The Master of Science program in Climate Change and Environmental Informatics is precisely designed to ensure a thorough and well-rounded academic experience. The curriculum involves 4 core courses and 4 elective courses, each carrying 3 credit hours. The number of course options available during the study plan is liable upon the availability of faculty as well as laboratory facilities.

The program integrates **Bloom's Taxonomy** to structure and enhance the learning experience. Bloom's Taxonomy classifies educational goals into six hierarchical levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating.

Responsibility for making detailed course outlines lies with the respective departmental Boards of Studies which ultimately undergo approval processes to ensure alignment with program objectives as well as academic standards. The curriculum modules were developed by taking insight from established international universities which are offering programs similar to "MS in Climate Change and Environmental Informatics" (refer to appendix A for more detail).

4.19. Graduate Attributes and Knowledge Profiles in Climate Change and Environmental Informatics

The Curriculum for the new MS program "Climate Change and Environmental Informatics" is precisely designed to train students based on 12 Graduate Attributes (GAs) incorporated under the PLOs.

A knowledge profile is a structured framework outlining the specific areas of expertise and competencies required within a curriculum. The knowledge profile encompasses various domains, each corresponding to a different area of learning to the program's objectives.

This structured approach ensures that students are not only well-versed in theoretical concepts but also equipped with practical skills necessary for real-world applications. The curriculum for

Climate Change and Environmental Informatics is structured around the following knowledge profiles:

Natural Sciences (WK1): Students will develop a systematic, theory-based understanding of natural sciences relevant to sustainable environmental protection, encompassing principles of ecology, environmental science, and earth sciences.

Mathematics and Computing (WK2): This component focuses on concept-based mathematical thinking, numerical analysis, statistics, and computational methods essential for data analysis, modeling, and simulation in environmental studies.

Engineering Fundamentals (WK3): Students will acquire a solid foundation in engineering fundamentals, including principles of environmental engineering, sustainable development, and systems thinking.

Engineering Specialization (WK4): Building upon the engineering fundamentals, students will delve into specialized knowledge areas relevant to ICT's application for environmental protection, such as remote sensing, geographic information systems (GIS), and environmental monitoring technologies.

Engineering Design (WK5): The curriculum emphasizes Design Thinking principles to support the development of innovative ICT's solutions for environmental monitoring, conservation, and sustainability.

Engineering Practice (WK6): Students will gain practical knowledge of engineering practices and technologies employed in environmental protection, including sensor networks, data analytics, and decision support systems.

Engineering in Society (WK7): Understanding the societal implications of ICT's applications in environmental protection, students will explore ethical considerations, public safety concerns, and the broader socio-economic impacts of engineering activities in the environmental domain.

Research Literature (WK8): Engagement with selected knowledge in the research literature of environmental science and ICT's applications, fostering critical thinking and research skills necessary for innovation and problem-solving in sustainable environmental protection.

The curriculum matrix will encompass a blend of non-engineering domain courses as well as engineering domain courses. This holistic approach will enable students to tackle complex environmental challenges through ICT applications, fostering a multidisciplinary mindset and facilitating Complex Problem Solving and Engineering Activities in the realm of environmental protection.

4.20. Assessment Criteria

1st term (15-20%)	Assignments/Quizzes and Presentation
Mid Term (25-30%)	Written (Long Questions, Short Questions, MCQs)
Final Term (45-50%)	Written (Long Questions, Short Questions, MCQs)

4.21. Suggested curriculum for MS

a. Core courses: Any 4 Courses from Core Courses List

Sr. no.	Course name	Department	Course code	Cr. Hrs.
1.	Research Methodology		RM-601	Qualifying Scores
2.	Intro to Environmental Informatics		IEI-602	3+0
3.	Information and Communication Technologies		ICT-603	2+1
4.	Environmental Chemistry and Climate Impact		ECC-604	3+0
5.	Mathematics for Environmental Informatics		MME-605	3+0
6.	Recent Trends in Environmental Informatics		RES-606	3+0
7.	Environmental Data Analytics and Visualization		EDA-608	2+1
8.	Digital Sustainability Strategies and Green Informatics		DSG-609	3+0
9.	Environmental Sciences and Climate Change		CES-610	3+0

b. Elective Courses:

Sr. no.	Course name	Department	Course code	Cr. Hrs.
1.	Remote Sensing and GIS		RSG-610	2+1
2.	Renewable Energy Technologies		RET-611	3+0
3.	Advanced Energy Modeling and Simulation		AEM-612	3+0

4.	Environmental Governance and CTs		EGI-613	3+0
5.	Climate Change Adaptation and Disaster Mitigation		CAD-607	3+0
6.	Sustainable Agriculture		SAT-614	2+1
7.	Air Pollution Control and Management		APC-615	3+0
8.	Environmental Meteorology and Pollution Modeling		EMM-616	3+0
9.	Smart Solid Waste Management		SWM-617	3+0
10.	Hydro informatics and Environmental Modeling		HEM-618	3+0
11.	Informatics in Natural Resource Management		INM-618	3+0
12.	Statistical Methods for Environmental Informatics		SME-620	3+0
13.	Informatics in Disaster Risk Reduction and Management		IDM-621	3+0
14.	Introduction to Machine Learning		ML-622	3+0
15.	Environmental Data Science and Technology Applications		EDT-623	3+0
16.	Systems Thinking and Sustainability		STS-624	3+0
17.	Informatics in Marine Environmental Management		IMM-625	3+0
18.	Computer Vision Techniques in Environment Monitoring		CTE-626	3+0
19.	Industrial wastewater pollution control		IWP-627	3+0
20.	Virtual Reality for Environmental Education and Advocacy		VER-628	3+0
21.	IoT-based techniques in Environmental Monitoring		IEM-629	3+0
22.	Eco-friendly Design and Sustainable Development		EDD-630	3+0

23.	Glacial Lake Outburst Floods (GLOFs): Risk Assessment and Mitigation		GRA-631	3+0
24.	Informatics in Wildlife Conservation		IWC-632	3+0
25.	Industrial Air Pollution Monitoring		IAM-633	3+0

4.22. List of Core Courses

From the total core courses, minimum of 4 courses are to be taken by the students.

4.23. Elective Courses

The elective courses have been formed keeping in view the needs in the field of Sustainable Integration of Environmental Development with Informatics in the country. Out of these, a student has to pass requisite number of courses to complete his total 24 credit hours of coursework

4.24. Proposed Study Plan for MS

Semester-I

Course	**Cr.hr**
Core course I	2+1
Core course II	3+0
Elective Course I	2+1
Elective Course I	3+0
Total	12

Semester-II

Course	**Cr.hr**
Core course III	2+1
Core course IV	3+0
Elective Course III	3+0

Research Methodology	Qualifying Scores
Total	9

Semester-III & IV

Course	**Cr.hr**
Elective Course IV	2+1
MS Thesis	6+0
Total	9

Total Program Credit Hours: 30

4.25. Course duration

Course	**Duration of Class**
Theory course of 03 Credit hours	3 classes of)1 hour per week OR 2 classes of 1.5 hour per week OR 1 class of 03 hours class per week
Practical (Lab) work/Field Work of 01 Credit hour	03 hours per week

Thesis (Third & Fourth Semesters)

MS Thesis: Every student should write a project report/thesis/research report/project/ internship in the final year up to maximum of 06 credit hours individually on a research topic approved by faculty in semester 3 and 4.

4.26. Proposed Research Areas and Benefit(s) to the Society

Major applied as well as theoretical research areas include but are not limited to:

- ICT applications in Climate change science: developments and applications

- Mitigation and adaptation to climate change using technology
- Reducing economic impacts of climate change using technology
- Industrial pollution, carbon emissions and their effects of climate change
- Predictive modelling for hazardous events like floods, rainfall, etc for data driven policy decisions

The inclusion of proposed program will benefit community in various ways including:

- Raising awareness about climate change and clarifying its fundamental concepts in youth and subsequently, the general public.
- Teaching youth on making necessary behavior changes to adapt to climate emergencies.
- Ability to identify and address climate-related issues in major sectors of Pakistan. This will significantly boost socio-economic well-being and ultimately promote sustainable development.
- Improving the present institutional capacity by providing relevant climate and sustainable development professionals

4.27. Intake

MS: 30 Seats

5. International practices:

List of International Universities offering programs similar to "MS in Climate Change and Environmental Informatics".

Sr. no.	University	Ranking (QS)	Ranking (THE)	Degree Title	Link
1.	John Hopkins University, USA	24	15	Energy Policy and Climate	MS in Energy Policy and Climate Hopkins Advanced Academic Programs (jhu.edu)
2.	Duke University, USA	50	25	Master of Environmental Management	Master of Environmental Manage Nicholas School of the Environment (duke.edu)

3.	University of Leeds, UK	86	128	Climate Futures: Science, Society, and Politics	Climate Futures: Science, Society and MSc | University of Leeds
4.	University of Helsinki, Finland	106	110	Environmental Change and Global Sustainability	EnvironmentalChange and Sustainability |Master's program | University of Helsin
5.	Erasmus University Rotterdam	208	80	Urban Environment, Sustainability& Climate Change	Program overview Master Environment, Sustainability & Climate Ch ErasmusUniversity Rotterdam (eur.nl)
6.	University of Hamburg, Germany	228	128	Integrated Climate System Sciences	www.sicss.uni-hamburg.de
7.	University of Milan, Italy	324	301-350	Environmental Change and Global Sustainability	Environmental change and global Sustainability (ECGS) | Università degli Studi di Milano Statale(unimi.it)
8.	SOAS (University of London), UK	443	501-600	Climate Change and Development	MSc/PGDip/PGCert Change and Climate Development (Online) | SOAS
9.	Liverpool University John Moores, UK	801-1000	401-500	Climate Change and Sustainability	Climate Change and Sustainability MSc | Liverpool John Moores University (ljmu.ac.uk)
10.	Antioch University			Environmental Studies, Sustainable Development & Climate Change	MS in Environmental Studies, sustainable Development & Climate Change › Antioch University

6. Detailed contents of Compulsory and Core courses

IEI-602	Intro to Environmental Informatics	3-0

Course Learning Outcomes (CLOs)	Domain	Taxonomy level	Program learning Outcomes (PLOs)
Understand the role of Information and Communication Technology (ICT) in environmental management.	Cognitive	Understanding (2)	PLO-01, PLO-07
Analyze different ICT tools and technologies used for environmental monitoring and data collection.	Cognitive	Analyzing (4)	PLO-01, PLO-02
Apply informatics solutions to manage and address environmental challenges such as pollution, resource management, and climate change.	Cognitive	Applying (3)	PLO-03, PLO-06
Evaluate the effectiveness of Informatics in enhancing sustainability and improving decision making in environmental management.	Cognitive	Evaluating (5)	PLO-07, PLO-08

Course Content:

Module 1:

- ICT tools and applications in environmental management
- Databases and data warehousing for environmental information, and Big data, IoT devices and their applications in environmental management.
- Geographic Information Systems (GIS) and their role in environmental management, GIS applications in natural resource management, disaster management, and pollution control, and Case studies on the use of GIS in managing environmental issues.

Module 2:

- Principles of remote sensing and applications of remote sensing in land use/land cover mapping, water resource management, and climate monitoring, Satellite imagery interpretation and its use in environmental management.
- Decision Support Systems and their applications for Environmental Management, Role of DSS in environmental policymaking and planning.

Module 3:

- Role of informatics (ICT's application) in managing water, energy, climate change and waste resources, ICT in promoting sustainable agriculture and forestry, and Case studies on the use of ICT in resource management.
- Informatics in risk assessment and assessment of environmental disasters, Early warning systems and real-time monitoring.

Module 4:

- Concept of smart cities, ICT infrastructure for smart cities and its environmental management, Smart grids, smart waste management, and smart water management systems.
- Informatics in climate change data collection and analysis, Climate modeling and simulation using ICT tools, ICT in supporting climate change adaptation and mitigation strategies, and Case studies on ICT applications in combating climate change.

Teaching Methodology

Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes

Recommended Books

- Helen Mazarakis (1996). Environmental Management Information Systems, International Business Communications.

- Wen Chen Hu and Naima Kaabouch (2012). Sustainable ICTs and Management Systems for Green Computing. Information Science Reference
- Jagbir Singh (2008). Information Technology & Environmental Management, M.D. Publications Pvt. Limited

ICT-603	**Information and communication Technology**	**2+1**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand fundamental ICT concepts and components.	Cognitive	Remembering (1)	PLO-05, PLO-07
Identify common communication technologies and applications.	Cognitive	Understanding (2)	PLO-05, PLO-07
Discuss the importance of cybersecurity and privacy in ICT.	Cognitive	Evaluating (5)	PLO-05, PLO-08
Develop practical skills in using ICT tools and technologies.	Psychomotor	Applying (3)	PLO-05, PLO-09
Demonstrate effective use of communication technologies in real-world scenarios.	Psychomotor	Applying (3)	PLO-05, PLO-9

Module 1: ICT System and Databases

- Information and Communication Technology (ICT), Historical evolution, Key components of ICT: Hardware, software, and communication networks. Evolution of ICT and its global significance.
- Basics of information systems, their Design, components, and functions. Introduction to databases: Relational databases, NoSQL databases. Environmental data storage principles and tools.

Module 2: Communication Technologies and Programming

- LAN, WAN, Internet. Wireless communication technologies (e.g., Wi-Fi, Bluetooth). Data transmission protocols and security in communication systems.

- Introduction to programming languages commonly used in ICT (MATLAB, Python, R). Basics of coding for data analysis and processing. Scripting and automation for ICT tasks.

Module 3: Cloud Computing, Virtualization, and Cybersecurity

- Introduction to cloud computing: Concepts and services, Cloud platforms (e.g., AWS, Google Cloud) for data storage and processing. Virtualization and its role in resource optimization.
- Principles of cybersecurity and data protection. Common threats and vulnerabilities in ICT systems. Securing environmental data and systems.

Module 4: Emerging ICT Technologies

- Artificial Intelligence (AI) and Machine Learning (ML) basics. Blockchain technology for secure data management. ICT in the Internet of Things (IoT).

Module 5: ICT Policy and Ethical Considerations

- ICT standards and policies. Ethical issues in ICT implementation and use. Balancing technological advancement with societal impacts.

Teaching Methodology

Lecturing, Written Assignments, Interactive Sessions, Guest Speakers, Visits of Met office

Practical/Lab Course Content

Throughout the lab curriculum, students will engage in practical exercises designed to introduce them to Information and Communication Technology (ICT) tools and concepts. The following content will be covered in the practical sessions:

Module 1: Hardware Familiarization:

- Students will familiarize themselves with various ICT hardware components, including personal computers, laptops, tablets, smartphones, routers, and switches. They will learn to identify different hardware components and understand their functions in ICT systems.

- Equipment: Personal computers, laptops, tablets, smartphones, routers, switches

Module 2: Operating System Installation and Configuration:

- Students will learn to install and configure different operating systems (e.g., Windows, Linux, macOS) on virtual machines or physical devices. They will explore basic operating system functionalities, user interfaces, and system settings.

- Software: Virtualization software (e.g., VirtualBox, VMware), Operating system installation images

Module 3: Networking Basics:

- Introduction to networking concepts such as IP addressing, subnetting, TCP/IP protocols, and network topologies. Students will practice configuring network settings on computers and devices and performing basic network troubleshooting tasks.
- Equipment: Network cables, routers, switches, patch panels

Module 4: Introduction to Programming:

- Basic programming concepts using high-level languages such as Python or Java. Students will write simple programs to perform tasks like data manipulation, file handling, and basic algorithm implementation.
- Software: Integrated Development Environments (IDEs) (e.g., PyCharm, Visual Studio Code), Python or Java runtime environments

Module 5: Database Management:

- Introduction to database management systems (DBMS) and Structured Query Language (SQL). Students will learn to create and manipulate databases, write SQL queries to retrieve and manipulate data, and perform database administration tasks.
- Software: Database management systems (e.g., MySQL, PostgreSQL), SQL query tools (e.g., MySQL Workbench, pgAdmin)

Module 6: Web Development Basics:

- Basic web development concepts including HTML, CSS, and JavaScript. Students will learn to create static web pages and style them using CSS. They will also learn to add interactivity to web pages using JavaScript.
- Software: Text editors (e.g., Sublime Text, Visual Studio Code), Web browsers

Recommended Books

- Rainer, R. K., Prince, B., Sanchez-Rodriguez, C., Splettstoesser-Hogeterp, I., & Ebrahimi, S. (2020). Introduction to information systems. John Wiley & Sons.
- Ashton, K. (2009, June 22). That “Internet of Things” Thing. RFID Journal.
- Sklar, B. (2021). Digital communications: fundamentals and applications. Pearson.

- Recker, J. (2021). Scientific research in information systems: a beginner's guide. Springer Nature.
- Craig Van Slyke (2008). Information Communication Technologies Concepts, Methodologies, Tools and Applications · Volume 2. Publisher:Information Science Reference
- Abraham Silberschatz, Henry F. Korth, Database System Concepts, sixth edition.
- Thomas Erl , Ricardo Puttini, Zaigham Mahmood. Cloud Computing: Concepts, Technology & Architecture (The Pearson Service Technology Series from Thomas Erl), 1st Edition.
- Charles J. Brooks, Christopher Grow, Philip A. Craig Jr. Cybersecurity Essentials 1st Edition.
- Michael Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems, 3RD EDITION Paperback, January 1, 2019.

ECC-604	**Environmental Chemistry and Climate Impact**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand environmental chemistry's role in climate science.	Cognitive	Understanding (2)	PLO-01, PLO-07
Analyze climate-relevant chemistry, including greenhouse effects, acid rain, and ozone chemistry.	Cognitive	Analyzing (4)	PLO-01, PLO-02, PLO-07
Apply environmental knowledge to address climate challenges, integrating climate considerations into solutions.	Cognitive	Applying (3)	PLO-01, PLO-03, PLO-07

Course Content:

Module 1: Fundamentals of Environmental Chemistry

- Concept and scope of environmental chemistry. Aquatic, atmospheric, and soil chemistry fundamentals. Greenhouse effect and its impact on biological systems.
- Chemistry of acid rain reactions and its environmental consequences. Ozone chemistry, causes, and adverse effects on the environment.

Module 2: Chemical Properties of Environmental Components

- Physical and chemical properties of water, wastewater, air, and soil. Acid-base equilibrium, chemical kinetics, and oxidation-reduction reactions.

Module 3: Environmental Microbiology and Climate

- Basics, classification, and growth mechanisms of microbes. Influence of environmental factors on microbial growth and distribution.
- Microbial metabolism and its role in biogeochemical cycles.

Module 4: Biodegradation and Bioremediation

- Mechanisms of coagulation, adsorption, and precipitation. Biodegradation and bioremediation of organic and inorganic pollutants.
- Understanding the environmental impact of biogeochemical cycles.

Module 5: Climate-Resilient Environmental Solutions

- Exploration of sustainable practices for mitigating climate-related environmental challenges.
- Integration of climate considerations into environmental chemistry solutions.

Module 6: Analytical Techniques for Climate Impact Assessment

- Introduction to environmental analytical techniques.
- Instrumental techniques for environmental analysis, emphasizing climate-related parameters.
- Application of analytical methods for assessing climate impact. Analysis of real-world case studies demonstrating the connection between environmental chemistry and climate change.
- Application of acquired knowledge to propose innovative and sustainable solutions for climate-related challenges.
- Critical evaluation of current environmental policies and practices in the context of evolving climate scenarios.

Teaching Methodology

Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes

Recommended Books

- Physico-chemical Processes in Environmental Engineering. John Wiley & Sons, USA.
- Microbiology and Chemistry for Environmental Scientists and Engineers. E & FN Spon.
- Principles of Environmental Chemistry. 1st Edition, Jones and Barlett, USA.
- Manahan, S. E. (2022). Environmental chemistry. CRC press.
- James Girard (2010). Principles of Environmental Chemistry. Publisher:Jones & Bartlett Learning
- Environmental Microbiology, Methods and Protocols. John M. Walker, John F. T. Spencer, Alicia L. Ragout de Spencer
- Principles of environmental chemistry. Girard, James
- Acid Rain, Causes, Effects, and Control. J. Laurence Kulp
- Brock Biology of Microorganisms (13th Edition) 13th Edition. Michael T. Madigan, John M. Martinko, David Stahl, David P. Clark

MME-605	**Mathematics for Environmental Informatics**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand the significance of mathematical modeling in environmental studies.	Cognitive	Understanding (2)	PLO-01, PLO-07
Gain proficiency in foundational mathematical concepts.	Cognitive	Applying (3)	PLO-02, PLO-04
Develop skills in optimization techniques and model validation.	Cognitive	Applying (3)	PLO-02, PLO-05

Course Content

Module 1: Basic Mathematical Concepts

- Calculus: Differential equations, integration, and their applications in environmental models. Linear Algebra: Matrices, vectors, and linear systems. And probability and Statistics: Probability distributions, statistical inference, and data fitting.

Module 2: Introduction to Mathematical Modeling in Environmental Studies

- Definition and importance of mathematical models and its role in environmental studies. Types of Models: Deterministic, stochastic models, static and dynamic models. Modeling Process: Formulation, analysis, validation, and application of models. And applications of Models in Environmental Decision-Making.

Module 3: Environmental System Modeling

- Population Dynamics: Lotka-Volterra Models: Predator-prey and competitive species models.
- Logistic Growth Models: Modeling population growth with carrying capacity. Ecosystem Models: Trophic Models: Energy flow and nutrient cycling in ecosystems. Biogeochemical Cycles: Modeling carbon, nitrogen, and phosphorus cycles.
- Water Resource Models: Hydrological Models: Rainfall-runoff models, watershed modeling.
- Water Quality Models: Modeling pollutant transport and fate in aquatic systems.

Module 4: Climate Change Models

- Modelling Climate systems and climate changes predictions.
- General Circulation Models (GCMs): Simulating global climate systems and interactions.
- Regional Climate Models (RCMs): Finer-scale climate predictions.
- Numerical Weather Prediction (NWP): Modeling atmospheric processes for weather forecasting.
- Applications in Climate Policy and Mitigation Strategies. Validation Techniques: Comparing model outputs with observed data to assess accuracy.
- Sensitivity Analysis: Evaluating how changes in model parameters affect outputs.

Module 5: Environmental Impact Assessment

- Impact Prediction Models: Estimating environmental impacts of human activities (e.g., land use changes, pollution).
- Risk Assessment Models: Modeling risk and uncertainty related to environmental hazards.

Module 6: Environmental Decision Support Systems and Optimization

Techniques

- Development of Decision Support Systems for Environmental Management.
- Linear Programming: Resource allocation and management problems.
- Nonlinear Optimization: Complex environmental systems and constraints.
- Decision Support Systems (DSS): Integrating models into decision-making processes for environmental management.

Module 7: Emerging Trends and Advanced Topics

- Integrated Models: Combining various environmental models for holistic assessments (e.g., coupled climate-water models). Machine Learning and AI: Application of advanced computational techniques to improve model predictions. And Modeling Uncertainty: Addressing uncertainties in model predictions and data.

Teaching Methodology

Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes

Recommended Books

- Banerjee, S. (2021). Mathematical modeling: models, analysis and applications. Chapman and Hall/CRC.
- Velten, K., Schmidt, D. M., & Kahlen, K. (2024). Mathematical modeling and simulation: introduction for scientists and engineers. John Wiley & Sons.
- Peter C. R. and Philip L. K. "Mathematical Models for Environmental Science
- Keith A. Houghton "Applied Environmental Statistics and Modeling.
- David F. Parkhurst · (2006). Introduction to Applied Mathematics for Environmental Science. Publisher:Springer US.
- Charles R. Hadlock (1998). Mathematical Modeling in the Environment. Publisher:Mathematical Association of America

RES-606	**Recent Trends in Environmental Engineering**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand the recent advancements and	Cognitive	Understanding (2)	PLO-01, PLO-07

trends in environmental science and engineering.			
Analyze emerging environmental technologies and innovations for sustainable development.	Cognitive	Analyzing (4)	PLO-01, PLO-06
Apply new scientific methods and engineering practices to address contemporary environmental challenges.	Cognitive	Applying (3)	PLO-03, PLO-05
Evaluate the effectiveness of recent trends in improving environmental quality and resource management.	Psychomotor	Evaluating (5)	PLO-01, PLO-03, PLO-06

Course Content:

Module 1: Environmental Science/Engineering

- Environment, its importance and current challenges in Environmental Science/Engineering, the role of technology and innovation in addressing environmental issues
- SDGs and their environmental implementations.

Module 2: Recent trends in Climate Challenges

- Global warming impacts on ecosystems, and Climate Change mitigation and adaptation strategies

- water conservation and management practices, methods for pollution control and environmental remediation, and recent developments in water treatment and purification technologies, Addressing water scarcity and pollution through engineering solutions
- Principles of sustainability in environmental science and engineering
- Innovations in green engineering and sustainable design, and Circular economy applications
- Advances in renewable energies, emerging technologies such as bioenergy and energy storage solutions, and Integration of renewable energy systems into existing infrastructures
- New approaches to biodiversity monitoring and conservation, Ecosystem service valuation and management, and restoration ecology.

Module 3: Environmental Monitoring and Data Analysis

- New technologies in environmental monitoring (e.g., satellite remote sensing, IoT sensors)
- Big data analytics and its application in environmental monitoring, Data visualization and interpretation techniques

Module 4: Environmental Policy and Regulation

- Recent changes in environmental policies and regulations, The role of international agreements and local regulations
- Policy-driven innovations in environmental science and engineering

Module 5: Technological Innovations and Emerging Trends

- Exploration of future trends such as synthetic biology, environmental genomics, and advanced materials
- Role of Artificial Intelligence (AI) and Machine Learning applications in environmental modeling, prediction, and data analysis.
- Corporate Social Responsibility (CSR): The role of businesses in promoting sustainable practices and innovations.
- New Approaches in Global Environmental Governance.

Teaching Methodology

Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes

Recommended Books

- Trends in Environmental Sustainability and Green Energy. Jinkeun Kim, Zhe Chen (2023)
- Environmental Science and Engineering. Maulin P. Shah, Mohammed J.K.

Bashir, Aliasgahr Ensafi, Zawawi Bin Daud, Fadi Hage Chehade (2024)
- Microbial Remediation of Hazardous Chemicals from Water & Industrial Wastewater Treatment Plants. Maulin P. Shah (2024)
- Zhang, C. (2024). Fundamentals of environmental sampling and analysis. John Wiley & Sons.
- Mackenzie Davis and Susan (2003). Principles of Environmental Engineering and Science. McGraw Hill.

CAD-607	**Climate Change Adaptation and Disaster Mitigation**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand the relationship between climate change adaptations and disaster mitigation.	Cognitive	Understanding (2)	PLO-01, PLO-06
Develop skills in applying climate models and international protocols for adaptation and mitigation.	Cognitive	Applying (3)	PLO-02, PLO-04
Analyze roles of stakeholders in addressing climate challenges in Pakistan.	Cognitive	Analyzing (4)	PLO-06, PLO-09

Course Content:

Module 1: Climate Dynamics and Impacts

- Climate change implications and disaster management, Key concepts in disaster management
- Examining roles and activities of stakeholders in adaptation and disaster management, Strategies for adapting to changing climate conditions

Module 2: **International Protocols and Governance**

- Climate models and their significance, international protocols addressing climate change, and Roles and responsibilities of government entities in climate adaptation and disaster management

Module 3: Hazards Management, Water Management, and Hydro-logical Modeling and Forecasting

- Understanding dynamics, risks, and strategies for floods, desertification, and landslides
- Specific mitigation for various natural disasters
- Managing hazards linked to glaciers, ice melting, and water resources
- Principles of water management in the context of climate change
- Building resilience against floods and droughts
- Hands-on lab work on water management techniques
- Basics of hydro-logical modeling for climate adaptation
- Application of hydro-logical models in disaster risk assessment
- Developing and implementing effective forecasting systems

Module 4: Community Engagement and NGO Involvement

- Engaging communities for sustainable disaster resilience
- The role of non-governmental organizations in climate initiatives, and collaborative efforts for effective governance

Module 5: Tools and Technologies for Climate Resilience

- Tools and technologies for climate change adaptation
- Practical applications of adaptation tools in disaster management
- Integrating climate considerations into broader development strategies

Teaching Methodology

Lecturing, Written Assignments, Interactive Sessions, Guest Speakers, Visits of Met office

Recommended Books

1. Climate Change: A Multidisciplinary Approach. 2nd Edition, Cambridge University Press, UK. BURROUGHS, William James (2007)
2. Climate Change: Science, Strategies, and Solutions. Brill Co., CLAUSSEN, Eileen

(2001)
3. Urban Development and Climate Change. Human Settlements Working Paper Climate Change and Cities 1, International Institute for Environment and Development, DAVID, Satterthwaite et al. (2007)
4. Climate Change: A Natural Hazard. MultiScience, KININMONTH, William (2004)
5. Adaptation to climate change / Mark Pelling. Abingdon, Oxon, England; New York Routledge, c2010. 9780415477505 (hardback)
6. Climate Change - Causes, Effects, and Solutions, 1st Edition, Hardy, J. T., John Wiley & Sons, 2003.
7. The Green House Effect, Climate Change and Ecosystems. Warrick, B & Jager, D. (Ed.). ECOPE 29. John Wiley & Sons. Chichester. UK 1991
8. Environmental Science, 6th Ed. Mc-Graw Hill, Cunningham W.P., & Saigo, B.W., 2001.

EDA-608	**Environmental Data Analytics and Visualization**	**2+1**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand the fundamental concepts of environmental data analytics and their importance in environmental science and management.	Cognitive	Understanding (2)	PLO-01, PLO-07
Analyze large environmental datasets to derive meaningful insights using data analytics techniques.	Psychomotor	Analyzing (4)	PLO-01, PLO-6
Apply various data visualization tools to represent complex	Cognitive	Applying (3)	PLO-03, PLO-05

environmental data effectively.			
Evaluate the effectiveness of different environmental data visualization techniques for decision-making and communication.	Cognitive	Evaluating (5)	PLO-03, PLO-06, PLO-07

Course Content:

Module 1: Data Analytics

- Aata analytics in environmental science, data types and sources (e.g., remote sensing, IoT sensors, field data), and data analysis process from data collection to decision-making
- Methods for data acquisition (satellite imagery, ground-based sensors), Data collection techniques: remote sensing, field surveys, sensor.
- Data management, cleaning and preprocessing techniques

Module 2: Techniques and methods

- Regression analysis (linear, multiple, and logistic regression), Time series analysis (trends, seasonal patterns, forecasting), Spatial analysis (interpolation, spatial autocorrelation), and Multivariate analysis: Principal Component Analysis (PCA), and Cluster Analysis Data visualization techniques for EDA (histograms, scatter plots, box plots)
- GIS concepts and tools, remote sensing technology
- Image acquisition, Image preprocessing techniques (e.g., atmospheric correction, image enhancement), and its applications in environmental monitoring.

Module 3: Big Data Analytics and Data Visualizations

- Big Data concepts and technologies, Large datasets handling and processing
- Visualization tools and software (e.g., Tableau, R, Python libraries such as Matplotlib and Seaborn), Principles of effective visualization (clarity, accuracy, and aesthetics).
- Interactive dashboards development using tools like Tableau and Power BI

Module 4: Case Studies and Applications

- Analysis of real-world environmental data sets and case studies

- Applications in areas such as climate change, pollution monitoring, and natural resource management.
- Successful data analytics projects and visualization strategies

Teaching Methodology

Lecturing**,** Written Assignments**,** Presentation/seminars**,** Interactive Sessions /Class Discussion**,** Guest Speakers**,** and Quizzes

Practical/lab content:

1. Data Collection and Preparation
2. Statistical Analysis and Modeling
3. Geographic Information Systems (GIS)
4. Importing and visualizing spatial data in QGIS.
5. Remote Sensing and Image Processing
6. Data Visualization Techniques
7. Interactive Dashboards and Web-Based Visualizations

Recommended Books

- William Menke (2022). Environmental Data Analysis with MatLab Or Python. Elsevier Science.
- Peter A. Burrough and Rachael A. (2015). "Principles of Geographical Information Systems. McDonnell
- Abbas F. M. Al-Karkhi, Wasin A. A. Alqaraghuli · (2019). Applied Statistics for Environmental Science with R. Publisher : Elsevier Science
- Rai, P. K., Mishra, V. N., & Singh, P. (2022). Geospatial Technology for Landscape and Environmental Management. Springer Singapore.

DSG-609	**Digital Sustainability Strategies and Green Informatics**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand the intersection between digital technologies	Cognitive	Understanding (2)	PLO-05, PLO-07

and environmental sustainability.			
Explore the role of Information Technology (IT) in addressing environmental challenges.	Cognitive	Understanding (2)	PLO-05, PLO-07
Acquire knowledge and skills related to sustainable practices in IT infrastructure and software development.	Cognitive	Applying (3)	PLO-05, PLO-6
Engage in practical exercises exploring Digital Sustainability Strategies and Green IT.	Psychomotor	Applying (3)	PLO-05, PLO-6

Course Content:

Module 1: Digital Sustainability and Principles of Green Informatics

- The intersection of digital technologies and environmental sustainability.
- Potential impact of IT on addressing environmental challenges.
- Methods for reducing energy consumption in IT infrastructure and Eco-friendly IT practices in data centers, networks, and devices.

Module 2: Circular Economy and Digital Transformation

- Circular economy in IT hardware and software, environmental impact of electronic waste through sustainable practices.
- Designing and managing energy-efficient communication networks.
- Eco-friendly approaches in designing and coding software.
- Digital technologies for sustainable urban development.
- Internet of Things (IoT) to collect and analyze environmental data.

Module 3: Data Analytics for Environmental Impact Assessment

- Analyzing large datasets to derive insights for environmental impact assessment.
- Machine Learning for Sustainable Decision-Making

Module 4: Corporate Social Responsibility in the Digital Age

- Integrating ethical considerations and corporate social responsibility into digital strategies.
- Ensuring sustainability in the procurement and lifecycle of IT products.

Module 5: Case Studies and Best Practices

- Real-world Applications: Analyzing case studies of organizations implementing digital sustainability strategies.
- Best Practices for Green IT: Identifying and applying industry best practices for sustainable IT.

Teaching Methodology

Lecturing, Written Assignments, Interactive Sessions, Guest Speakers, Visits of Met office

Recommended Books

- The Green IT Guide, Ten Steps Toward Sustainable and Carbon-Neutral IT Infrastructure, Mike Halsey.
- Sustainability Awareness and Green Information Technologies, Tomayess Issa, Theodora Issa, Touma B. Issa, Pedro Isaias.
- Green IT Strategies and Applications, Bhuvan Unhelkar
- Greening Through IT: Information Technology for Environmental Sustainability First Edition, Bill Tomlinson.
- Sustainable IT Architecture: The Progressive Way of Overhauling Information Systems with SOA, Pierre Bonnet, Jean-Michel Detavernier, Dominique Vauquier.
- Energy-Efficient Computing and Data Centers, Luigi Brochard, Vinod Kamath, Julita Corbalán, Scott Holland, Walter Mittelbach, Michael Ott.
- ICT Innovations for Sustainability, Lorenz M. Hilty, Bernard Aebischer.
- Harnessing Green IT, Principles and Practices, San Murugesan, G. R. Gangadharan.

7. Detailed Contents of Elective Courses

RSG-610	**Remote Sensing and GIS**	**2+1**

Course Learning Outcomes (CLOs)	Domain	Taxonomy Level	Program Learning Outcomes (PLOs)
Demonstrate proficiency in acquiring and preprocessing remote sensing data.	Cognitive	Applying (3)	PLO-02, PLO-05
Apply GIS for climate disaster mapping and hazard assessment.	Cognitive	Applying (3)	PLO-03, PLO-05
Integrate remote sensing and GIS for environmental decision-making.	Cognitive	Creating (6)	PLO-03, PLO-05, PLO-07
Engage in hands-on activities to apply remote sensing and GIS techniques in the lab.	Psychomotor	Applying (3)	PLO-05, PLO-09

Course Content:

Module 1: GIS, Spatial Data Analysis & Remote Sensing

- Introduction to GIS, Spatial Data Models
- Coordinate Systems and Map Projections, Working on Google Earth / Google Maps
- Spatial Analysis Techniques (Overlay analysis, buffer analysis, and spatial queries, Network analysis and least-cost path analysis)
- Spatial Interpolation (Methods of interpolation (IDW, Kriging) Applications of spatial interpolation in environmental and resource management
- 3D GIS and Terrain Analysis (Digital Elevation Models (DEMs) and their applications)
- Geostatistical Analysis (Spatial autocorrelation and variogram analysis)
- Remote Sensing Platforms and Sensors, Active and Passive remote sensing.

Module 2: Data Acquisition and Processing

- Absolute and Relative Georeferencing
- Digitization and Topological errors
- Attributes and Data joining and Geodatabases
- Data Downloading (DIVA GIS, USGS Earth Explorer)
- Spatial Data import and Export (KMLs, Cad and Excel files)
- Remote sensing data (multispectral, hyperspectral, panchromatic)
- Satellites data sources (Landsat, Sentinel, MODIS, commercial satellites)

Module 3: Satellite Image Analysis and Processing

- Digital Elevation Model and Satellite Imagery Downloading and Processing
- Elevation, Contours, Slope, Aspect extraction
- Image classification using supervised and unsupervised techniques
- Watershed and Hydrological analysis using DEM Lecture based examination

Module 4: Remote Sensing and GIS Integration and their Applications

- Integrating Remote Sensing Data into GIS
- GIS-based Modeling
- Techniques for combining raster and vector data
- Decision support systems in GIS
- Applications in Environmental Monitoring, Urban and Regional Planning, Disaster Management, and Environmental protection and resource conservation

Teaching Methodology

Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion Gues, Speakers, and Quizzes

Practical/lab content:

1. Data Collection and Preparation
2. Review of Image processing and GIS software
3. Demonstration of GPS operations
4. Interpretation of satellite images for different application
5. Statistical Analysis and Modeling
6. Geographic Information Systems (GIS)
7. Classification LULC
8. Remote Sensing and Image Processing
9. Preparation of GIS Maps for different utilities

Recommended Books

- Petrou, M. M., & Kamata, S. I. (2021). Image processing: dealing with texture. John Wiley & Sons.

- Pucha-Cofrep, F., Fries, A., Cánovas-García, F., Oñate-Valdivieso, F., González-Jaramillo, V., & Pucha-Cofrep, D. (2018). Fundamentals of GIS: applications with ArcGIS. Franz Pucha Cofrep.
- Wise, S. (2018). GIS fundamentals. CRC Press.
- Emery, W., & Camps, A. (2017). Introduction to satellite remote sensing: atmosphere, ocean, land and cryosphere applications. Elsevier.
- Bolstad, P. (2016). GIS fundamentals: A first text on geographic information systems. Eider (PressMinnesota).
- GIS Fundamentals: A First Text on Geographic Information Systems, NEW and UPDATED Sixth Edition, Paul Bolstad, (2019)
- Fundamentals of Satellite Remote Sensing: An Environmental Approach, Second Edition 2nd Edition, Kindle Edition, Emilio (2016)
- Fox, L. (2015). Essential Earth imaging for GIS. Esri Press
- Lavender, S., & Lavender, A. (2015). Practical handbook of remote sensing. CRC Press.
- Lillesand, T., Kiefer, R. W., & Chipman, J. (2015). Remote sensing and image interpretation. John Wiley & Sons.

RET-611	**Renewable Energy Technologies**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand renewable energy resources and technologies for sustainability and energy conservation.	Cognitive	Understanding (2)	PLO-01, PLO-03, PLO-04
Explore solar, wind, hydropower, geothermal, hydrogen, and nuclear energy basics.	Cognitive	Understanding (2)	PLO-01, PLO-03, PLO-04
Cover economic aspects, temporal	Cognitive	Analyzing (4)	PLO-01, PLO-05, PLO-06

considerations, and comparative review of sustainable energy technologies.			
Engage in hands-on exercises using renewable energy equipment and software for analysis and modeling.	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-06

Module 1: Renewable Energy and Solar Energy Technologies

- Global energy demand and supply, types of renewable energy sources: solar, wind, biomass, geothermal, hydro, and ocean energy, and its role in sustainable development.
- Renewable Energy and Climate Change Mitigation
- Solar radiation fundamentals, Photovoltaic (PV) systems: principles, Types, and components.
- Solar thermal systems: design, applications and challenges.

Module 2: Types of energies:

- Wind resource assessment, Aerodynamics of wind turbines, Types of wind turbines and their applications. And Design, Siting, and Installation of Wind Farms
- Biomass resources and their availability, Conversion technologies: combustion, gasification, anaerobic digestion. And Biofuels: biodiesel, bioethanol, and biogas.
- Geothermal resources and their classification, Geothermal power plants: types and working principles, and Direct use applications of geothermal energy.
- Hydropower potential and resource assessment, Types of hydropower plants: run-of-the- river, reservoir, and pumped storage, and Turbines used in hydropower plants.
- Ocean energy resources: wave, tidal, and ocean thermal energy conversion (OTEC), Technologies for harnessing ocean energy, and Environmental impacts and challenges of ocean energy.

Module 3: Energy Storage Systems

- Importance of energy storage in renewable energy systems,
- Types of energy storage: batteries, flywheels, supercapacitors, hydrogen storage, Integration of storage with renewable energy sources.

Module 4: Hybrid Renewable Energy Systems

- Concept and design of hybrid renewable energy systems, Optimization techniques for hybrid systems, and Case studies of hybrid systems

Module 5: Emerging Technologies and Future Trends

- Advances in renewable energy technologies,
- Emerging technologies: artificial intelligence in renewable energy,
- Advanced materials, etc, Future trends and research directions in renewable energy.
- Case Studies: Renewable Energy Policy Success Stories

Teaching Methodology

Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

- Kalogirou, S. A. (2023). Solar energy engineering: processes and systems. Elsevier.
- Goswami, D. Y. (2022). Principles of solar engineering. CRC press.
- Letcher, T. (Ed.). (2023). Wind energy engineering: A handbook for onshore and offshore wind turbines. Elsevier.
- Twidell, J. (2021). Renewable energy resources. Routledge.

AEM-612	**Advanced Energy Modeling and Simulation**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Provide overview of energy management, renewable energy modeling.	Cognitive	Understanding (2)	PLO-01, PLO-03, PLO-04
Analyze energy economics, carbon mitigation, sustainable building design.	Cognitive	Analyzing (4)	PLO-01, PLO-05, PLO-06

Understand energy policy, regulations, building automation, sustainable design.	Cognitive	Understanding (2)	PLO-01, PLO-07, PLO-08
Engage in practical exercises using software for modeling and analyzing energy systems.	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-09

Course Content:

Module 1: Energy Modeling

- Energy systems and networks, Renewable energy resources and non-renewable energy resources, and Importance of Energy Modeling and Simulation.
- Fundamental Principles and types of Modeling,
- Numerical methods and solving Equations, Exponential Growth and Decay Modeling, logistic models, and Empirical Modeling, linear and multiple regression, Correlation, simulation of models

Module 2: Models Calibration and Validation:

- Mathematical Foundations for Advanced Modeling
- Advanced differential equations and linear algebra applications,
- Modeling Renewable Energy Sources, modeling of solar, wind, tidal, and hydro power systems,
- Accuracy, Precision and Bias, error estimation, Mean absolute error, and Mean bias error (MBE), Comparison and Validation of Models, Coefficient of multiple determination
- Intermittency and variability in renewable energy generation.

Module 3: Energy overview and Resources of Pakistan

- Role of the states, National Power policy, Performance of Pakistan Power sector, Power generation potential of installed energy systems,
- Present energy state, Energy sources and policy suggestions for future,
- Global energy policies,
- Energy management solutions, Energy conservation and sustainability.

Module 4: Future Trends in Energy Modeling

- Modeling Decarbonization Pathways
- Role of Artificial Intelligence (AI) and Machine Learning in Energy Modeling
- Big Data and the Internet of Things (IoT) in Energy Systems
- Decentralized Energy Systems and Peer-to-Peer Energy Trading
- Energy Systems under Climate Change Scenarios
- Emerging Trends in Global Energy System Simulation

Teaching Methodology

Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books:

- Thumann, A., & Mehta, D. P. (2020). Handbook of energy engineering. River Publishers.
- Bilash Kanti Bala (1998). Energy and Environment: Modelling and Simulation. Nova Science publication Inc.
- Velten, K., Schmidt, D. M., & Kahlen, K. (2024). Mathematical modeling and simulation: introduction for scientists and engineers. John Wiley & Sons.
- David M. Kammen and Daniel M. Kammen. Handbook of Energy Systems: Energy Conversion, Storage, and Utilization by
- Harold Klee and Randal Allen (2018). Simulation of Dynamic Systems with MATLAB and Simulink"
- Steven I. Gordon, Brian Guilfoos (2017). Introduction to Modeling and Simulation with MATLAB (R) and Python.
- Hooman Farzaneh (2019). Energy Systems Modeling Principles and Applications. Publisher:Springer Nature Singapore

EGI-613	**Environmental Governance and Informatics**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand the principles and frameworks of environmental	Cognitive	Understanding (2)	PLO-01, PLO-07

governance and the role of ICTs in supporting these frameworks.			
Analyze the impact of Information and Communication Technologies (ICTs) on environmental policy-making and governance.	Psychomotor	Analyzing (4)	PLO-01, PLO-6
Apply ICT tools for monitoring, reporting, and improving environmental governance processes.	Cognitive	Analyzing (4)	PLO-02, PLO-03, PLO-05

Course Content:

Module 1: Environmental Governance and Informatics' role

- Definition and Importance of Environmental Governance
- Key Principles: Transparency, Accountability, Participation, Global Challenges
- Governance Frameworks: Multilevel Governance, Adaptive Governance,
- Stakeholders in Environmental Governance: Government, NGOs, Corporations, Local Communities
- Scope of ICTs, Evolution and Current Trends: Cloud Computing, Artificial Intelligence, Big Data
- ICTs' Role in Society: Connectivity, Data Management, Decision Support

Module 2: Intersection of Environmental Governance and Informatics

- Informatics (ICT's applications) and its Role in Governance
- Global and national ICT Law and Global Environmental Governance,
- Applications in Policy Development and Implementation
- Informatics for developing Environmental Monitoring mechanism and Data Collection

Module 3: Informatics for Environmental Governance

- Geographic Information Systems (GIS) and Remote Sensing
- Environmental Data Management Systems
- Decision Support Systems (DSS) for Environmental Management
- Social Media and Crowdsourcing for Environmental Issues

Module 4: Challenges and Ethical Considerations

- Data Privacy and Security in Environmental Governance
- Digital Divide and Access Issues
- Informatics and the Risk of Surveillance
- Balancing Technological Advancement with Ethical Concerns

Module 5: Policy and Regulatory Frameworks

- International Standards and Agreements: e.g., UNEP, Global Environmental Facilities
- National Policies on ICTs and Environmental Governance
- Role of International Organizations and NGOs
- Best Practices and Guidelines

Module 6: Future Trends and Innovations

- Emerging Technologies: Blockchain for Transparency, AI for Predictive Analytics
- Innovations in ICTs for Enhanced Environmental Governance
- Future Research Directions
- Case Studies of Successful ICT Integration in Environmental Governance

Teaching Methodology

Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes

Recommended Books:

- Jérôme Duberry, Josep Ibáñez · (2014).Environmental Governance and New ICTs The Impact of New Information and Communication Technologies on Global Environmental Governance. Publisher:Universitat Pompeu Fabra.
- Michael T. Wright "Digital Tools for Environmental Governance"
- James Meadowcroft and Oluf Langhelle "Environmental Governance: A Handbook of Theory and Practice".
- Jérôme Duberry · (2021). Global Environmental Governance in the Information Age Civil Society Organizations and Digital Media. Publisher:Taylor & Francis Group

SAT-614	**Sustainable Agriculture**	**2+1**

Course Learning Outcomes (CLOs)	Domain	Taxonomy Level	Program Learning Outcomes (PLOs)
Explore smart irrigation technologies for water management in agriculture.	Cognitive	Understanding (2)	PLO-01, PLO-05, PLO-10
Use IoT for real-time water monitoring and sensor integration in agriculture.	Cognitive	Applying (3)	PLO-02, PLO-04, PLO-05
Apply digital tools and ICTs for crop health monitoring and climate-resilient practices.	Cognitive	Applying (3)	PLO-01, PLO-05, PLO-06
Gain hands-on experience with lab equipment for sustainable agriculture practices.	Psychomotor	Applying (3)	PLO-02, PLO-05, PLO-09

Course Content

Module 1: Sustainable agriculture:

- Principles of sustainable agriculture, Conventional and sustainable agriculture system
- Need of sustainable agriculture and historical development in agricultural sector
- Soil Ecology and its Role in Sustainable Agriculture
- Soil Fertility Management and the Use of Organic Fertilizers
- Impact of Chemical Fertilizers and Pesticides on Soil Health
- Conservation Tillage and No-Till Farming
- Practices to Improve Soil Health (Crop Rotation, Cover Crops, Composting)

Module 2: Water Management in Sustainable Agriculture

- Efficient water use in Agriculture
- Overview of Integrated Water Resource Management (IWRM) for Agriculture
- Smart Irrigation Techniques (Rainwater Harvesting, Drip, Sprinkler)
- Water Conservation and Management in Drylands and Arid Regions
- Climate Changes impacts on water and agriculture

Module 3: Sustainable farming and Ecosystem Management

- Principles and practices in organic farming, Crop rotation and conservation tillage, Integrated pest management
- Ecological Principles and agroecosystems
- Biodiversity and its significance in agriculture
- Water conservation and management

Module 4: Applications and Role of Informatics in Sustainable Agriculture

- Data-driven farming and Precision agriculture, use of machine learning and deep learning models
- GIS and Remote sensing in agriculture
- Digital tools and mobile applications for agriculture

Module 5: Future directions in Sustainable Agriculture

- Advances in sustainable agricultural in a growing global population
- Climate-smart farming, Urban agriculture, and Role of renewable energy in sustainable agriculture.
- Opportunities and future challenges in sustainable agriculture

Teaching Methodology

Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes

Practical/lab content:

1. Introduction to Sustainable Agriculture Laboratory
2. Soil Sampling and Analysis for Soil Health Assessment
3. Preparation and Application of Organic Fertilizers
4. Composting Techniques for Sustainable Waste Management
5. Demonstration and Use of Drip Irrigation Systems
6. Analysis of Soil pH and Nutrient Content
7. Water Quality Testing and Management in Agriculture
8. Installation and Monitoring of Rainwater Harvesting Systems
9. Hands-on Training on Precision Agriculture Tools
10. Use of Geographic Information Systems (GIS) for Farm Management

11. Implementation of Integrated Pest Management (IPM) Strategies
12. Preparation and Application of Organic Pesticides
13. Design and Implementation of Agroforestry Systems
14. Application of Remote Sensing in Crop Monitoring
15. Use of Mobile Applications for Farm Management

Recommended Books:

- Rattan Lal and B.A. Stewart. (2013) "Principles of Sustainable Soil Management in Agroecosystems" edited by
- Harwood, R. R. (2020). A history of sustainable agriculture. In Sustainable agricultural systems (pp. 3-19). CRC Press.
- Bell, M. M. (2024). Farming for us all: Practical agriculture and the cultivation of sustainability. Penn State Press.
- Gliessman, S. R., Méndez, V. E., Izzo, V. M., & Engles, E. W. (2022). Agroecology: Leading the transformation to a just and sustainable food system. CRC Press.
- Desai, B.K. and B.T.Pujari (2014). Sustainable Agriculture:A Vision for Future, Publisher:New India Publishing Agency.
- Singh, J., & Yadav, A. N. (Eds.). (2020). *Natural bioactive products in sustainable agriculture*. Springer Nature.

APC-615	**Air Pollution Control and Management**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand air pollution sources, characteristics, and control strategies.	Cognitive	Understanding (2)	PLO-01, PLO-05, PLO-07
Explore complexities of air quality management and	Cognitive	Analyzing (4)	PLO-01, PLO-06, PLO-07

regulatory frameworks.			
Engage in hands-on exercises using air quality monitoring equipment and emission sampling tools.	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-05
Utilize air pollution control technologies and software for data analysis and modeling.	Cognitive	Applying (3)	PLO-03, PLO-05, PLO-05

Course Content:

Module 1: Air Pollution and Dispersion of Air pollutants

- Types of air pollutants, Classification of air pollutant, and sources of air pollution
- Impacts of air pollution on eco systems, human health and environment.
- Case Study: Smog Events in Major Cities
- Atmospheric dispersion of air pollutants, Dispersion models and metrological factors
- Emission sources (Stationary, area and Mobile)

Module 2: Air Pollution in Urban and Industrial Areas

- Urban Air Quality Challenges (Traffic, Construction, Industrial Emissions)
- Smart City Solutions for Air Quality Improvement
- Air Pollution Hotspots and Industrial Emissions Control
- Role of Urban Planning in Air Quality Management
- Low-Emission Zones and Green Transportation
- Case Study: Managing Air Quality in Industrialized Regions

Module 3: Air Pollution Control Technologies and management

- Particulate matter control: Cyclone Separator, Electrostatic Precipitator, Scrubber, Filtration
- Emission Reduction in Industrial Processes and Transportation
- Gaseous pollution control: Condensation, Absorption, adsorption and chemical scrubbing
- Green and Sustainable Technologies for Reducing Emissions Emerging

technologies for air pollution control.

- Air quality management plan, Role of EIA (Environmental Impact Assessment) in air pollution control
- Implementation of cleaner production techniques and best practices of Air Pollution Management

Module 4: Regulatory Frameworks and Air Quality Standards

- National and International Air Quality Regulations (Clean Air Act, WHO Guidelines)
- Role of Regulatory Agencies (EPA, UNEP, European Environmental Agency)
- Air Quality Management Plans and Policies
- Emissions Trading Systems and Carbon Credits
- Regulations on Industrial and Vehicular Emissions

Module 5: Applications and case studies

- Policy and technological solutions implemented in various regions
- Analysis of global and local case studies in air pollution control
- Opportunities and future challenges in air pollution management
- Case Study: Comparing Air Quality Policies in Different Countries

Teaching Methodology

Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes

Recommended Books:

- Mihelcic, J. R., & Zimmerman, J. B. (2021). Environmental engineering: Fundamentals, sustainability, design. John wiley & sons.
- Nelson L. Nemerow, Franklin J. Agardy, Joseph A. Salvato (2009). Environmental Engineering Environmental Health and Safety for Municipal Infrastructure, Land Use and Planning, and Industry. Publisher:Wiley.
- Arcadio P. Sincero and Gregoria A. Sincero. Environmental Engineering –, Prentice Hall of India.
- Riffat, R., & Husnain, T. (2022). Fundamentals of wastewater treatment and engineering. Crc Press.
- Environmental Pollution Control Engineering- CS Rao, Wiley Eastern Ltd., New Delhi.
- H. Brauer, Y. B. G. Varma (2012). Air Pollution Control Equipment. Publisher:Springer Berlin Heidelberg

EMM-616	**Environmental Meteorology and Pollution Modeling**	**3-0**

Course Learning Outcomes (CLOs)	Domain	Taxonomy Level	Program Learning Outcomes (PLOs)
Apply meteorological principles to analyze pollution dispersion in atmosphere, water, and soil.	Cognitive	Applying (3)	PLO-01, PLO-06, PLO-07
Utilize Gaussian Plume Model (GPM) for various pollution sources and stack design.	Cognitive	Applying (3)	PLO-01, PLO-03, PLO-05
Demonstrate proficiency in advanced dispersion modeling and trajectory analysis.	Cognitive	Analyzing (4)	PLO-01, PLO-03, PLO-06
Engage in hands-on exercises with environmental monitoring equipment and modeling software.	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-09

Course Content:

Module 1: Environmental Meteorology and Atmospheric Stability

- Fundamentals of Meteorology, Atmospheric composition and structure. Secondary pollutants; Effects of air pollution in regional and global scale, air pollution episodes; Emission factors inventory and predictive equations.
- Atmospheric Stability and its Role in Pollution Dispersion
- Vertical Temperature Profiles and Inversions
- Turbulence and Its Impact on Pollutant Mixing
- Boundary Layer Meteorology and Its Influence on Pollutants

Module 2: Transport and Dispersion of Pollutants

- Principles of Atmospheric Dispersion, Advection, Diffusion, and Dispersion of Air Pollutants
- Local vs. Long-Range Transport of Pollutants
- Impact of Wind Patterns on Pollutant Distribution

Module 3: Effects of Air Pollution and Air Monitoring Instruments

- Effect of air pollutions on Human health, plants, animals and microbes, archeological monuments and aesthetics. Respirable dust sampler and source monitors.
- Types of Environmental Pollution Models (Gaussian, Eulerian, Lagrangian)
- Conceptual Foundations of Pollution Modeling
- Input Parameters for Models: Meteorological and Emission Data
- Case Study: Modeling Air Pollution in an Urban Environment

Module 4: Mass Transport:

- Gas-liquid mass transfer; Henry's constant, mass transfer between gaseous and aqueous phases.
- Two film theory, Solid-liquid mass transfer
- Langmuir and Freundlich isotherms, linear isotherms, i.e., partitioning coefficients,
- Hydrophobicity and partitioning, Adsorption rates and factors affecting the adsorption rates.

Module 5: Climate Change and Pollution Modeling

- Interactions Between Climate Change and Air Quality
- Modeling the Impact of Climate Change on Pollutant Dispersion
- Global Climate Models and Their Use in Predicting Long-Term Air Quality
- Case Study: Modeling the Impact of Climate Change on Ozone and Particulate Matter Levels

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes

Recommended Books

- Burroughs, H. E., & Hansen, S. J. (2020). Managing indoor air quality. River Publishers.
- Karl B. Schnelle, Karl B. Schnelle, Jr., Charles A. Brown (2016). Air Pollution Control Technology Handbook. Publisher:CRC Press

- Mwh. (2012). Physico-chemical Processes in Environmental Engineering. John Wiley & Sons, USA
- Environmental Pollution Control Engineering- CS Rao, Wiley Eastern Ltd., New Delhi.
- Harrison, R. M. (Ed.). (2023). Pollution: causes, effects and control. Royal society of chemistry.

SWM-617	**Smart Solid Waste Management**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand the concepts and principles of solid waste management and smart technologies used for waste handling.	Cognitive	Understanding (2)	PLO-01, PLO-05
Analyze the challenges and opportunities associated with integrating smart technologies in solid waste management systems.	Psychomotor	Analyzing (4)	PLO-04, PLO-5
Apply smart technologies and data-driven approaches for optimizing waste collection, processing, and disposal.	Cognitive	Applying (3)	PLO-03, PLO-05

Design and implement smart waste management strategies to enhance sustainability and resource recovery.	Cognitive	Creating (6)	PLO-03, PLO-06, PLO-09

Course Content:

Module 1: Solid Waste Management

- Definition and Classification of Solid Waste, Environmental and socio-economic consequences of solid waste
- Generation sources of waste, Types of waste, Composition of wastes
- Characteristics of waste (Physical, Chemical and Biological)
- Generation rate of solid waste, and Factors affecting generation and quantification of waste
- Onsite handling, storage & processing
- Collection system of solid waste
- Transfer and transport

Module 2: Solid Waste Processing and Sorting

- Mechanical and Biological Treatment of Waste
- AI and Robotics in Automated Waste Sorting
- Material Recovery Facilities (MRFs)
- Waste Characterization and Composition Analysis
- Case Study: AI-Driven Waste Sorting Technologies

Module 3: Waste Treatment Technologies

- Composting and Organic Waste Management
- Incineration and Thermal Treatment
- Waste-to-Energy Technologies
- Plasma Gasification

Module 3: Disposal of solid waste

- Classification of disposal and/or treatment method of wastes, Landfill disposal method, Leachate management and gas collection system, Composting, Anaerobic digestion, Incineration and other treatment technologies
- Numerical problems for design of disposal and/or advanced treatment methods

Module 4: Integrated waste management

- Waste hierarchy
- 3Rs (reduce, reuse and recycling), Techniques of 3Rs
- Benefits of reuse and recycling

Module 5: Public Participation and Future Trends in Smart Waste Management

- Engaging Communities in Waste Reduction and Recycling
- Behavioral Economics and Public Incentives for Smart Waste Systems
- Role of Mobile Apps and Citizen Science in Monitoring Waste Management
- Artificial Intelligence and Machine Learning in Waste Management
- Blockchain for Waste Tracking and Accountability
- Zero Waste Cities and the Role of Technology
- Emerging Waste-to-Product Technologies
- Case Study: Smart Waste Initiatives Driven by Communities

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes

Recommended Books:

- Ni-Bin Chang, Ana Pires · (2015). Sustainable Solid Waste Management: A Systems Engineering Approach. Publisher:Wiley
- Biswaranjan Acharya, Satarupa Dey, Mohammed Zidan · (2022). IoT-Based Smart Waste Management for Environmental Sustainability. Publisher:CRC Press.
- Amalendu Bagghi., "Design of landfills and integrated solid waste management", Published by John Wiley & Sons, ISBN: 0-471-25499-1 (Latest Edition).
- Abhijit Das, Biswajit Debnath, Potluri Anil Chowdary, Siddhartha Bhattacharyya (2023). Technological Advancement in E-waste Management Towards Smart, Sustainable, and Intelligent Systems. Publisher:CRC Press.
- Diaz, L. F., Golueke, C. G., Savage, G. M., & Eggerth, L. L. (2020). Composting and recycling municipal solid waste. CRC Press.
- Syed E. Hasan (2022). Introduction to Waste Management: A Textbook. Publisher: Wiley
- Timothy G. Townsend, Jon Powell, Pradeep Jain, Qiyong Xu, Thabet Tolaymat, Debra Reinhart (2015). Sustainable Practices for Landfill Design and Operation. Publisher:Springer New York
- Mihelcic, J. R., & Zimmerman, J. B. (2021). *Environmental engineering: Fundamentals, sustainability, design*. John wiley & sons.
- George Tchobanoglous, Hilary Theisen, S. A. Vigil (2014). Integrated Solid Waste Management Engineering Principles and Management Issues. Publisher:McGraw-Hill Education (India) Private Limited

HEM-618	Hydro informatics and Environmental Modeling	3-0

Course Learning Outcomes (CLOs)	Domain	Taxonomy Level	Program Learning Outcomes (PLOs)
Explore hydroinformatics and environmental modeling, focusing on floods, urban systems, and processes.	Cognitive	Understanding (2)	PLO-01, PLO-06, PLO-07
Gain insights into application domains of hydroinformatics, emphasizing floods, urban water systems, and dynamics.	Cognitive	Understanding (2)	PLO-01, PLO-06, PLO-07
Integrate climate change into hydrology, addressing climate variability effects on urban runoff modeling.	Cognitive	Applying (3)	PLO-01, PLO-05, PLO-07
Use monitoring equipment, sensors, and modeling software for practical study of hydroinformatics and	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-09

environmental modeling.			

Course Content:

Module 1: Hydroinformatics

- Hydroinformatics: definition, scope, and importance. History and evolution of hydroinformatics.
- Role of informatics in water management
- Basic principles of environmental modeling, types of environmental models: deterministic, stochastic, and dynamic models.
- Model development process: conceptualization, calibration, validation, and sensitivity analysis.

Module 2: Hydrological Modeling

- Introduction to hydrological processes and their modeling.
- Rainfall-runoff models: SCS-CN method, unit hydrograph theory, and related.
- Surface and groundwater interaction models.
- River flow dynamics and modeling techniques.
- Flood routing and inundation modeling, risk assessment and management.
- Transport and transformation of pollutants in water bodies.
- Eutrophication and its modeling.

Module 3: Environmental Data Analysis

- Types of environmental data: spatial, temporal, and spatiotemporal.
- Techniques for environmental data analysis: statistical, geostatistical, and time-series analysis. Remote sensing and GIS in environmental data analysis.
- Downscaling techniques for climate change scenarios. Modeling climate change impacts on hydrological and environmental systems.
- Ecosystem modeling, modeling interactions between different components of ecosystems.

Module 4: Real-time Monitoring and Prediction

- Real-time data acquisition and monitoring systems.
- Forecasting techniques in hydroinformatics. Early warning systems for environmental hazards.
- Artificial intelligence (AI) and machine learning (ML) in hydroinformatics.
- Big data analytics in environmental modeling.
- Emerging trends and future trends in hydroinformatics.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books:

- Roman Morris (2022). Hydroinformatics: Analysis and Modeling. Publisher:Callisto Reference
- Praveen Kumar, Mike W. Toews, and Pratap Bhanu Mehta. Hydroinformatics: Data Integrative Approaches in Computation, Analysis, and Modeling.
- Hydrological Modeling and the Water Cycle by Soroosh Sorooshian, Kuo-lin Hsu, and Hoshin V. Gupta.
- William G. Gray, Genetha A. Gray (2017). Introduction to Environmental Modelling.
- Chadwick, A., Morfett, J., & Borthwick, M. (2021). Hydraulics in civil and environmental engineering. Crc Press.
- Karamouz, M., Ahmadi, A., & Akhbari, M. (2020). Groundwater hydrology: Engineering, planning, and management. CRC press.
- Jain, S. K., & Singh, V. P. (2023). Water resources systems planning and management. Elsevier.

INM-619	**Informatics in Natural Resource Management**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand conservation principles and the role of Informatics in modern efforts.	Cognitive	Understanding (2)	PLO-07, PLO-09
Proficiently use GIS, remote sensing, and biodiversity databases	Cognitive	Applying (3)	PLO-05, PLO-09

for monitoring and planning.			
Acquire practical skills in wildlife monitoring, mobile apps, and addressing cybersecurity challenges in conservation ICT.	Cognitive	Applying (3)	PLO-05, PLO-08

Course Content:

Module 1: ICT in Natural Resource Management

- Informatics applications in Natural Resource Management (NRM), Benefits and challenges
- Data collection methods (e.g., sensors, field surveys), Data storage, management, and analysis, and Use of databases and data analytics tools
- Fundamentals of GIS and Remote Sensing, Data collection and analysis techniques
- Applications in mapping and monitoring natural resources

Module 2: Decision Support Systems (DSS)

- Introduction to DSS and their role in NRM
- Design and implementation of decision support tools
- Case studies of DSS in resource management

Module 3: Environmental Monitoring, Assessment, and Modelling

- Informatics for monitoring environmental parameters
- Use of satellite imagery and sensors for real-time monitoring
- Impact assessment using Informatics
- Environmental modeling techniques, Simulation of natural resource scenarios
- Tools and software for environmental modeling

Module 4: Community Involvement and Informatics

- Informatics for community engagement and participation
- Crowdsourcing and citizen science platforms
- Case studies of community-driven NRM projects

Module 5: Policy and Ethics in Informatics

- Data privacy and security issues

- Ethical considerations in using Informatics for NRM
- Policy frameworks and regulations

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books:

- Prasad, R., Ohmori, S., & Simunic, D. (Eds.). (2022). Towards green ICT. CRC Press.
- Yiwen Li, Wenwen Zhang, Bin Zhao, Basil Sharp, Yu Gu, Shi-Chun Xu, Lanlan Rao (2022). Natural Resources and Human Development Role of ICT in Testing the Resource-Curse Hypothesis in N11 and BRICS Countries
- Laxmi K. Sharma, Prem C. Pandey (2021). Advances in Remote Sensing for Natural Resource Monitoring. Publisher:Wiley.
- Kucera, G. (2020). Time in geographic information systems. CRC Press.
- Verbyla, D. L. (2022). Satellite remote sensing of natural resources. CRC Press.
- Ina Ehnert, Klaus J. Zink, Wes Harry (2013). Sustainability and Human Resource Management. Publisher:Springer Berlin Heidelberg

SME-620	**Statistical Methods for Environmental Informatics**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand essential statistical concepts and measurements.	Cognitive	Understanding (2)	PLO-01, PLO-07
Apply statistical methods in climate and disaster management research.	Cognitive	Applying (3)	PLO-02, PLO-05

Use SPSS for analyzing climate-related data.	Cognitive	Applying (3)	PLO-05, PLO-06

Course Content:

Module 1: Statistical Methods and Basic Concepts:

- Statistical Methods and their application in Environmental Science, and Statistical Software for Environmental Data Analysis
- Model Types: Deterministic vs. stochastic models, static vs. dynamic models.
- Modeling Process: Formulation, analysis, validation, and application of models.
- Calculus: Differential equations, integration, and their applications in environmental models. Linear Algebra: Matrices, vectors, and linear systems.
- Probability and Statistics: Probability distributions, statistical inference, and data fitting.

Module 2: Data Collection and System Modelling

- Data Collection Methods: Surveys, Experiments, Remote Sensing
- Data Quality and Preprocessing
- Population Dynamics: Lotka-Volterra Models: Predator-prey and competitive species models.
- Logistic Growth Models: Modeling population growth with carrying capacity.
- Biogeochemical Cycles: Modeling carbon, nitrogen, and phosphorus cycles.
- Water Resource Models: Hydrological Models: Rainfall-runoff models, watershed modeling.
- Water Quality Models: Modeling pollutant transport and fate in aquatic systems.

Module 3: Climate Models and Impact Assessment

- Climate Models, General Circulation Models (GCMs): Simulating global climate systems and interactions. And Regional Climate Models (RCMs): Finer-scale climate predictions.
- Weather Prediction Models,
- Numerical Weather Prediction (NWP): Modeling atmospheric processes for weather forecasting.

- Impact Prediction Models: Estimating environmental impacts of human activities (e.g., land use changes, pollution).
- Risk Assessment Models: Modeling risk and uncertainty related to environmental hazards.

Module 4: Model Validation, Sensitivity Analysis. Emerging Trends

- Validation Techniques: Comparing model outputs with observed data to assess accuracy.
- Sensitivity Analysis: Evaluating how changes in model parameters affect outputs.
- Integrated Models: Combining various environmental models for holistic assessments (e.g., coupled climate-water models).
- Machine Learning and AI: Application of advanced computational techniques to improve model predictions.
- Modeling Uncertainty: Addressing uncertainties in model predictions and data.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes

Recommended Books

- Velten, K., Schmidt, D. M., & Kahlen, K. (2024). Mathematical modeling and simulation: introduction for scientists and engineers. John Wiley & Sons.
- Niss, M., & Blum, W. (2020). The learning and teaching of mathematical modelling. Routledge.
- Vic Barnett (2005). Environmental Statistics Methods and Applications. Publisher:Wiley
- Francesco Finazzi, Michela Cameletti (2018). Quantitative Methods in Environmental and Climate Research. Publisher:Springer International Publishing.
- Velten, K., Schmidt, D. M., & Kahlen, K. (2024). Mathematical modeling and simulation: introduction for scientists and engineers. John Wiley & Sons.

IDM-621	**Informatics in Disaster Risk Reduction and Management**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**

Understand ICT's role in disaster resilience for preparedness, response, and recovery.	Cognitive	Understanding (2)	PLO-01, PLO-07
Utilize GIS, remote sensing, and data analysis for effective disaster response and decision-making.	Cognitive	Applying (3)	PLO-01, PLO-05
Leverage ICT for early warning systems, communication technologies, and environmental impact assessment in disaster management.	Cognitive	Applying (3)	PLO-01, PLO-05, PLO-06
Engage in hands-on exercises using ICT tools and equipment for disaster resilience and environmental recovery.	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-07

Module 1: Disaster Risk Reduction and Management (DRRM) and Informatics

- DRRM concepts and disaster management, Key principles and frameworks (e.g., Sendai Framework)
- Role of Informatics in DRRM
- Geographic Information Systems (GIS), Remote Sensing and satellite imagery
- Early Warning Systems (EWS)
- Mobile and web-based applications

Module 2: Data Collection and Management and Analysis

- Methods for collecting disaster-related data
- Data management and integration
- Use of Big Data and IoT in disaster monitoring
- Risk assessment methodologies (e.g., hazard mapping, vulnerability analysis)
- ICT applications in risk assessment

Module 3: Early Warning Systems (EWS) and Disaster Response

- Design and implementation of EWS
- Communication strategies and tools (e.g., SMS alerts, social media)
- Evaluation of EWS effectiveness
- ICT applications in disaster response (e.g., coordination platforms, resource tracking)
- Post-disaster damage assessment and recovery planning
- Role of social media and crowdsourcing in response efforts

Module 4: Resilience Building and Community Involvement

- ICT solutions for community engagement and education
- Tools for enhancing community resilience
- Participatory approaches and citizen science

Module 5: Ethical and Privacy Considerations

- Data privacy and security issues
- Ethical implications of using ICT in disaster management
- Case studies of ethical dilemmas
- Analysis of real-world applications of ICT in disaster management
- Hands-on projects and simulations

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

- Prasad, R., Ohmori, S., & Simunic, D. (Eds.). (2022). Towards green ICT. CRC Press.
- Dimiter Velev, Plamena Zlateva, Yuko Murayama (2019).
- Julie Dugdale, Osamu Uchida, Terje Gjøsæter (2024). Information Technology in Disaster Risk Reduction. Publisher:SPRINGER INTERNATIONAL PU.
- John R. W. Smith and Mark L. Gardner Handbook of Disaster Risk Reduction and Management.
- "The Role of Information and Communication Technology in Disaster Management"by David G. K. R. Singh
- Shailesh Nayak, Sisi Zlatanova (2009). Remote Sensing and GIS Technologies for Monitoring and Prediction of Disasters. Publisher:Springer

Berlin Heidelberg.

ML-622	**Introduction to Machine Learning**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand the fundamental concepts and techniques of machine learning.	Cognitive	Understanding	PLO-01, PLO-02
Analyze the performance of machine learning models.	Cognitive	Analysis	PLO-03, PLO-04
Implement machine learning models using programming languages.	Cognitive	Application	PLO-04
Apply machine learning algorithms to solve real-world problems.	Cognitive	Application	PLO-02, PLO-04
Evaluate ethical implications of machine learning applications.	Affective	Valuing	PLO-06

Course Content

Module 1: **Machine Learning and Core Concepts**

- Machine learning and its applications in environmental studies.
- Regression and classification models, linear regression, logistic regression, and classification techniques.
- Clustering methods like K-means and hierarchical clustering, and dimensionality reduction techniques like PCA (Principal

Component Analysis).

Module 2: Data Preprocessing and Exploration

- Data collection and cleaning techniques to handle missing values, outliers, and inconsistent data.
- Correlation analysis and principal component analysis.
- Tools and libraries for data visualization, including Matplotlib, Seaborn, and Plotly. Learn how to create meaningful visual representations of data.

Module 3: Machine Learning Algorithms

- Regression models and Logistic Regression, assumptions, and applications.
- Decision Trees and Random Forests methods, how they work, their strengths, and limitations.
- Hyperplanes, margins, and kernel tricks used in SVMs.
- Instance-based learning and distance metrics in K-Nearest Neighbors.
- Neural networks, activation functions, forward and backward propagation, and an overview of deep learning architectures.

Module 4: Model Evaluation and Validation

- Data splitting and cross-validation methods
- Accuracy, precision, recall, F1-score, and ROC-AUC and their applications.
- overfitting and underfitting issues
- Grid search and random search.

Module 5: Implementation of Machine Learning Models

- Python libraries like scikit-learn, TensorFlow, and Keras.
- Hands-on experience in building machine learning models in real-world applications and integrating them into existing systems
- Issues related to bias in data and algorithms, and techniques to ensure fairness in machine learning models.
- Data privacy laws and regulations, and best practices for data protection.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

- Alpaydin, E. (2020). Introduction to machine learning. MIT press.
- Sen, J., Mehtab, S., & Engelbrecht, A. (2021). Machine learning: algorithms, models and applications. BoD–Books on Demand.
- Andreas Müller, Sarah Guido, Introduction to Machine Learning with Python: A Guide for Data Scientists 1st Edition Murphy, K. P. (2022).

Probabilistic machine learning: an introduction. MIT press.
- Christopher M. Bishop, (2008), Pattern Recognition and Machine Learning.
- Wes McKinney, (2022) Python for Data Analysis, 3E
- Andreas Müller, Sarah Guido, Introduction to Machine Learning with Python: A Guide for Data Scientists 1st Edition
- Christopher Bishop, 2006, Pattern Recognition and Machine Learning
- Charu C. Aggarwal, 2023, Neural Networks and Deep Learning

EDT-623	**Environmental Data Science and Technology Applications**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand fundamental concepts of data science and its environmental applications.	Cognitive	Remembering (1)	PLO-01, PLO-05
Develop skills for collecting, cleaning, and preprocessing environmental data.	Psychomotor	Applying (3)	PLO-04, PLO-5
Apply statistical methods and data visualization for insights.	Cognitive	Analyzing (4)	PLO-02, PLO-03, PLO-05

Module 1: **Basics of Data Collection and Cleaning**

- Principles of data collection in environmental sciences.
- Types of environmental data sources: sensors, satellites, field measurements.
- Techniques for cleaning and preprocessing environmental data.
- Hands-on experience in collecting environmental data using various sources and tools.

Module 2: Statistical Methods and Data Visualization and Interpretation

- Descriptive statistics and exploratory data analysis.
- Inferential statistics for hypothesis testing and confidence intervals.
- Regression analysis and its applications in environmental studies.
- Data visualization methods
- Interpretation of visualized environmental data patterns.

Module 3: Machine Learning and Deep Learning

- Machine learning algorithms.
- Application of machine learning in environmental data analysis.
- Case studies demonstrating the impact of machine learning on environmental research.
- Hands-on practice with data visualization tools and libraries such as matplotlib, seaborn, and Plotly.
- Neural networks and deep learning and applications in image analysis and remote sensing.
- Ethical considerations in using deep learning for environmental studies.
- Time series decomposition and trend analysis.
- Forecasting environmental trends using time series models.

Module 4: Applications of Environmental Data Science in Policy

- Integration of environmental data science in policy formulation.
- Case studies demonstrating the impact of data-driven policies on environmental conservation.
- Communicating scientific findings to policymakers through data-driven approaches.

Module 5: Practical Projects in Environmental Data Science

- Implementation of data science techniques in real-world environmental projects.
- Collaborative projects focusing on solving environmental challenges using data-driven approaches.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

- Jerry Davis. (2023). Introduction to Environmental Data Science. Publisher:CRC Press
- Williams Sawyer. Using Information Technology: A Practical Introduction to Computer & Communications. 6th Edition, McGraw-Hill
- Wickham, H., Çetinkaya-Rundel, M., & Grolemund, G. (2023). R for data

science. " O'Reilly Media, Inc.".
- Efron, B., & Hastie, T. (2021). Computer age statistical inference, student edition: algorithms, evidence, and data science (Vol. 6). Cambridge University Press.

STS-624	**Systems Thinking and Sustainability**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand systems thinking principles in sustainable development.	Cognitive	Understanding (2)	PLO-01, PLO-07
Explore interconnected perspectives in environmental, social, and economic systems.	Cognitive	Understanding (2)	PLO-01, PLO-07
Analyze sustainable system dynamics to build resilience and involve stakeholders.	Cognitive	Analyzing (4)	PLO-02, PLO-07

Course Content

Module 1: Systems Thinking

- Foundations of Systems Thinking, principles and concepts.
- Application of systems thinking to address sustainability challenges.
- Holistic Approach: how systems thinking provide a holistic perspective on sustainability.
- The interconnected nature of environmental, social, and economic systems.
- Exploring positive and negative feedback loops in systems.

- Analyzing how dynamic systems impact sustainable practices.
- Complexity in Sustainable Systems
- Exploring strategies to enhance resilience in sustainable initiatives.

Module 2: System Boundaries and Stakeholder Involvement

- Identifying and setting boundaries in sustainable systems.
- Analyzing the role of stakeholders in sustainable decision- making.

Module 3: Systems Thinking Tools and Techniques

- Causal Loop Diagrams: Introduction and application.
- Stock and Flow Diagrams: diagrams to model system dynamics.

Module 4: Systems Thinking in Environmental Management

- Systems thinking to address environmental challenges.
- Sustainable waste management systems and Circular Economy.

Module 5: Social Systems and Economic Systems

- Social components in sustainable development.
- The role of communities in sustainable practices.
- Integrating systems thinking into economic sustainability.
- Applying systems thinking to enhance sustainability in business.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

1. Systems Thinking for Sustainable Development, Climate Change and the Environment, Edward Saja Sanneh
2. Down to Earth: Politics in the New Climatic Regime, Bruno Latour

IMM-625	**Informatics in Marine Environmental Management**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**

Integrate ICT with Marine Pollution Monitoring and Control.	Cognitive	Applying (3)	PLO-01, PLO-05, PLO-07
Explore effects of pollution, oil spills, coastal development, beach erosion, and sea level changes on marine environment.	Cognitive	Understanding (2)	PLO-01, PLO-06, PLO-07
Emphasize technology for pollution modeling and environmental control.	Cognitive	Applying (3)	PLO-01, PLO-03, PLO-05
Engage in hands-on exercises using marine monitoring equipment and GIS software.	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05

Course Content:

Module 1: **Marine Pollution Monitoring and Modeling**

- Impact of pollution on marine ecosystems.
- Coastal development and its implications.
- Informatics in real-time pollution monitoring.
- Pollution dispersion models and hands-on training using ICT tools for modeling.

Module 2: **Marine Biology and Coastal Ecology**

- Study of marine organisms, fisheries, and mangroves.
- Coastal geology and its role in marine ecosystems.
- Integration of ICT for monitoring marine biodiversity.
- Sustainable management of marine resources.
- Informatics in optimizing resource utilization.

- Balancing economic activities with environmental conservation.

Module 3: **Sea Water Intrusion and Rising Sea Levels**

- Understanding sea water intrusion phenomena.
- Monitoring and predicting sea levels rising.
- Technological solutions for coastal resilience.

Module 4: **Case Studies**

- Real-world case studies in marine pollution management.
- Integration of ICT's application for effective decision-making.
- Innovations in technology for sustainable marine practices.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

1. Marine Pollution – Monitoring, Management and Mitigation, Amanda Reichelt-Brushett
2. IoT Technology with Marine Environment Protection and Monitoring, Mohammed Abdulhakim Al-Absi, Ahmadhon Kamolov, Ahmed Abdulhakim Al-Absi, Mangal Sain & Hoon Jae Lee
3. Hofer, T.N. 2008. Marine Pollution: New Research. Nova Science Publisher
4. Clark, R.B., Frid, C., Attrill, M. 2001. Marine Pollution. Oxford University Press.
5. Hassan, D. 2006. Protecting the Marine Environment from Land Base Source of Pollution. Ashgate Publishing.
6. Introduction to Marine Biology 4th Edition, George Karleskint, Richard Turner , James Small.
7. Geographic Information Science and Systems, Paul A. Longley, Michael F. Goodchild, David J. Maguire, David W. Rhind
8. Marine Ecology for the Non-Ecologist, Andrew Caine
9. Remote Sensing of the Environment: An Earth Resource Perspective, J. R. Jensen

CTE-626	Computer Vision Techniques in Environment Monitoring	3-0

Course Learning Outcomes (CLOs)	Domain	Taxonomy Level	Program Learning Outcomes (PLOs)
Understand fundamentals of computer vision in environmental monitoring.	Cognitive	Understanding (2)	PLO-01, PLO-05
Examine imaging devices used in environmental monitoring.	Cognitive	Analyzing (4)	PLO-02, PLO-05
Discuss challenges and opportunities in computer vision for environmental monitoring.	Cognitive	Evaluating (5)	PLO-06, PLO-07

Course Content:
Module 1: Computer Vision in Environmental Sciences

- Computer vision and its applications in environmental monitoring.
- Techniques for data collection, analysis, and visualization in environmental studies.
- Imaging devices such as satellites, drones, and ground-based sensors used in environmental monitoring.
- Cleaning, enhancing, and preparing images for analysis.
- Computer vision algorithms for detecting objects in environmental images.
- Techniques for classifying species, vegetation, and land cover using computer vision.

Module 2: Remote Sensing and Satellite Imagery Analysis

- Interpret satellite imagery for environmental monitoring applications.
- Methods for detecting changes in environmental features over time using computer vision.

Module 3: 3D Reconstruction and Visualization

- Methods to create three-dimensional models of environmental landscapes.
- Computer vision methods in immersive visualization techniques.

Module 4: Video Analysis for Environmental Monitoring

- Role of computer vision in analyzing temporal changes and patterns in environmental videos.
- Video analysis to study animal behavior, plant growth, and other dynamic environmental factors.

Module 5: Integration with Other Technologies

- Computer vision integration with Internet of Things (IoT) devices and environmental sensors.
- The synergy between computer vision, machine learning, and predictive modeling in environmental science.
- Challenges in implementing computer vision for environmental monitoring and exploring future opportunities.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

1. Computer Vision - A Modern Approach, by D. Forsyth and J. Ponce, Prentice Hall, 2003.
2. Computer Vision - Algorithms and Applications, Szeliski R., Springer, 2011.
3. Algorithms for Image Processing and Computer Vision, J. R. Parker, Willey Publishing Inc. 2011
4. A Computer Vision-Based Water Level Monitoring System for Touchless and Sustainable Water Dispensing, Andrea Felicetti, Marina Paolanti, Rocco Pietrini, Adriano Mancini, Primo Zingaretti & Emanuele Frontoni

IWP-627	**Industrial wastewater pollution control**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand industrial wastewater pollution control principles and legal frameworks.	Cognitive	Understanding (2)	PLO-01, PLO-03
Apply pollution prevention techniques and advanced treatment methods in industrial settings.	Cognitive	Applying (3)	PLO-02, PLO-04
Evaluate wastewater treatment and disposal methods for industrial applications.	Cognitive	Evaluating (5)	PLO-02, PLO-05
Demonstrate proficiency in industrial wastewater pollution control through practical lab exercises.	Psychomotor	Applying (3)	PLO-03, PLO-06

Course Content:

Module 1: **Strategic Industrial Environmental Management**

- Industrial wastewater management, Evaluation of Operation & Maintenance (O&M) costs.
- Solid waste management in industrial contexts.
- Effective management of air discharges from industries.

Module 2: Fundamentals of Industrial Wastewater

- Characteristics of industrial wastewater.
- Differentiating polar solvents from nonpolar solvents.
- Emulsification and its relevance in wastewater treatment.
- Addressing colloidal suspensions in industrial effluents.

Module 3: Legal Frameworks and Regulatory Compliance

- Historical perspective on permitting and reporting.
- Overview of water, groundwater, and air pollution control laws.
- Compliance with regulations in the industrial setting.

Module 4: **Types of Waste from Diverse Industries**

- In-depth exploration of waste types from various industries.
- Specific considerations for chemical descaling, degreasing, and electroplating.
- Case studies from industries like textiles, tanneries, and synthetic rubber.
- Groundwater contamination prevention through stormwater management.
- Segregation and treatment of industrial stormwater.
- Design storm considerations and system failure protection.

Module 5: Waste Characterization and pollution Prevention Strategies

- Conducting waste characterization studies and audits.
- Environmental audit practices for industrial settings.
- Analysis of industrial wastewater, air discharges, and solid waste streams.
- Policy and approach to pollution prevention.
- Source reduction techniques for sustainable industrial practices.
- Conducting waste audits and realizing the benefits of pollution prevention.

Module 6: **Advanced Treatment and Disposal**

- Principle and non-principal treatment mechanisms for wastewater.
- Overview of physical, chemical, and biological treatment methods.
- Addressing industrial waste in liquid, solid, and gaseous forms.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

1. Industrial Water Pollution Control by W. Wesley Eckenfelder, Jr. and
2. INDUSTRIAL WASTEWATER MANAGEMENT, TREATMENT AND DISPOSAL, WEF, 2008

3. Handbook of Industrial Pollution and Control by S. C. Bhatia
4. Hazardous Waste Management by Michael D. LaGrega, Phillip L. Buckingham and Jeffery
   C. Evans
5. Water Quality- Characteristics, Modeling and Modification by George Tchobanoglous and Edward D. Schroeder
6. Industrial water pollution control, Eckenfelder, W. Wesley.
7. Wastewater Engineering: Treatment and Resource Recovery, 5th Edition, Metcalf & Eddy, Inc., George Tchobanoglous, H. Stensel, Ryujiro Tsuchihashi and Franklin Burto
8. Industrial Pollution Prevention Handbook 1st Edition, Harry Freeman.
9. Biological Wastewater Treatment:Principles, Modelling and Design, Guanghao Chen, Mark C.M. van Loosdrecht, George A. Ekama, Damir Brdjanovic

VRE-628	**Virtual Reality for Environmental Education and Advocacy**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand VR applications in environmental education and advocacy.	Cognitive	Understanding (2)	PLO-01, PLO-05, PLO-10
Develop skills in designing immersive learning environments for environmental education in VR.	Cognitive	Applying (3)	PLO-03, PLO-05, PLO-09
Explore VR's role in biodiversity conservation, climate change	Cognitive	Analyzing (4)	PLO-02, PLO-06, PLO-07

communication, and environmental empathy.			
Gain practical experience in developing and using VR for environmental education and advocacy.	Psychomotor	Applying (3)	PLO-03, PLO-05, PLO-6

Course Content:

Module 1: Virtual Reality (VR) and Environmental Education

- The basics of Virtual Reality (VR) and its applications, VR hardware and software relevant to environmental education and advocacy.
- VR environments for immersive and engaging environmental education.
- VR simulations to educate users about environmental concepts, ecosystems, and conservation practices.
- Environmental narratives using VR storytelling techniques.
- Integrating VR into advocacy campaigns for environmental causes.
- Use of VR for simulating diverse ecosystems and awareness about biodiversity.

Module 2: Virtual Eco-Tours and Field Trips

- VR experiences to simulate virtual eco-tours to natural habitats.
- Planning and executing virtual field trips for environmental education.

Module 3: VR and Climate Change Communication

- Using VR to visualize the impacts of climate change on ecosystems.
- Crafting effective climate change messages through immersive VR experiences.

Module 4: Virtual Reality and Environmental Empathy

- Examining how VR can evoke empathy towards environmental issues.
- Utilizing VR to influence sustainable behaviors through experiential learning.

Module 5: Evaluating Impact and Effectiveness

- Assessing the effectiveness of VR in environmental education.
- Evaluating the overall user experience and engagement.

Module 6: Ethics and Inclusivity in VR for Environmental Education

- Ethical issues related to the use of VR in environmental education.
- Ensuring diverse and inclusive VR experiences for all users.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

1. Virtual realities in environmental education: the project LAKE, Volume 2, pages 131–142, (1997).
2. Impact of Environmental Education with VR Equipment on Learning Performance and Environmental Identity, Zhao Yu & Xun Lin
3. Climate Crisis in Virtual Environments: Exploration and Evaluation of Virtual Reality and Mixed Reality for Climate Change Education in Sea Level Rise Simulation, Zixiang Xu, Yuan Liang, Abraham G. Campbell & Soumyabrata Dev
4. The Application of Virtual Reality Technology in Environmental Art Design, Kunming Luo & Xiaoyu Wang
   Virtual Reality and Augmented Reality: Myths and Realities, Bruno Arnaldi, Pascal Guitton, Guillaume Moreau.
5. Virtual and Augmented Reality for Environmental Sustainability: A Systematic Review, Laura D Cosio, Oğuz 'Oz' Buruk, Daniel Fernández Galeote, Isak De Villiers Bosman, Juho Hamari.
6. Virtual Reality: Concepts and Technologies, Philippe Fuchs, Guillaume Moreau, Pascal Guitton.

IEM-629	**IoT based techniques in Environmental Monitoring**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**

Develop IoT principles and architecture for environmental monitoring applications.	Cognitive	Understanding (2)	PLO-01, PLO-03, PLO-05
Explore sensors and devices in environmental monitoring for air, water quality, and agriculture.	Cognitive	Understanding (2)	PLO-01, PLO-05, PLO-07
Understand wireless protocols, connectivity, and data acquisition for environmental data.	Cognitive	Understanding (2)	PLO-01, PLO-04, PLO-05
Gain practical experience in IoT-based environmental monitoring systems and data analysis.	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-07

Course Content:

Module 1: IoT in Environmental Monitoring

- Internet of Things (IoT) and its applications in environmental monitoring.
- The components and architecture of IoT systems for environmental data collection.
- Sensors used in environmental monitoring, including temperature, humidity, air quality, and water quality sensors.
- IoT devices and platforms suitable for collecting, transmitting, and processing environmental data.

Module 2: Wireless Communication Protocols

- Wireless communication protocols such as MQTT, CoAP, and LoRaWAN for efficient data transmission in environmental monitoring.
- Selection of connectivity options based on environmental monitoring requirements.

Module 3: Data Acquisition and Cloud Platforms

- Collecting environmental data through IoT devices and sensors.
- Data processing techniques and analytics methods.
- Integrating IoT environmental data with cloud platforms for storage, analysis, and accessibility.
- Security considerations when using cloud-based solutions for environmental monitoring.

Module 4: IoT Applications in Environmental Monitoring

- IoT-based air quality monitoring using sensors.
- Examining real-world applications and case studies of IoT in air quality monitoring.
- Detailed exploration of IoT-based sensors for monitoring water quality.
- Analyzing practical examples of IoT applications in water quality monitoring.
- Understanding how IoT technologies contribute to environmental monitoring in agriculture.
- Examining IoT applications in optimizing resource usage and crop management.

Module 5: **Energy Efficiency in Environmental Monitoring Systems**

- Strategies for optimizing power consumption in IoT-based environmental monitoring systems.
- Exploring ways to incorporate renewable energy sources for IoT devices in remote locations.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

1. Advanced Systems for Environmental Monitoring, IoT and the application of Artificial Intelligence, Jamal Mabrouki, Mourade Azrour
2. Smart Environmental Monitoring Based on IoT: Architecture, Issues, and Challenges, Meenakshi Srivastava & Rakesh Kumar

3. IoT-based Intelligent Modelling for Environmental and Ecological Engineering, IoT Next Generation EcoAgro Systems, Paul Krause, Fatos Xhafa
4. IoT Based Environment Monitoring System, A. Vidhyavani, S. Guruprasad, M. K. Praveen Keshav, B. Pranay Keremore & A. Koushik Gupta
5. IoT-Enabled Sensor Node for Environmental Monitoring, Parag Chourey, Nirbhow Jap Singh, Kirti Soni & Ravinder Agarwal
6. Environmental Monitoring Using Internet of Things, International Journal of Electrical and Computer Engineering (IJECE), Vijay M Mane.
7. Environmental Monitoring with Arduino: Building Simple Devices to Collect Data About the World Around Us, by Emily Gertz, Patrick Di Justo.
8. Wireless Sensor Networks, Principles, Design and Applications, Shuang-Hua Yang.
9. Wireless Sensor Networks for Environmental Monitoring, Anna Lanzolla.
10. Remote Sensing and GIS for Ecologists, by Martin Wegmann, Benjamin Leutner, Stefan Dech.

EDD-630	**Eco-friendly Design and Sustainable Development**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Grasp sustainable design principles and their historical evolution.	Cognitive	Understanding (2)	PLO-01, PLO-06, PLO-07
Apply eco-friendly urban planning strategies and address urban challenges.	Cognitive	Applying (3)	PLO-02, PLO-06, PLO-07
Implement sustainable design in diverse projects for	Cognitive	Applying (3)	PLO-03, PLO-06, PLO-07

real-world applications.			
Engage in practical exercises using software and analytical methods for eco-friendly design and sustainable practices.	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-09

Course Content:

Module 1: Sustainable Design and Urban Planning

- Sustainable design principles, Historical context and evolution of eco-friendly design
- Integration of sustainability in architecture and product development
- Strategies for eco-friendly urban planning
- Smart city concepts and sustainable infrastructure
- Addressing urban challenges through sustainable design

Module 2: Energy-Efficient Buildings

- Passive design strategies, Optimizing building orientation and form for energy efficiency
- Case studies on successful energy-efficient building designs

Module 3: Sustainable Materials and Life Cycle Analysis

- Evaluation of materials' sustainability
- Life cycle analysis in design decision-making
- Incorporating sustainable materials in real-world projects

Module 4: Green Roofs, Living Walls, and Biodiversity

- Designing urban spaces to enhance biodiversity
- Implementation of green roofs and living walls
- Benefits of biophilic design in urban environments

Module 5: Circular Economy in Design and Production

- Concepts of circular economy in the design process
- Strategies for sustainable production and consumption

- Eco-labeling and certifications for sustainable products

Module 6: Innovation and Future Trends

- Biomimicry and nature-inspired innovations
- Sustainable transportation design and urban mobility
- Social and cultural considerations in eco-friendly design
- Exploring emerging trends and future directions in sustainable development
- Practical implementation of sustainable design in diverse projects
- Challenges and solutions in applying sustainable principles

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

1. Design for Environmental Sustainability, Life Cycle Design of Products, Carlo Arnaldo Vezzoli
2. Eco-Designing for Sustainability, Nahid Khan, Manoj Kumar Jhariya, Abhishek Raj, Arnab Banerjee & Ram Swaroop Meena
3. Biomimetics, Biodesign and Bionics, Technological Advances Toward Sustainable Development, Amilton José Vieira Arruda, Felipe Luis Palombini
4. Sustainable DevelopmentPrinciples, Frameworks, and Case Studies, Okechukwu Ukaga, Chris Maser, Michael Reichenbach.
5. Green Infrastructure, Incorporating Plants and Enhancing Biodiversity in Buildings and Urban Environments, John W. Dover.
6. Ecological Design 1st Edition, George F. Thompson.
7. Sustainable Site Design: Criteria, Process, and Case Studies for Integrating Site and Region in Landscape Design 1st Edition, Claudia Dinep, Kristin Schwab.
8. Green Building Illustrated Illustrated Edition, Francis D. K. Ching, Ian M. Shapiro.

GRA-631	**Glacial Lake Outburst Floods (GLOFs): Risk Assessment and Mitigation**	**3-0**

Course Learning Outcomes (CLOs)	Domain	Taxonomy Level	Program Learning Outcomes (PLOs)
Define Glacial Lake Outburst Floods (GLOFs) and understand their impacts.	Cognitive	Understanding (2)	PLO-01, PLO-07, PLO-05
Analyze causes of GLOFs including geological, climatic factors, and lake dynamics.	Cognitive	Analyzing (4)	PLO-01, PLO-02, PLO-06
Acquire skills in GLOF risk assessment, simulation modeling, and lake management.	Cognitive	Applying (3)	PLO-03, PLO-04, PLO-06
Use field equipment, remote sensing, modeling tools, and GIS for GLOF mitigation.	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-07

Course Content:

Module 1: Comprehensive Study of Historical GLOF Events, Causes and Trigger

- Glacial Lake Outburst Floods (GLOFs), Historical case studies of significant GLOF events
- Understanding the impact of GLOFs on ecosystems and communities
- Identifying the geological and climatic factors leading to GLOFs
- Examining the role of glacial lakes in flood initiation
- Understanding the interplay of natural and human-induced triggers

Module 2: Advanced Risk Assessment Methodologies

- Quantitative risk assessment models for GLOFs
- GIS-based approaches for mapping vulnerable areas
- Incorporating uncertainty and dynamic factors in risk assessments

Module 3: Simulation Modeling for GLOF Scenarios

- Developing numerical models for simulating GLOF events
- Scenario-based simulations and predictive modeling
- Assessing the potential impact on downstream areas

Module 4: Sustainable Management of Glacial Lakes

- Basics of sustainable lake and reservoir management
- Balancing ecological, social, and economic dimensions
- Principles for maintaining water quality and biodiversity

Module 5: Integrated Water Resource Management for Glacial Lakes

- Strategies for sustainable water resource management
- Integrated approaches for glacial lake ecosystems
- Collaborative governance for lake conservation

Module 6: Case Studies on Successful Sustainable Lake Management Projects

- Showcasing successful projects in glacial lake management
- Learning from real-world examples of sustainable practices
- Analyzing the outcomes and challenges of implemented strategies

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

1. Integrated risk assessment of glacier lake outburst flood (GLOF) disaster over the Qinghai– Tibetan Plateau (QTP), Volume 17, pages 2849–2863, (2020).
2. Glacial Lake Outburst Flood Disasters and Integrated Risk Management in China, Volume 8, pages 493–497, (2017)
3. Geospatial Analysis of Glacial Lake Outburst Flood (GLOF), Manish Rawat, Ashish Pandey & Praveen Kumar Gupta
4. Glacial Lake Outburst Flood Hazard and Risk Assessment of Gangabal Lake in the Upper Jhelum Basin of Kashmir Himalaya Using Geospatial Technology and Hydrodynamic Modeling, Ahmed et al.

5. Hazard from Himalayan glacier lake outburst floods, Georg Veh georg.veh@uni- potsdam.de, Oliver Korup, and Ariane Walz.
6. Risk and Uncertainty Assessment for Natural Hazards, Jonathan Rougier, Steve Sparks, Lisa Hill
7. Increasing risk of glacial lake outburst floods from future Third Pole deglaciation, Zheng et al.
8. Remote Sensing of Glaciers, Techniques for Topographic, Spatial and Thematic Mapping of Glaciers, Edited ByPetri Pellikka, W. Gareth Rees
9. Field techniques in glaciology and glacial geomorphology, Hubbard, Bryn
10. Finding a Sustainable Balance: GIS for Environmental Management (Applying GIS), Sunny Fleming, Matt Artz

IWC-632	**Informatics in Wildlife Conservation**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand wildlife conservation importance for biodiversity and ecosystem health.	Cognitive	Understanding (2)	PLO-01, PLO-07
Recognize ICT applications in wildlife conservation efforts.	Cognitive	Understanding (2)	PLO-01, PLO-05
Explore GIS, remote sensing, telemetry, GPS, and satellite tracking in wildlife monitoring.	Cognitive	Applying (3)	PLO-01, PLO-05
Engage in hands-on exercises using ICT tools and equipment	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-09

for wildlife conservation.			

Course Content:

Module 1: **Wildlife Conservation and Informatics**

- Understanding the importance of wildlife conservation for biodiversity and ecosystem health.
- The Informatics in wildlife conservation efforts

Module 2: GIS, Remote Sensing, and Tracking Technologies in Wildlife Monitoring

- Exploring GIS and Remote Sensing technologies for monitoring and mapping wildlife habitats.
- The use of satellite imagery in wildlife tracking, habitat assessment, and landscape analysis.
- The use of radio telemetry in tracking animal movements and behavior.
- GPS and satellite tracking devices in studying wildlife migration and ecology.

Module 3: Data Management and Analysis

- Big data analytics in processing and analyzing large datasets.
- The importance of data security and ethical considerations in wildlife conservation data management.

Module 4: Conservation Drones and Robotics

- Unmanned aerial vehicles (UAVs) in wildlife monitoring, anti-poaching efforts, and habitat assessment.
- The integration of robotics for tasks such as animal tracking, data collection, and surveillance.

Module 5: ICT in Anti-Poaching Operations and Case Studies

- Role of surveillance technologies, including cameras, sensors, and real-time monitoring systems, in anti-poaching efforts.
- Machine learning algorithms in predicting and preventing wildlife crimes.
- Real-world case studies highlighting successful applications of ICT in wildlife conservation.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class

Discussion, Guest Speakers, and Quizzes.

Recommended Books

1. Wildlife Biodiversity Conservation, Multidisciplinary and Forensic Approaches, Susan C. Underkoffler, Hayley R. Adams
2. Digital technology and the conservation of nature, Volume 44, pages 661–673, (2015)
3. Wildlife Ecology, Conservation, and Management, John M. Fryxell, Anthony R. E. Sinclair, Graeme Caughley
4. Remote Sensing and GIS for Ecologists: Using Open Source Software (Data in the Wild), Martin Wegmann, Benjamin Leutner, Stefan Dech.
5. Camera Traps in Animal Ecology, Methods and Analyses, Allan F. O'Connell, James D. Nichols, K. Ullas Karanth.
6. Acoustic localization of terrestrial wildlife: Current practices and future opportunities, Tessa Rhinehart.

IAM-633	**Industrial Air Pollution Monitoring**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand industrial air pollution sources, types, and impacts.	Cognitive	Understanding (2)	PLO-01, PLO-07
Explore air pollution monitoring techniques and regulatory frameworks.	Cognitive	Understanding (2)	PLO-01, PLO-06
Design effective air pollution control systems for particulate matter and gaseous pollutants.	Cognitive	Applying (3)	PLO-01, PLO-03, PLO-05
Engage in hands-on exercises using	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-09

specialized equipment and software for air pollution monitoring in industry.			

Course Content:

Module 1: Industrial Air Pollution and Monitoring Techniques

- The sources, types, and impacts of industrial air pollution, national and international regulations governing industrial air quality.
- Methods for collecting air samples in industrial settings
- Data collection using state-of-the-art monitoring instruments.

Module 2: Emission Sources in Industries

- Air pollution emissions from different industrial activities.
- Differentiation between stationary and non-stationary pollution sources.
- Air quality standards and guidelines for industrial emissions.
- Strategies for ensuring adherence to established air quality standards.

Module 3: Designing Air Pollution Control Systems

- Technologies for controlling industrial air pollution.
- Designing control systems that seamlessly integrate with industrial processes.
- The principles and applications of cyclones and fabric filters.
- Design considerations for effective particulate matter removal.

Module 4: Gaseous Pollutant Control Technologies

- Designing systems for removing gaseous pollutants using absorption and adsorption.
- Application and design considerations for catalytic converters.

Module 5: Ventilation System Design

- Principles and design strategies for diluting airborne contaminants.
- Designing systems to capture and remove pollutants at the source.

Module 6: Real-Time Monitoring and Sensor Technologies

- Continuous Emission Monitoring Systems (CEMS), Implementation and design considerations

- Advancements in Sensor Technologies

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

1. Industrial Air Pollution Monitoring, Andrew G. Clarke
2. Industrial Air Pollution, Assessment and Control, Aysen Müezzinoğlu, Martin Lloyd Williams
3. Air Pollution Control Engineering, Second Edition, 1999, McGraw-Hill, ISBN: 0070393672
4. C. David Cooper and F. C. Alley, Air Pollution Control: A Design Approach, Fourth Edition,.2010, Waveland Pr Inc, ISBN: 157766678X
5. Air Pollution Control Technology Handbook, Karl B. Schnelle Jr., Charles A. Brown.
6. Industrial Air Pollution Monitoring, Andrew G. Clarke.
7. Handbook of Air Pollution From Internal Combustion Engines
8. Pollutant Formation and Control, Eran Sher.
9. Air Quality 6th Edition, Wayne T. Davis, Joshua S. Fu, Thad Godish
10. Principles of Air Quality Management, Roger D. Griffin

UHM-634	**Urban Heat Island (UHI) Monitoring**	**3-0**

Course Learning Outcomes (CLOs)	**Domain**	**Taxonomy Level**	**Program Learning Outcomes (PLOs)**
Understand Urban Heat Island (UHI) causes and impacts on urban environments.	Cognitive	Understanding (2)	PLO-01, PLO-07
Learn and apply UHI monitoring technologies, including satellite and ground-based sensors.	Cognitive	Applying (3)	PLO-01, PLO-05

Implement sustainable urban planning and mitigation strategies considering UHI.	Cognitive	Applying (3)	PLO-01, PLO-03, PLO-06
Engage in hands-on practical exercises using specialized equipment and software for UHI monitoring.	Psychomotor	Applying (3)	PLO-02, PLO-03, PLO-05, PLO-09

Course Content:

Module 1: **Urban Heat Island (UHI), Formation and Processes**

- Urban Heat Island, its causes, and the impact on urban environments.
- Monitoring UHI for sustainable urban planning.
- Examining how land-use changes contribute to UHI.
- Understanding the processes that trap and retain heat in urban areas.

Module 2: UHI Monitoring Technologies, Data Collection and Analysis

- Utilizing satellite imagery for large-scale UHI assessments.
- Implementing ground-based sensors for local and precise UHI monitoring.
- Temperature Measurements: Techniques for collecting temperature data in urban areas.
- Spatial and Temporal Analysis: Analyzing UHI patterns over different timescales and geographic locations.

Module 3: Climate and Microclimate Influence

- The relationship between UHI and regional climate.
- Identifying local features affecting UHI, such as green spaces and water bodies.

Module 4: Urban Planning and Mitigation Strategies

- Incorporating UHI considerations into urban planning.
- Implementing mitigation techniques like green roofs, cool pavements, and urban forestry.

- The health implications of UHI on urban populations.
- Assessing the social and economic consequences of UHI.

Module 6: Community Engagement, UHI Awareness, and Governance

- Developing strategies to engage communities in UHI awareness.
- Involving citizens in UHI monitoring through participatory approaches
- Understanding policies and regulations related to UHI.
- Effective governance models for UHI management.

Teaching Methodology

- Lecturing, Written Assignments, Presentation/seminars, Interactive Sessions /Class Discussion, Guest Speakers, and Quizzes.

Recommended Books

1. Urban Heat Island (UHI) Mitigation, Hot and Humid Regions, Napoleon Enteria, Matteos Santamouris, Ursula Eicker
2. Urban Heat Island Monitoring with Global Navigation Satellite System (GNSS) Data, Jorge Mendez-Astudillo, Lawrence Lau, Isaac Yu Fat Lun, Yu-Ting Tang & Terry Moore
3. Urban Heat Island Studies in Hot and Humid Climates: A Review of the State of Art in Latin-America, Massimo Palme
4. Urban Heat Island (UHI) Implications and a Holistic Management Framework, Hafiza Saba Islam, Talib Elahi Butt, Shaker Mahmood Mayo, Siddiqa Amin & Maria Ali
5. Urban Climate Mitigation Techniques, Mat Santamouris, Denia Kolokotsa
6. Heat Islands: Understanding and Mitigating Heat in Urban Areas, Lisa Mummery Gartland
7. Urban Remote Sensing, Qihao Weng, Dale Quattrochi, Paolo Gamba
8. Urban Microclimate, Designing the Spaces Between Buildings, Evyatar Erell, David Pearlmutter, Terence Williamson.
9. Sustainable Mitigation Strategies for Urban Heat Island Effects in Urban Areas, by Irfeey et. Al.