UNIVERSITY OF DHAKA

Outcome-based Curriculum
of
Master of Science in
Soil, Water and Environment

(Session: 2022-2023 and onwards)

Department of Soil, Water and Environment
The University of Dhaka
Bangladesh
2024

OUTCOME-BASED CURRICULUM

PART - A and B

1. **Title of the Academic Program:** Master of Science in Soil, Water and Environment

Program Overview	
Degree	Master of Science in Soil, Water and Environment
Abbreviated form of the Degree	M. S. in SWE
Program Offering Entity (POE)	Department of Soil, Water and Environment
Acronym of the POE	Department of SWE
Faculty	Faculty of Biological Sciences
Awarding Institution	University of Dhaka
Location	Dhaka, Bangladesh
Bangladesh National Qualifications Framework (BNQF) Level	7 and 9
Mode of Study	Full Time
Language of Study	English
Applicable Session	2022- 2023 and onwards

2. **Name of the University:** The University of Dhaka
3. **Vision of the University:**
    - To create new areas of knowledge and disseminate this knowledge to the society and the nation as well.
    - To enrich the global pool of knowledge by making notable contributions in the fields of teaching and research.
    - To strive and transform the world in positive ways through advanced education, impactful research with new knowledge, and the translation of knowledge into solutions.
    - To create sustained environments to advance the motto of the University and to build and maintain excellence.
4. **Mission of the University:**

Sl. No	Description
UM1	Generating new knowledge through a broad array of scholarly, research and creative endeavors, which provide a foundation for dealing with the immediate and long-range needs of society.
UM2	Building strength through creative innovation, entrepreneurship, research, intellectual curiosity and partnerships.
UM3	Empowering our students to fulfill their academic and professional passions in the university that is diverse, welcoming, and inclusive for all students, faculty, and staff.
UM4	Serving society through coordinated countrywide outreach programs that meet continuing educational needs in accordance with the university's designated status.
UM5	Fostering a diverse community of students, staff, and faculty. It is dedicated to access, affordability, and ensuring that the benefits of its transformative educational opportunities are not limited by financial circumstance or background.

UM6	Maintaining a level of excellence and standards in all programs that will give them national and international significance.
UM7	Supporting the community of alumni through imaginative programs that enrich their lifelong relationship with the University and that expand the collective contributions to the world.

5. **Name of the Program Offering Entity:** Department of Soil, Water and Environment

6. **Vision of the Program Offering Entity:**
The vision of the department is to be a regional hub that will take the lead in solving all the regional problems and global problems, for that matter. The department will advance the understanding of soil, water, and environmental sciences by devoting its cutting-edge facilities to research. The department is also committed to transferring its research-based findings to all the stakeholders, including farmers, policymakers, scientists, and other citizens.

7. **Mission of the Program Offering Entity:**

Sl. No	Description
M1	To recruit top quality students and educate them into skilled academic and research scholars in the focal area of soil, plants, water and environmental sciences through offering advanced courses.
M2	To create partnership in research collaboration, student-faculty exchange programs in the academic institutions, among national and international institutions in such a manner that students could keep up with the changing needs of the local people looking for soil, water, and environmental sciences graduates.
M3	To innovate new technology and develop new knowledge for the sustainable utilization of soil, agriculture, ecosystem and water resources, transfer them to the end-users, research partners and stakeholders for making policy, and to formulate necessary packages for the restoration of environmental degradation, mitigating, adopting and combating climate change and other natural disasters.

8. **Name of the Degree:**
Master of Science in Soil, Water and Environment

9. **Description of the Program:**
The department was established in 1949 in the name of the Department of Soil Science. The Department of Soil Science was renamed as the Department of Soil, Water and Environment in the year 2000 to broaden the scope of the academic arena. Since then, the department has been offering a one year Master of Science degree in Soil, Water and Environment with an aim to produce trained personnel for agriculture and environment related fields.

10. **Program Educational Objectives (PEOs):**

PEOs	Description	Domain
PEO 1	To educate and train the graduates theoretically and practically on Soil, Water and Environment with a broad-based knowledge regarding agriculture, soils, water and the sustainable resource utilization and management, climate change, greenhouse effects, etc.	Fundamental
PEO 2	To develop innovative ideas and knowledge to capacitate graduates for managing and sustaining the bio-resources for the survival of human habitats and of ecosystem restoration.	Fundamental
PEO 3	To incorporate advance knowledge and skills for the designing and formulation of contemporary issues regarding soil-plant-water-air continuum	Thinking, personal

PEO 4	To facilitate the graduates to be leaders in the research and development domain for accelerating the society development through agro-farming, mitigation and adaptation strategis and entrepreneurship development.	Social, personal
PEO 5	Implication of research knowledge/ideas on society development through livelihood development with integrating much awareness involving local stakeholders.	Social, personal

11. Program Learning Outcomes (PLOs):

PLOs	Statement
PLO 1	Explain the fundamental concepts of soil, water and environment and correlate their influence on ecosystems and their services.
PLO 2	Explore the nature and properties of soil, water and environmental components to address regional, national and global issues.
PLO 3	Highlight the principles of soil, water and environment to ensure safety, security and wellbeing of future generation.
PLO 4	Respond to societal problems and demand through the findings of the research communication, motivation and extension.
PLO 5	Create social awareness regarding environmental components and promote the measures to sustain soil health, food security, soil-plant-lithoshere management, soil ecology and environmental safety.
PLO 6	Identify and analyze soil, water and environment related problems and resolve by applying appropriate strategic knowledge of these branches.
PLO 7	Proper scientific methods to investigate the soil-plant-water-environmental processes and their interactive systems on food security for healthy environments and their utilization in valid and logical field and laboratories.
PLO 8	Apply the knowledge base and research skills to current issues about soil, water and environmental resources, their management, and ecological balance with long-term sustainability which creates bridge between economic, social and policy level.
PLO 9	Ability to speak, communicate, write up of thesis and publish original scientific work in the peer reviewed journals professional-level presentations of their research.
PLO 10	Justify knowledge and information technology on the scientific method, experiment design, research implementation in qualitative and quantitative analysis and interpret the results using appropriate statistical techniques and computer applications.

12. Graduate Attributes (GAs):

GAs	Description	Domain
GA1	Comprehensive knowledge and understanding of the subject areas, and the ability to applying their knowledge in multidisciplinary areas.	Fundamental domain
GA2	Digital skills to compete with the different aspects of Soil, Water and Environment	Fundamental domain
GA3	Application of critical thinking in innovative and problem-solving aptitudes.	Thinking domain
GA4	Creative responses and advanced thinking should be applied to combat the future challenges.	Thinking domain
GA5	Professional development in applying the entrepreneurial and take leadership roles in their chosen occupations.	Personal domain

GA6	Self-awareness and reflective attitudes of the graduates; flexible and resilient and have the capacity to accept and give constructive feed back; hence they act with integrity and take responsibility for their actions.	Personal domain
GA7	Leadership in managing in their respective professions with positive and collaborative ways.	Social domain
GA8	Carries social values and ethics in society development as a responsible member of the valued society.	Social domain
GA 9	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	Life-long learning domain

13. Mapping mission of the university with PEOs

PEOs	UM1	UM2	UM3	UM4	UM5	UM6	UM7
PEO1	3	1	2	3	3	1	2
PEO2	2	3	1	1	2	2	1
PEO3	2	1	3	2	1	3	3
PEO4	1	2	2	2	3	2	2
PEO5	3	3	3	3	2	3	2

***Level of correlation:** (1) Weak, (2) Moderate, and (3) Strong*

14. Mapping PLOs with the PEOs

PLOs	PEO 1	PEO 2	PEO 3	PEO 4	PEO 5
PLO 1	*	*			
PLO 2		*	*		
PLO 3		*	*		
PLO 4				*	*
PLO 5				*	*
PLO 6		*	*		
PLO 7	*	*	*	*	*
PLO 8		*			
PLO 9			*		
PLO 10			*		

15. Teaching- Learning and Assessment Strategy[a]

[a]**Strategy:** Students in each class will have two class representatives (one male and one female) to communicate with the students, several study circles to discuss the delivered lectures within/among the circles and finally with the teacher if needed. Regular attendance, counseling, asking questions, creation of problems and make solutions, arrangement of discussions, demonstrations, etc. will be maintained.

[b]**Visual:** Picture, Diagram, Demonstration, Display, Handouts, Films, Flip-chart

[c]**Auditory:** To the spoken word, sounds and Noise

[d]**Kinesthetic**/Practical: Physical experience- touching, feeling, holding, doing, practical hands on experience

M. S. Degree
Session: 2022-2023 and onward

General description of the program:

1. The course of study for the degree of M. S. in Soil, Water and Environment shall extend over one academic year. The M. S. degree will be awarded in three different focal areas and the name of the degree will be -

M. S. in Soil, Water and Environment (Focal area: Soil Science) **or**
M. S. in Soil, Water and Environment (Focal area: Water Science) **or**
M. S. in Soil, Water and Environment (Focal area: Environmental Science)

2. A student must earn 30 credits for successful completion of his/her M.S. program. Each student has to take 20 credits of theory courses, 4 credits of practical and 2 credits of field works (for Group A: Non-thesis Group) or 6 credits of thesis work (for Group B: Thesis Group), 2 credits of seminar, and 2 credits of viva-voce.

3. A minimum of 12 class-hours will constitute one credit for theory courses. For one credit of practical/field work there shall be at least 20 hours of laboratory/field works. Each credit shall carry 25 marks.

4. Marks for a theory course will be distributed as:

Class attendance	5%
In-course assessment	35%
Course Final Examination	60%

a) The basis for awarding marks for class attendance will be:

Attendance (%)	**Marks (%)**
95 and above	5
90 to less than 95	4
85 to less than 90	3
80 to less than 85	2
75 to less than 80	1
Less than 75	0

b) In-course tests of minimum one hour duration shall be conducted and evaluated by the course teacher. There will be a minimum of 2 (two) written tests for 4- credit courses and a minimum of 1(one) written test for 2- credit courses. A student failing to appear in an in-course test will not be allowed to sit for any make up test. An absence in any in-course test for any reason shall be counted as zero for assessment averaging purposes.

c) The course final examination will be conducted centrally by the Controller of Examinations. The course final examinations will be of 3 hours duration for 4- credit courses and 2 hours for 2- credit courses.

5. Marks for a practical course (Group A) will be distributed as:

Class attendance	10%
Continuous assessment	30%
Course Final Examination	60%

6. Marks for a thesis (Group B) will be distributed as:

Thesis presentation	40%
Thesis evaluation by external examiners	60%

7. The 20 (twenty) credits of theory courses (ten courses) shall be similar for both non-thesis (Group A) and thesis (Group B) students. A student shall select four to five courses from his/her own focal area and at least two courses from each of the other two focal areas. A student may select SWE 501 and SWE 502 courses to fulfill the required numbers of courses for each of the focal areas, however, he/she will not be allowed to select both courses for the same focal area.

SUMMARY OF COURSES

Core Courses (compulsory for all students)		
Course No	**Course Title**	**Credit**
SWE 541	Practical for Group A (non-thesis), Soil Science focal area	4
SWE 542	Practical for Group A (non-thesis), Water Science focal area	4
SWE 543	Practical for Group A (non-thesis), Environmental Science focal Area	4
SWE 544	Field Work and Community Outreach for Group A (non-thesis), Soil Science focal area	2
SWE 545	Field Work and community Outreach for Group A (non-thesis), Water Science focal area	2
SWE 546	Field Work and Community Outreach for Group A (non-thesis), Environmental Science focal Area	2
SWE 547	Thesis for all students of Group B (thesis group)	6
SWE 548	Seminar (for all students)	2
SWE 549	Viva-voce (for all students)	2

Optional Courses (can be used for any focal area)		
Course No	**Course Title**	**Credit**
SWE 501	Practical for Group A (non-thesis), Soil Science focal area	4
SWE 502	Practical for Group A (non-thesis), Water Science focal area	4

Optional Courses (for Soil Science focal area)		
Course No	**Course Title**	**Credit**
SWE 511	Soil Classification	2
SWE 512	Advanced Soil Physics	2
SWE 513	Advanced Soil Chemistry	2
SWE 514	Coastal and Wetland Soil Management	2
SWE 515	Soil Technology	2
SWE 516	Soil Carbon Dynamics	2
SWE 517	Land Evaluation and Crop Modeling	2

Optional Courses (for Water Science focal area)		
Course No	**Course Title**	**Credit**
SWE 521	Water Pollution	2
SWE 522	Water Treatment Technology	2
SWE 523	Water Resource Management	2
SWE 524	Marine Ecosystem	2
SWE 525	Maritime Law and Conventions	2
SWE 526	Marine Meteorology and Research	2
SWE 527	Integrated Water Resource Management	2

Optional Courses (for Environmental Science focal area)		
Course No.	**Course Title**	**Credit**
SWE 531	Environmental Microbiology	2
SWE 532	Environmental Quality	2
SWE 533	Environmental Impact Assessment	2
SWE 534	Environmental Ecology	2
SWE 535	Environmental Biotechnology	2
SWE 536	Environmental Law	2
SWE 537	Agricultural Environment and Ecosystem Services	2

DETAILED COURSE CONTENTS

Core Courses (compulsory for all students)

Course Code: SWE 541	**Credits:** 4 (100 Marks)	**Course Type:** Core course
Course Title: Practical for Group A (non-thesis), Soil Science focal area		
Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment		
Rationale of the Course: This course is designed in a way that the students will carry out practical experiments assigned by the course teacher with an aim in conducting a comprehensive quantitative analysis of soil, and related attributes to monitor soil/land quality and their sustainable management potentials.		
Course Objectives: The objective of this course is to train the graduate students in a way that they can design and utilize soil resources in a pragmatic manner to attain food security and the goals of SDGs.		
Mapping with SDGs: This course is relevant to achieve SDG 2 (Zero hunger), 4 (Quality education), 13 (Climate action) and 15 (Life on land).		

Course Learning Outcomes (CLOs) and Mapping with PLOs		
Upon completion of this course the students will be able to learn:		**PLOs covered**
CLO 1	sample processing for laboratory analyses, testing, and quantification of soil/land properties, data analysis interpretation, modeling and subsequently policy approach.	PLO 5, 6 & 7

Course Contents			
Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Related to SWE 512** Determination of Soil Moisture Characteristic Curve in the laboratory by using Pressure Plate Apparatus. Determination of Plant Available water from Soil Moisture Characteristic Curve.		CLO 1
2	**Related to SWE 513** Chemistry of submerged soils and their dynamic changes that occur in soil solution involving thermodynamic principle, solubility and stability of specific ions, sorption theory and models; chemistry related to problem soils like acid, saline and submerged soils.		CLO 1
3	**Related to SWE 516** Soil organic carbon (SOC) determination by wet oxidation method, and bulk density measurement; SOC contents, variability and ultimate SOC stock; collection of time series data and other associated facts and figures (like aerial photo or Landsat images etc.) for change detection.		CLO 1
4	**Related to SWE 517** Students will undertake a comprehensive land evaluation project, applying concepts and techniques learned throughout the course.		CLO 1

Learning Materials	
Recommended Readings	*Lal, Rattan; John Kimble; Ronald Follett and Bobby Stewart. 1998. Soil processes and the global C cycle. CRC Press.* *Kutsch, Werner; Michael Bahn and Andreas Heinemeyer. 2010. Soil Carbon dynamics: an integrated methodology. Cambridge University Press, U.K.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	Visual, Auditory and Kinesthetic[d]	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 542	**Credits:** 4 (100 Marks)	**Course Type:** Core course
Course Title: Practical for Group A (non-thesis), Water Science focal area		
Prerequisite(s): B.S. (Honors) Degree in Soil, Water and Environment		
Rationale of the Course: This course is designed in a way that the students will carry out practical experiments assigned by the course teacher with an aim conducting a comprehensive survey of a watershed or flood plain unit to monitor water quality and water management potential.		
Course Objectives: The objective of this course is to provide students a comprehensive practical knowledge of water quality parameters and water science in general.		
Mapping with SDG: This course is relevant to achieve SDG 4 and 14		

Course Learning Outcomes (CLOs) and Mapping with PLOs		
Upon completion of this course the students will be able to learn:		**PLOs covered**
CLO 1	sample processing for laboratory analyses, water quality parameters measurements in the laboratory, data interpretation, and recommendation.	PLO 4, 5 & 6
CLO 2	analysis of different parameters of potable, industrial, and wastewater.	PLO 4, 5 & 6
CLO 3	monitor, evaluate, and manage surface and ground water resources	PLO 4, 5 & 6
CLO 4	analysis of the soil, water, and plant samples from marine ecosystems will give a comprehensive understanding of their sustainability as a habitat.	PLO 4, 5 & 6
CLO 5	assessment of the threats to the quality of water resources	PLO 4, 5 & 6

Course Contents			
Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Related to SWE 521** Determination of heavy metal contents in wastewater, Analysis of water quality parameters and pollutants. Data interpretation.		CLO 1
2	**Related to SWE 522** Monitoring of water quality and treatment processes by using different coagulants and flocculants for potable, industrial, and wastewater.		CLO 2 & 1
3	**Related to SWE 523** A field work will be carried in selected sites of watershed management and surface and ground water monitoring areas in different parts of Bangladesh. An assessment study to find out sources of surface water pollution in the rivers of Bangladesh. Possible intrusion of contaminants in ground water sources of Bangladesh		CLO 3
4	**Related to SWE 524** Analysis of the soil, water, and plant samples from marine ecosystems. Measurement of pH, electric conductivity (EC), Sodium adsorption ratio (SAR), Geo-accumulation index, and		CLO 4

	percentage of chloride and sulfate in the collected samples will be measured.		
5	**Related to SWE 527** Assessment of the threats to the quality of water resources, the identification of risk and the measures taken to protect them;		CLO 5

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual, Auditory and Kinesthetic[d]	
CLO 3	Visual and Auditory	
CLO 4	Visual and Auditory	
CLO 5	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 543	**Credits:** 4 (100 Marks)	**Course Type:** Core course

Course Title: Practical for Group A (non-thesis), Environmental Science focal area

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: This course is designed in a way that the students will carry out practical experiments assigned by the course teacher with an aim conducting a comprehensive survey and research on Environmental Microbiology, Environmental Quality, Environmental Impact Assessment, Environmental Ecology, Environmental Biotechnology, Environmental Law, Agricultural Environmental and Ecosystem Services.

Course Objectives: The objective of this course is to provide students a comprehensive practical knowledge on different technological parameters of environment, ecology and ecosystem services, Environmental Quality, Environmental Impact Assessment and Biotechnology, Environmental Law, Agricultural Environment in general.

Mapping with SDG: This course is relevant to achieve SDG 4, 6, 13, 14, 15 and 17.

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course the students will be able to learn:		**PLOs covered**
CLO 1	the techniques and methods required for analysis of all the components of the environment and use of different experimental designs for the successful completion of a study; learn various instrumental techniques employed in environmental analysis; learn the skills of writing a research paper.	PLO 4, 5, 6
CLO 2	teach students how to develop research programs; to enable students to enhance their ability to understand, plan and execute experiments; to appropriately analyse and interpret quantitative data generated in experiments using appropriate statistical methods; to enhance research and personal development skills; and, to introduce relevant statistical software tools to develop proficiencies that will come into play at some point in their future career.	PLO 1, 3, 5
CLO 3	understand how soil environment supports microbial growth and how microorganisms support formation and development of soils. Also learn about the shift in microbial communities, their metabolism and transformation of chemical species under submergence	PLO 1, 5, 9, 10
CLO 4	learn basic concepts of environmental quality, equity related to environmental issues, indicators, standards and criteria setting; work on urban and industrial air pollution sites, and do emission inventories and air pollution modeling for air quality management; understand water quality monitoring and planning to meet desired uses.	PLO 1, 5, 9, 10
CLO 5	explain the different categories of the projects and apply for the clearance certificate as required by the specification; explain the parameters of EIA quantification and structure of the EIA report	PLO 1, 2, 4
CLO 6	explain and understanding of the required laws and issues; explain standards for different environmental parameters and different mitigation measures.	PLO 1, 5, 9, 10

CLO 7	The Ecology, Ecosystem, Environment and their interactions regarding soil as a habitat for organisms;	PLO 1, 5, 9, 10
CLO 8	the Environmental Conservation Rules that are laid out under the Act, outlining the standards of the air, water and other components of the environment.	PLO 1, 2, 5, 9, 10.
CLO 9	Acquire knowledge on terrestrial ecosystems, global warming potential of greenhouse gases and be able to fore-cast regarding their future directions and consequences	PLO 1, 5, 9, 10

Course Contents

Sl No.	Topic	Class Hours	CLOs covered
1	**Related to SWE 501:** Environmental Sampling and Analysis: Basics of Environmental Sampling and Analysis, Environmental Sampling Design, Environmental Sampling Techniques, Quality Assurance and Quality Control of Environmental Analysis, Sources of Error in Analysis; Common Operations and Wet Chemical Methods in Environmental Laboratories;Sample Preparation for Environmental Analysis: Principles of Acid Digestion and Selection of Acid, Alkaline Digestion and Other Extraction Methods.	12	CLO 1
2	**Related to SWE 502:** Execute experiments using appropriate statistical methods, and to introduce relevant statistical software tools to develop proficiencies that will come into play at some point in their future career.	12	CLO 2
3	**Related to SWE 531:** Subjective or Sensory evaluation: appearance, texture, colour, odour, flavour, taste and additional quality factors; Paired Preference Test (PPT), Ranking Test (RT), Hedonic Tests (HT); Isolation of biodegradative microbes from environment; Detection of Non-culturable state of microorganisms; Detection of indicators and pathogenic microbes in potable water ; Water purification (*viz*., flocculation, chlorination, ozonation etc.).	8	CLO 3
4	**Related to SWE 532:** Determination of different nutrient elements and heavy metal contents in solid wastes, wastewater, soil and plant samples; determination of water quality parameters of different industrial waste effluents.	8	CLO 4
5	**Related to SWE 533:** Analyses of effluents collected from different industries.	5	CLO 5
6	**Related to SWE 534:** Measurements of greenhouse gas (CO_2, N_2O, CH_4) fluxes and introduction to inoculation techniques.	5	CLO 6
7	**Related to SWE 535:** Analysis of water and soil for quality assessment and biochemical characterization of microbes	5	CLO 7
8	**Related to SWE 537:** Measurement of soil quality and fluxes of greenhouse gases.	5	CLO 8, 9

Learning Materials	
Recommended Readings	*Microbial Ecology: Fundamentals and Applications by Ronald M. Atlas* *Arcadio, P.A and A.S. Gregoria. 2008. Environmental Engineering. Prentice-Hall, Inc, USA* *Marr, I.L. and Cresser, M. S. 1983. Environmental Chemical Analysis. International Textbook Company, Blackie & Son Ltd. Bishopbriggs, Glasgow G64 2NZ, and Furnival House, 14-18 High Holborn, London WC IV 6BX.* *Ecology – Concepts and Application. Manuel C. Molles Jr. (2001).* *Ecology - Theories and Application. Peter Stiling (2001).*
Supplementary Readings	*Handbook: Environmental Procedures and Guidelines* *Environmental Impact Assessment For Changing World- Dr Subrota Kumar Saha*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual, Auditory and Kinesthetic[d]	
CLO 3 to 9	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 544	**Credits:** 2 (50 Marks)	**Course Type:** Core course

Course Title: Field Work and Community Outreach for Group A (non-thesis), Soil Science focal area

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: This course is designed where the students will carry out in situ practical experiments assigned by the respective course teacher. After the successful completion of the experiments, the student will acquire knowledge practically in implementing the potentials of the soil resources and their successful utilization in attaining the goals of SDGs.

Course Objectives:
The objective of this course is to provide students a comprehensive knowledge of soil classification, advanced soil physics, advanced soil chemistry, coastal and wetland soil management, soil technology, soil carbon dynamics, and land evaluation and crop modelling etc.

Mapping with SDG: This course is relevant to achieve SDG **2 (Zero hunger)**, **4 (Quality education), 13 (Climate action) and 15 (Life on land).**

Course Learning Outcomes (CLOs) and Mapping with PLOs		
Upon completion of this course the students will be able to learn:		**PLOs covered**
CLO 1	soil resources exploration, assessment/ quantification, data analysis, interpretation, modeling and subsequently approaches of way forward.	PLO 4, 5 & 6

Course Contents			
Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Related to SWE 511** learn the key characteristics of soils in the orders of Soil Taxonomy and have a working knowledge of the WRB system of soil classification for world soil resources.		CLO 1
2	**Related to SWE 514** Field visit based on ecosystem vulnerable areas; identify the need-based assessment of potential resources and their utilization aspects; in situ recommendation and farmers advisory services to enhance the ecosystem services		CLO 1
3	**Related to SWE 515** A field visit will be carried out in different research institutes of Bangladesh to give an idea on the technology generated by the respective institutes.		CLO 1
4	**Related to SWE 516** Depth-wise various soil and core samples as well as grid-wise surface samples collection in groups from the field of a proposed area (case study)		CLO 1
5	**Related to SWE 517** Different Models and yield estimation will be observed by the students at field levels.		CLO 1

Learning Materials	
Recommended Readings	*FAO, 2017. Voluntary guidelines for sustainable Land management. Rome, Italy.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	Visual, Auditory and Kinesthetic[d]	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 545	**Credits:** 2 (50 Marks)	**Course Type:** Core course
Course Title: Field work and community outreach for Group A (non-thesis), Water Science focal area		
Prerequisite(s): B.S. (Honors) Degree in Soil, Water and Environment		
Rationale of the Course: This course is designed with an aim for the students to conduct a comprehensive field work to visit and survey a watershed or flood plain unit to monitor water quality and water management potential.		
Course Objectives: The objective of this course is to provide students a comprehensive knowledge of basic water science, management of water resources, and reach local communities to understand their livelihoods and find solutions of the problems related to water resources.		
Mapping with SDG: This course is relevant to achieve SDG 4 and 14.		

Course Learning Outcomes (CLOs) and Mapping with PLOs		
Upon completion of this course the students will be able to learn:		**PLOs covered**
CLO 1	treatment and management water pollution	PLO 1 to 8
CLO 2	watershed management	PLO 1 to 8
CLO 3	marine ecosystem	PLO 1 to 8
CLO 4	marine pollution	PLO 1 to 5
CLO 5	oceanographic processes	PLO 2, 3, & 8
CLO 6	integrated water resource management	PLO 7 & 8

Course Contents			
Sl. No	**Topic**	**Class Hours**	**CLOs covered**
1	**Related to SWE 521** Visit to polluted areas and contaminated sites, and different industrial plants of Bangladesh to collect wastewater, and soil and plant samples.		CLO 1
2	**Related to SWE 522** A field-level visit will be conducted to acquire practical knowledge from the surface water treatment plant at Saydabad, the sewage treatment plant at Pagla and effluent treatment plant visit at Karnafuli pulp and paper industry at Rangamati.		CLO 1
3	**Related to SWE 523** Climatological and Hydrological Data Collection and analysis of data for watershed management plan and contaminant assessment.		CLO 2

4	**Related to SWE 524** Methodical collection and analysis of the soil, water, and plant samples from marine ecosystems will give a comprehensive understanding of their sustainability as a habitat. Therefore, students are encouraged to visit Cox's Bazar, Teknaf, and St. Martin coral island to collect the mentioned samples. Furthermore, such pragmatic in-situ fieldwork is essential to have a look into the coral islands of Bangladesh and the effect of climate change on them which concurs with SDG 14.		CLO 3
5	**Related to SWE 525** Visit marine pollution by oil, chemicals, hazardous substances, garbage, and sewage, etc. Liability against marine pollution, clearing process, and materials used to recover the pollution damage, shore reception facility, emergency oil pollution preparedness, and response.		CLO 4
6	**Related to SWE 526** Ocean tours for study of indication of atmospheric and oceanic interactions; how Oceanographic processes influencing marine weather; Study of meteorological instruments and Oceanographic instruments used in marine research, and Remote sensing techniques for observing marine weather and climate.		CLO 5
7	**Related to SWE 527** Gender approaches and strategies for mainstreaming gender in IWRM; Policies, goals, strategies and institutional arrangement for IWRM		CLO 6

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual, Auditory and Kinesthetic[d]	
CLO 3	Visual and Auditory	
CLO 4	Visual and Auditory	
CLO 5	Visual and Auditory	
CLO 6	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 546	**Credits:** 2 (50 Marks)	**Course Type:** Core course

Course Title: Field Work and Community Outreach for Group A (non-thesis), Environmental Science focal area

Prerequisite(s): B.S. (Honors) in Soil, Water and Environment

Rationale of the Course: This course is designed to the students will carry out practical experiments assigned by the course teacher with an aim conducting a comprehensive survey and research on Environmental Microbiology, Environmental Quality, Environmental Impact Assessment, Environmental Ecology, Environmental Biotechnology, Environmental Law, Agricultural Environmental and Ecosystem Services.

Course Objectives: The objective of this course is to provide students a comprehensive knowledge of basic water chemistry, water pollution, causes/sources, measurements, data interpretation, and recommendations for sustainable aquatic systems considering all physico-chemical water quality parameters.

Mapping with SDG: This course is relevant to achieve SDG **4, 6, 13, 14, 15 and 17.**

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course the students will be able to		PLOs covered
CLO 1	get an in-depth knowledge of analytical techniques related to soil, water, and environmental analysis. The students will also acquire a thorough understanding of experimental designs that are employed for conducting experiments in different branches of soil, water, and environmental sciences.	PLO 1 to 7
CLO 2	understand how soil environment supports microbial growth and how microorganisms support formation and development of soils. Also learn about the shift in microbial communities, their metabolism and transformation of chemical species under submergence learn basic concepts of environmental quality, equity related to environmental issues, indicators, standards and criteria setting; work on urban and industrial air pollution sites, and do emission inventories and air pollution modeling for air quality management; understand water quality monitoring and planning to meet desired uses.	PLO 1 to 7
CLO 3	explain the different categories of the projects and apply for the clearance certificate as required by the specification; explain the parameters of EIA quantification and structure of the EIA report	PLO 1 to 5
CLO 4	explain and understanding of the required laws and issues; explain standards for different environmental parameters and different mitigation measures.	PLO 1 to 5
CLO 5	Define/Distinguish among Ecology, Ecosystem, Environment and their interactions regarding soil as a habitat for organisms	PLO 1 to 5
CLO 6	Acquire knowledge on terrestrial ecosystems, global warming potential of greenhouse gases and be able to fore-cast regarding their future directions and consequences	PLO 1 to 5
CLO 7	about the environmental issues; the mechanism for management of effluent discharged from different industries;	PLO 1 to 5, 8, and 9

CLO 8	the laws and harmful effects of pesticides on crop, soil and water and other environmental issues.	PLO 1 to 4, 9, and 10
CLO 9	Measure the impacts of intensive rice systems and industrial crop processing.	PLO 5, and 8 to10

Course Contents

Sl No.	Topic	Days Required	CLOs covered
1	**Related to SWE 501:** Environmental Sampling and Analysis: Basics of Environmental Sampling and Analysis, Environmental Sampling Design, Environmental Sampling Techniques, Quality Assurance and Quality Control of Environmental Analysis, Sources of Error in Analysis; Converting Raw Data in Reportable Form, Reporting Analytical Data, Presentation of Results: Graphs and Tables.	10	CLO 1
2	**Related to SWE 502:** Laboratory-based experiments, Pot experiments, Field-based experiments, Basic experimental designs.	10	CLO 2
3	**Related to SWE 531:** Sampling at urban waste management sites; Isolation of heavy metal degrading microbes from mine sites; Visiting heavy industries and observing their waste management procedures.	3	CLO 3
4	**Related to SWE 532:** Visit to polluted areas, contaminated soil sites and different industrial plants of Bangladesh to collect solid wastes, wastewater, and soil and plant samples.	3	CLO 4
5	**Related to SWE 533:** Visit to different categories industries (Green, Yellow, Orange and Red) and Waste management site with special reference to Matuail Sanitary Landfill; Collection of samples from visited institutions and Report writing. EIA; Case study (Gupta Khali - Baakh Khali - Boalia Irrigation, Maowa Bridge, and Ruppur Reactor Projects, Jamuna Bridge). Green industry visit.	5	CLO 5
6	**Related to SWE 534:** Measurements of greenhouse gas (CO_2, N_2O, CH_4) concentrations and Introduction of inoculation techniques under field conditions.	4	CLO 6
7	**Related to SWE 535:** A visit to a food processing ndustry to observe and understand the utilization of biotechnological tools in product processing and to safeguard environmental pollution. Collection of environmental and microbial samples for laboratory analyses.	3	CLO 7
8	**Related to SWE 536:** The following case studies on the judgments of High Court and Appellate Divisions on Environmental Issues are major concern: 1. BLAST and others vs. Bangladesh and others [Vehicular Pollution Case] Writ Petition No. 1694/2000.	10	CLO 8

	2. Bangladesh Environmental Lawyers Association (BELA) Vs. Government of Bangladesh and others, 2010, 39 CLC (HCD). 3. Metro Makers and Developers Limited and others Vs. Bangladesh Environmental Lawyers' Association Limited (BELA) and others, 2012, 41 CLC (AD). 4. Bangladesh Environmental Lawyers Association (BELA) Vs. Bangladesh, 2009, 38 CLC (HCD). 5. Bangladesh Environmental Lawyers Association (BELA) Vs. Bangladesh represented by the Secretary, Ministry of Environment and Forest and 18 others, 2010, 39 CLC (HCD).		
9	**Related to SWE 537:** Measurement of impacts of intensive rice systems and industrial crop processing; and Identification of technological innovations.	4	CLO 9

Learning Materials	
Recommended Readings	Microbiology: Concepts and Applications by Michael Joseph Pelczar *Mendham et. al. 2002. Vogel's Textbook of Quantitative Chemical Analysis. Pearson Education Ltd., India.* *Bluman, A. G. 2014. Elementary Statistics: A Step by Step Approach. McGraw-Hill Education.* *The greenhouse effect, climate change and Ecosystems. Bert Bolin, Bo R. Döös, Jill Jäger and Richard A. Warrick (1986).*
Supplementary Readings	*Marr, I.L. and Cresser, M. S. 1983. Environmental Chemical Analysis. International Textbook Company, Blackie & Son Ltd. Bishopbriggs, Glasgow G64 2NZ, and Furnival House, 14-18 High Holborn, London WC IV 6BX.* *Climate change and Agriculture, ASA Spec.Publ. No. 59.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual, Auditory and Kinesthetic[d]	
CLO 3	Visual and Auditory	
CLO 4	Visual and Auditory	
CLO 5	Visual and Auditory	
CLO 6	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Optional Courses (can be used for any focal area)

Course Code: SWE 501	**Credits:** 2 (50 Marks)	**Course Type:** Optional course
Course Title: Analytical Techniques		
Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment		
Rationale of the Course: The course is designed for graduate students of the department with a focus on the analytical techniques required for the analysis of soil, water, and environmental samples. This course covers the basics of environmental sampling and analysis, common operations done in environmental laboratories, skills required for the preparation of environmental samples, classical and sophisticated analytical techniques, know-how of data analysis, knowledge of planning and executing a research program, and crafts of writing a research paper.		
Course Objectives: The objective of this course is to teach the techniques and methods required for analysis of all the components of the environment. This will aid them when they carry out their research work at MS and PhD levels, in different research organizations, and academia, for that matter. The laboratory part will complement the theoretical part and is likely to provide students with hands-on experience.		
Mapping with SDG: This course is relevant to achieve SDG 2, 4 & 11.		

Course Learning Outcomes (CLOs) and Mapping with PLOs		
Upon completion of this course, the students will be able to:		**PLOs covered**
CLO 1	understand the basics of environmental sampling, analysis, sampling techniques, and quality assurance and quality control procedures.	PLO 1, PLO 2 & PLO 3
CLO 2	learn some of the essential operations in environmental laboratories performing wet chemical analysis along with safety and waste disposal activities.	PLO 1 & PLO 2
CLO 3	know the principles of sample preparation techniques, including digestion, extraction, and derivatization.	PLO 1, PLO 2 & PLO 9
CLO 4	learn various instrumental techniques employed in environmental analysis.	PLO 2, PLO 3 & PLO 9
CLO 5	learn how to process raw data into something meaningful; learn how to present results in a scientific manner.	PLO 1 & PLO 4
CLO 6	learn how to plan and execute an elaborate research program.	PLO 1, PLO 4 & PLO 8
CLO 7	learn the skills of writing a research paper.	PLO 1, PLO 4 & PLO 8

Course Contents			
Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Environmental Sampling and Analysis:** Basics of Environmental Sampling and Analysis, Environmental Sampling Design, Environmental Sampling Techniques, Quality Assurance and Quality Control of Environmental Analysis, Sources of Error in Analysis	4	CLO 1
2	Common Operations and Wet Chemical Methods in Environmental Laboratories	2	CLO 2

3	**Sample Preparation for Environmental Analysis:** Principles of Acid Digestion and Selection of Acid, Alkaline Digestion and Other Extraction Methods, Extraction for SVOC and Non-VOC from Liquid or Solid Samples	4	CLO 3
4	**Analytical techniques:** Titrimetry, Gravimetry, Spectrophotometry, Atomic Absorption Spectroscopy, Infrared Spectroscopy, Atomic Emission Spectroscopy, Chromatography, Atomic Mass Spectrometry, Molecular Mass Spectrometry, Nuclear Magnetic Resonance Spectroscopy, Thermal Analysis	10	CLO 4
5	Converting Raw Data in Reportable Form, Reporting Analytical Data, Presentation of Results: Graphs and Tables.	3	CLO 5
6	Planning and Execution of a Research Program	4	CLO 6
7	Crafts of Writing Research Papers	3	CLO 7

Learning Materials	
Recommended Readings	*Mendham, J., Dennet, R. C., Bernes, J. D., & Thomas, M. J. K. (2003). Vogel's Textbook of Quantitative Chemical Analysis* *Zhang, C. (2007). Fundamentals of Environmental Sampling and Analysis. John Wiley & Sons.* *Ellison, C. (2010). McGraw-Hill's Concise Guide to Writing Research Papers*

Mapping CLOs with the Teaching-Learning and Assessment Strategy (*VAK)		
CLOs	**Teaching- Learning Strategy[a]**	**Assessment Strategy**
CLO 1	[b]Visual, [c]Auditory, and Kinesthetic[d]	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual and Auditory	
CLO 3	Visual, Auditory, and Kinesthetic	
CLO 4	Visual, Auditory, and Kinesthetic	
CLO 5	Visual, Auditory, and Kinesthetic	
CLO 6	Visual and Auditory	
CLO 7	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 502	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Design of Experiments

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: This course is designed to provide the Graduate students of the department a comprehensive knowledge on planning and execution of a variety of agricultural and environmental experiments through applying appropriate statistical techniques as well as analyzing and interpreting experimental datasets. This course also emphasizes a better understanding of how to interpret and present numerical data generated in experiments to a high standard by using a variety of statistical software.

Course Objectives: The objective of this course is to provide students with direct experience of a range of skills required by modern-day agricultural/environmental scientists to undertake and present their research to appropriate audiences. This course aims to teach students how to develop research programs; to enable students to enhance their ability to understand, plan, and execute experiments; to appropriately analyze and interpret quantitative data generated in experiments using appropriate statistical methods.

Mapping with SDG: The course is relevant to achieving SDG goals No. 4 (Quality Education), 13 (Climate Action), and 15 (Life on Land).

Course Learning Outcomes (CLOs) and Mapping with PLOs

After successful completion of the course, students will be able to -		**PLOs covered**
CLO 1	understand the nature and characteristics of research activities; the life cycle of a research project from concepts, through planning to execution; the effective communication of results; and the emerging problems and more fundamental ethical issues related to a research program.	PLO 6
CLO 2	learn about the different types of agricultural experiments, and understand the basic principles of experimental design.	PLO 7 & PLO 10
CLO 3	use the one-way and two-way ANOVA techniques to determine any significant difference among treatment means.	PLO 7 & PLO 10
CLO 4	understand the experimental design applicable to different single-factor experiments, including the procedures for randomization, plot layout, and analysis of variance with actual experiments.	PLO 7 & PLO 10
CLO 5	understand the experimental design applicable to two-factor experiments, as well as the interactions between two or more variable factors.	PLO 7 & PLO 10
CLO 6	understand the concept of simple and multiple correlation and regression, and compute the correlation coefficient, the equation of regression line, and the coefficient of determination.	PLO 10
CLO 7	use different statistical packages on the computer to process experimental data by selecting the most appropriate methods and extracting the important information from the output of the tests.	PLO 10

Course Contents

Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Planning and Execution of a Research Program:** *Scientific Research:* The nature of scientific research and innovation, Categories of research, Types of research activities, Limitations on research activities, Developing a research topic.	5	CLO 1

	The Life Cycle of a Project: Developing a new project, building a research proposal, submitting a proposal, Proposal review, Project planning and management, Measures of performance, Reporting requirements, Risk analysis, Intellectual property issues. *Research Communication:* Preparing a publication, Seminars and conference presentations. *Research Issues*: Management structures, The impact of problems, Ethics in research.		
2	**Agricultural Experiments:** Hydroponics, Sand culture, Laboratory-based experiments, Pot experiments, Field-based experiments, Basic experimental designs.	3	CLO 2
3	**Analysis of Variance (ANOVA):** One-way analysis of variance, Two-way analysis of variance, Comparison between treatment means - the least significant difference test; Duncun's multiple-range test and Tukey test.	4	CLO 3
4	**Single-Factor Experiments:** Completely randomized design, Randomized complete block design, Latin square design, and Lattice design with their merits and demerits; Analysis of experimental data.	6	CLO 4
5	**Two-Factor Experiments:** Interaction between two factors, Factorial experiment, Split-Plot design, Strip-Plot design, Analysis of experimental data.	4	CLO 5
6	**Correlation and Regression Analysis:** Simple linear correlation and regression, Multiple linear correlation and regression, Nonlinear relationship, Regression line, Coefficient of determination.	4	CLO 6
7	**Use of different Statistical Programs.**	4	CLO 7

Learning Materials	
Recommended Readings	*Pruzan, P. 2016. Research Methodology: The Aims, Practices, and Ethics of Science. Springer.* *Leedy, P. D. and Ormrod, J. E. 2019. Practical Research: Planning and Design. 12th Edition. Pearson* *Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedures for Agricultural Research. John Wiley & Sons, Inc.* *Petersen, R. G. 1994. Agricultural Field Experiments: Design and Analysis. CRC Press, Taylor & Francis Group, LLC.*
Supplementary Readings	*Bluman, A. G. 2014. Elementary Statistics: A Step by Step Approach. McGraw-Hill Education.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLOs 1-6	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLOs 7	Visual, Auditory, and Kinesthetic[d]	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the opening days *(if available)*.

Optional Courses (for Soil Science focal area)

Course Code: SWE 511	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Soil Classification

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: SWE 511 (Soil Classification) is designed for Graduate students of the department so that they get a comprehensive idea about the soil classification systems of the world. This course focuses on modern soil classification systems including U.S. Soil Taxonomy, FAO-UNESCO Soil Map of the World and World Reference Base (WRB) System of Soil Classification. Additionally this course encompasses soil classification in Bangladesh and other SAARC countries.

Course Objectives: At the end of the course the students should be able to understand and utilize the principles of soil classification, learn the key characteristics of soils in the orders of Soil Taxonomy and have a working knowledge of the WRB system of soil classification for world soil resources.

Mapping with SDG: This course is relevant to achieve SDG 4 and 15.

Course Learning Outcomes (CLOs) and Mapping with PLOs		
Upon completion of this course the students will be able to:		**PLOs covered**
CLO 1	acquire knowledge on the concepts, objectives and usefulness of soil classification.	PLO 1& 2
CLO 2	understand the historical development of soil classification and modern soil classification systems.	PLO 1 & 2
CLO 3	understand the rationale, structure, nomenclature and categories of U.S. Soil Taxonomy and classify soils using the system.	PLO 1 & 7
CLO 4	understand the major soil groupings and soil units of FAO-UNESCO world soil map.	PLO 2& 5
CLO 5	familiar with the basic principles of WRB and interpret the names of reference soil groups of WRB.	PLO 2& 5
CLO 6	understand classification of Bangladesh soils and the soils of other SAARC countries.	PLO 2& 5

Course Contents			
Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Classification**: Meaning, types and uses of classification.	2	CLO 1
2	**Classification of Soils**: Developmental history of soil classification; Modern soil classification systems.	5	CLO 2
3	**Soil Taxonomy**: objectives, structure, nomenclature, categories and diagnostic horizon. Detailed study of Soil Taxonomy. Keys to soil taxonomy. Use of Soil taxonomy for soil survey. Temperature and moisture regimes. Soil family – the 5^{th} level of soil taxonomy.	8	CLO 3
4	**FAO-UNESCO Soil Map of the World**: objectives, structure, nomenclature. Description of major soil groupings and soil units.	5	CLO 4

5	**World Reference Base (WRB) for Soil Resources System of Soil Classification:** Background and basics; The rules for classifying soils and creating map legends; Diagnostic horizons, properties and materials; Key to the Reference Soil Groups with lists of principal and supplementary qualifiers; Description, distribution, use and management of Reference Soil Groups.	6	CLO 5
6	**Soil classification** in Bangladesh and SAARC countries.	4	CLO 6

Learning Materials	
Recommended Readings	*Soil Survey Staff. 1999. Soil Taxonomy - A Basic System of Soil Classification for Making and Interpreting Soil Surveys. Second Edition. USDA-NRCS. Washington, D.C.* *FAO.1988. FAO/Unesco Soil Map of the World. Soil Resources Reports No. 60. FAO, Rome.* *IUSS Working Group WRB. 2015. World Reference Base for Soil Resources 2014, update 2015. International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome.*
Supplementary Readings	*Hussain, M. S. 2020. Soil Classification. Dhaka Univ. Press, Dhaka.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual, Auditory and Kinesthetic[d]	
CLO 3	Visual, Auditory and Kinesthetic[d]	
CLO 4	Visual and Auditory	
CLO 5	Visual and Auditory	
CLO 6	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 512	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Advanced Soil Physics

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: SWE 512 (Advanced Soil Physics) is designed for Graduate students of the department so that they get a theoretical understanding of flow process of water, solutes, air and heat in the soil. This course focuses on water flow in unsaturated soil, solute movement, gaseous exchange, and energy transfer in the soil. In addition, ground water drainage and pollution will also be discussed.

Course Objectives: The objective of this course is to provide students a comprehensive knowledge on water movement within the soil profile under unsaturated condition, solute movement in the soil, ground water and its pollution, flow of air in the soil, energy transfer and heat flow within the soil.

Mapping with SDG: This course is relevant to achieve SDG 4 and 15.

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course the students will be able to-		**PLOs covered**
CLO 1	explain the equations of water flow under unsaturated condition in the soil and measure unsaturated hydraulic conductivity of a soil.	
CLO 2	understand solute movements and effect of solutes on water flow in the soil.	
CLO 3	explain ground water and aquifer, drainage design equations, and ground water pollution.	
CLO 4	understand soil air and soil respiration.	
CLO 5	understand gas movement and exchange in the soil, greenhouse gases.	
CLO 6	explain energy balance, heat transfer and modification of soil thermal regime.	

Course Contents

Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	Flow in unsaturated Vs saturated soil, Relation of conductivity to suction and wetness, Equations of unsaturated flow- The continuity equation and the combined flow equation, Hydraulic Diffusivity, Measurement of unsaturated hydraulic conductivity in the field.	7	CLO 1
2	Convective transport of solutes, Diffusion of solutes, Hydrodynamic dispersion, Miscible displacement and Breakthrough curves, Combined transport of solutes, Effects of solutes on water movement in the soil.	9	CLO 2

3	Ground water, Aquifer- confined and unconfined, Ground water drainage and factors influencing drainage, Drainage design equations, Ground water pollution.	5	CLO 3
4	Composition of soil air, Measurement of soil-air content, Soil respiration and aeration requirements. Convective flow of air in the soil, Diffusion of gases in the soil, Formulation of diffusion processes, Measurement of gaseous convection and diffusion in soils, Emissions of greenhouse gases in the soil.		CLO 4 and 5
5	Modes of energy transfer, Energy balance for a bare soil, Conduction of heat in soil, Volumetric heat capacity of soil, Thermal conductivity and diffusivity of soil, Thermal regime of soil and its modification.	4	CLO 6

Learning Materials	
Recommended Readings	*Hillel, D. 1998. Environmental Soil Physics. Academic Press. London, UK* *Scott, H. D. 2000. Soil Physics: Agricultural and Environmental Applications. C State Univ. Press, Ames, Iowa, USA.*
Supplementary Readings	

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	Visual[b] and Auditory[c] and Kinesthetic[d]	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual and Auditory	
CLO 3	Visual and Auditory	
CLO 4	Visual and Auditory	
CLO 5	Visual and Auditory	
CLO 6	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 513	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Advanced Soil Chemistry

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: The course is designed to accomplish a vivid understanding of soil chemical processes from basic soil components to crucial chemical changes in soil like salinity, acidity development, organic and metallic pollution threshold involving sorption and solubility-all of which affects plant growth, ecosystem, and environment.

Course Objectives: The objectives of this course are to provide students a comprehensive knowledge on chemistry of soil components and their significance, dynamic changes that occur in soil solution involving thermodynamic principle, solubility and stability of specific ions, sorption theory and model, chemistry related to problem soils like acid, saline and submerged soils.

Mapping with SDG: This course is relevant to achieve SDG 2 & SDG 4.

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course the students will be able to:		**PLOs covered**
CLO 1	understand the basic chemical bonding and reactions that occur among soil components, how nutrients chemically transform and participate in C, N, P, S cycle.	PLO 2 & 3
CLO 2	Explain how chemical equilibrium and kinetics is related to ion solubility, what stability diagram indicates and how it is developed.	PLO 2 &3
CLO 3	Understand sorption mechanism in soil and their impact on environment	PLO 3 & 4
CLO 4	Understand chemistry behind soil acidity problem and their solution	PLO 2 & 8
CLO 5	Understand chemistry behind soil salinity problem and their solution.	PLO 3 & 8
CLO 6	Understand how chemistry of submerged soil is different from upland soil and associated changes.	PLO 2 & 8

Course Contents

Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1.	**A brief review of the soil components:** Layer silicates, organic matter, water and air. Amorphous and crystalline oxides and hydroxides of iron, manganese, aluminum and silicon in soils, their physical and chemical characteristics. Chelate formation, ligand exchange, Clay-organic complex, C, N, P, and S cycles in soil, water and air.	6	CLO 1
2.	**Soil Solution–Solid Phase equilibrium:** Concepts of Chemical equilibrium, thermodynamic equilibrium, Electro chemistry and chemical kinetics: Measurement of the Soil Solution; Speciation of the Soil Solution; Ion Activity and Activity Coefficients; Stability Diagrams.	6	CLO 2
3.	**Sorption Phenomena on Soils:** Introduction and Terminology; surface complexes; Adsorption Isotherms; Equilibrium-based Adsorption Models, Double-Layer Theory and Models, Points of Zero Charge	6	CLO 3
4.	**Chemistry of acid soils:** Active and potential acidity; sub-soil acidity; solution chemistry of aluminum; mechanism of pH change; liming	5	CLO 4

	materials; lime potential; Buffer capacity and lime requirement of soil; acidity effects on plant growth		
5.	**Chemistry of salt-affected soils:** Soil salinity development, classification of salinity, salinity measurements- ECe, ESP, SAR and important relations; salinity effects on plant growth, salinity reclamation with amendments and management practice	5	CLO 5
6.	**Chemistry of submerged soils:** Reduction sequence in submerged soil; Electrochemical changes (Eh, pH, EC) in submerged soil, Solubility of nutrients –Fe, Mn, N, S, P under submerged condition, alternate wetting drying effects on soil properties.	2	CLO 6

Learning Materials	
Recommended Readings	*Bohn, H, Mcneal B L, Connor G A O 1979.* ***Soil Chemistry.*** *Sparks D S, 2003.* ***Environmental Soil Chemistry.*** *Lindsay, W. L. 1979.* ***Chemical Equilibria in Soils****.*
Supplementary Readings	*Brady, N.C. and R.R. Weil. 2002.* ***The Nature and Properties of Soil****. (13th ed.) Pearson Education, Singapore* *Tan, K. H. 1993.* ***Principles of Soil Chemistry****. (2nd ed.) Marcel Dekker, Inc.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	Visual[b] and Auditory[c]	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual and Auditory	
CLO 3	Visual and Auditory	
CLO 4	Visual, Auditory and Practical[d]	
CLO 5	Visual, Auditory and Practical	
CLO 6	Visual, Auditory and Practical	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 514	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Coastal and Wetland Soil Management

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: The rationale of this course is to get a theoretical idea on Coastal and Wetland ecosystems and their resources, and their potentials, and sustainable management to achieve the goals of SDGs. Now-a-days coastal and wetland environment becomes hot issues due to climate change and carbon emissions. As a result, formulation of eco-friendly technologies is very much urgent in these hotspots.

Course Objectives: The objective of this course is to assist students to gain knowledge, and apply knowledge in the motivation of local stakeholder's, policy makers to mitigate recent climate change and other environmental issues.

Mapping with SDG: This course is relevant to achieve SDG 4 & SDG 15.

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course the students will be able to:		**PLOs covered**
CLO 1	explain guidelines on sustainable ecosystem management and their vulnerability regarding climate change and food security issues.	PLO 2, 4, 6, & 5
CLO 2	get an idea on the vulnerable or fragile ecosystem and their management	PLO 4 to 8
CLO 3	coastal and wetland ecosystem restoration and policy development	PLO 5 to 8

Course Contents

Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1.	**Wetland and its resources:** Definition of wetland and Ramsar convention; kinds of wetlands; importance of wetlands; wise management of wetlands; major wetlands sites/ecosystems of Bangladesh; eco-resources of wetlands of Bangladesh; degradation of wetland resources; policies regarding wetland management and food security issues; basin soils of Bangladesh; haor agriculture; recommended policies on haor/basin ecosystem management.	6	CLO 1
2.	**Hydric soils:** properties or criteria; formation of redoximorphic features; effects of soil texture on redoximorphic feature appearance.	3	CLO 1
3.	**Coastal zone:** Defining the coastal zone; salient features coastal morphology and hydro-morphogical dynamics; classification of the coast line; coastline movement; land accretion and erosion in the coastal estuary; agro-ecological zones in the coastal zone of Bangladesh.	3	CLO 1
4.	**Ecosystems:** Major ecosystems in the coastal zone: aquatic ecosystems, terrestrial ecosystems, interconnected ecosystems. Blue carbon sequestration processes in the coastal ecosystems.	3	CLO 2
5.	**Coastal resources**: resources degradation in the coastal zone of Bangladesh; policies on coastal resources restoration due to overuse and climate change effects.	3	CLO 2

6.	**Coastal hazards:** Salinity, waterlogging, pollution from ship breaking industry, pollution from agro-chemicals and oil spills etc.	3	CLO 2
7.	**Shrimp farming:** Evolution, history, present situation, economic development and environmental impacts.	2	CLO 2
8.	**Peat soils:** degradation of peat soils due agricultural intensification and climate change; policies on peat soil restoration and utilization.	2	CLO 3
9.	**Innovative technologies for the livelihoods development of local stakeholders:** salt farming, api-farming, sand mining, coir industry, crab fattening, hydroponics vegetable farming, and other integrated farming, etc.	3	CLO 3
10.	**ICZM:** History and concepts; coping with climate change; Bangladesh and the estuary; an agenda for future. Adaptation to climate change in the coastal zone. Ecotourism etc.	2	CLO 3

Learning Materials	
Recommended Readings	*BCAS, 1994. Wetlands of Bangladesh. Bangladesh Centre for Advanced Studies, Dhaka.* *Islam, MR. 2004. Where land meets the sea. The University Press Limited.* *Ahmed, AU. 2008. Assessment of Vulnerability to Climate Change and Adaptation Options for the Coastal People of Bangladesh. Practical Action, Bangladesh, Dhaka.* *Koen de Wilde, 2010. Moving coastlines. The University Press Limited.*
Supplementary Readings	

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	Visual[b] and Auditory[c] and Kinesthetic[d]	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual and Auditory	
CLO 3	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 515	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Soil Technology

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: Soil technology, agricultural sustainability, and effectiveness of available technologies for managing soil and water resources are crucial demand for food security and healthy environment.

Course Objectives: This multidisciplinary course aims to guide the students to improve knowledge on (i) Strategies, constraints, and challenges of soil technology; (ii) Expanding decision support system for agrotechnology transfer (DSSAT); (iii) Technologies for integrated soil and sediment research; (iv) Managing problems of soil and sediment pollution; and (v) Designing future technologies for soil, water and agriculture.

Mapping with SDG: This course is relevant to achieve SDG 4, 13 & 15

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course the students will be able to:		**PLOs covered**
CLO 1	Learn about the strategies, constraints, and challenges of soil technologies.	PLO 1
CLO 2	Know the duties of agriculture leaders and policy makers; Decision Support System for Agrotechnology Transfer (DSSAT).	PLO 1, 2, 4 &8
CLO 3	Acquire knowledge on technological base for soil and agricultural sustainability; resource inventory; effectiveness of available technologies for managing soil and water resources.	PLO 1 & 2
CLO 4	Gain knowledge on technology adaptation, compilation, applications, and technology transfer.	PLO 1 & 5
CLO 5	Acquire knowledge on technologies (GIS and RS) for integrated soil and sediment research.	PLO 1, & 6
CLO 6	Explore knowledge on managing problems of soil & sediment pollutions.	PLO 2 & 6
CLO 7	Acquire knowledge of precision agriculture for designing future technologies for soil, water and agriculture.	PLO 3 & 7

Course Contents

Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	Course objectives, Basic concepts of soil technologies: strategies, constraints, and challenges.	Three	CLO 1
2	Duties of agriculture leaders, policy changes; expanding decision support system for agro technology transfer (DSSAT).	Eight	CLO 2
3	Technological base for soil and agricultural sustainability; agronomic potential and resource inventory, effectiveness of available technologies for managing soil and water resources.	Four	CLO 3

4	Technology adaptation; compilation of technologies and applications; technology transfer.	Four	CLO 4
5	GIS and RS technologies for integrated soil and sediment research.	Four	CLO 5
6	Research and development priorities, Managing problems of soil and sediment pollution.	Four	CLO 6
7	Precision Agriculture: Designing future technologies for soil, water and agriculture.	Three	CLO 7

Learning Materials	
Recommended Readings	*Rehman, T. (1996). Technologies for sustainable agriculture in the tropics: Edited by J. Ragland and R. Lal. American Society of Agronomy Inc., Crop Science Society of America Inc., and Soil Science Society of America Inc., Madison, Wisconsin, USA. ASA Special Publication Number 56, 1993. 313 pp.*
Supplementary Readings	*Manfreda, S., & Eyal, B. D. (Eds.). (2023). Unmanned Aerial Systems for Monitoring Soil, Vegetation, and Riverine Environments.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual and Auditory	
CLO 3	Visual and Auditory	
CLO 4	Visual and Auditory	
CLO 5	Visual, Auditory and Kinesthetic[d]	
CLO 6	Visual and Auditory	
CLO 7	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 516	**Credits:** 2 (50 Marks)	**Course Type:** Core course

Course Title: Soil Carbon Dynamics

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: This course is projected to illustrate the principles and processes involved in global C cycle along with its dynamics and sequestration potentials in soil as well as management strategies associated with climate change issues with special reference to Bangladesh.

Course Objectives: The objectives of this course are to illustrate the global carbon cycling among major pools and reservoirs and its fluxes, budget and overall terrestrial carbon sequestration and dynamics in relation to present day land use changes and other anthropogenic activities affecting global warming, climate change and food security issues with recent data and research. Lecture will also focus on sustainable management strategies with special reference to Bangladesh.

Mapping with SDG: This course is relevant to achieve SDG 4.

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course the students will be able to:		**PLOs covered**
CLO 1	Explain various sources, sinks, pools and fluxes of C in global C cycle	PLO 1, 7 & 8
CLO 2	Describe the processes and mechanism of C sequestrations in different reservoirs in relation to major anthropogenic activities	PLO 8 & 9
CLO 3	Illustrate terrestrial C dynamics in natural and human intervened ecosystem as well as various methods and models to measure the change of organic carbon in soil	PLO 8 & 10
CLO 4	Apply various management options to minimize C emission with special reference to Bangladesh	PLO 8, 9 & 10

Course Contents

Sl. No.	Topic	Class Hours	CLOs covered
1	**Carbon Cycle:** Introduction and geochemical history of C; allotropes and radiocarbon dating. Sources and sink of C, major pools and reservoirs of global C and their fluxes in global C cycle; Global C budget etc.	6	CLO 1
2	**Carbon sequestration:** Basic concept; Ocean and terrestrial C sequestration. Storage and distribution of C in global soil orders and in various ecological zones. Pedospheric processes influencing C. Mechanism of C sequestration in soil. Soil erosion and biomass burning affecting global C balance. Soil C sequestration in relation to land use change and other anthropogenic activities.	5	CLO 1 & 2
3	**Carbon Dynamics:** Terrestrial C dynamics in natural and human intervened ecosystem. C dynamics in forest and grasslands. C dynamics in upland and wetland agro-ecosystem.	5	CLO 2
4	**Management Strategies:** Carbon management –CCS, Ocean Fertilization and deep injection etc.; Carbon Trade, IPCC to minimize C emission. Soil management practices to reduce C emission and increase C sequestration in soil. Potentials of C sequestration in Bangladesh soils. Use of Biochar and biofuels.	5	CLO 2

5	**Carbon model:** Measurement of organic carbon in soil; Measurement of the change of soil organic carbon –flux method and repeated inventory method; Modeling approach –Roth-C and CENTURY method.	5	CLO 3
6	**Soil Organic matter (SOM):** Composition and characteristics, indicator of soil quality. Non-humic and humic fractions –extraction, fractionation and characterization. Management of organic soils. Organic Farming. Organic matter status in Bangladesh soils with sustainable management approaches.	6	CLO 4

Learning Materials	
Recommended Readings	*Lal, Rattan; John Kimble; Elissa Levine and Bobby Stewart. 1995. Soils and global change. Lewis Publishers, U.S.A.,* *Lal, Rattan; John Kimble; Ronald Follett and Bobby Stewart. 1998. Soil processes and the global C cycle. CRC Press.* *Kutsch, Werner; Michael Bahn and Andreas Heinemeyer. 2010. Soil Carbon dynamics: an integrated methodology. Cambridge University Press, U.K.* *Tan, K. H. 1993. Principles of Soil Chemistry. (2nd ed.) Marcel Dekker, Inc.*
Supplementary Readings	*Brady, N.C. and Weil, R.R. 2013. The nature and properties of soils. Pearson Education Inc.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual, Auditory and Kinesthetic[d]	
CLO 3	Visual and Auditory	
CLO 4	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: **SWE 517**	**Credits**: 2 (50 Marks)	**Course Type**: Optional course

Course Title: Land Evaluation and Crop Modeling

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the course: The course on Land Evaluation and Crop Modeling is designed to provide students with essential knowledge and skills related to assessing land suitability for agricultural purposes and predicting crop growth and yield under various environmental conditions. The course on Land Evaluation and Crop Modeling addresses the pressing need for sustainable land use practices, informed agricultural decision-making, and resilient food systems. By equipping students with the knowledge and tools to assess land suitability, model crop growth dynamics, and evaluate environmental impacts, the course aims to empower future professionals to address the complex challenges facing global agriculture and food security.

Course Objectives: The objectives of the course aim to prepare students for careers in agriculture, environmental science, land management, and rural development, where they can contribute to sustainable food production, natural resource conservation, and resilient livelihoods in a changing world. The specific objectives include: 1. Understanding land evaluation principles, 2. Mastering crop modeling technique, 3. Fostering critical thinking and problem-solving skill, 4. Prompting sustainability and resilience.

Mapping with SDGs: This course is relevant to SDGs 12, 13 and 15

Course Contents

Sl. No.	Topic	Class Hours	CLOs covered
1	**Basic Concepts and procedures of land evaluation**, principles of FAO's land evaluation, key definitions of the FAO framework, map units of Natural Resource Inventories (NRI).	4	CLO 1
2	**Defining Land Utilization Type (LUT),** selecting land use requirements, evaluating land qualities from diagnostic land characteristics, overall suitability from land qualities.	4	CLO 2
3	**Spatial Analysis** of geographically based land characteristics, Digital Elevation Models for Land Evaluation, Global Positioning System for Land Evaluation.	3	CLO 3
4	**Statistical modeling** for land evaluation, yield estimation, multivariate statistical methods for land evaluation, use of principal components in yield prediction.	3	CLO 4
5	**Dynamic simulation modeling** for land evaluation, Dynamic simulation of crop yield, key issues in dynamic simulation modeling.	4	CLO 5
6	**Introduction to economic land evaluation**, Economic land Evaluation in automated land evaluation System, Risk Analysis, decision theory and multi-objective decision making.	4	CLO 4
7	**Uncertainty**, error propagation, Monte Carlo simulation, fuzzy logics and continuous classification, spatial variability.	3	CLO 6
8	**Pre-FAO land classification methods**: USDA land capability classification and international variants, USBR land suitability for irrigation; AEZ and its relation to FAO style land evaluation, Modern non-FAO land classification methods.	6	CLO 7

Learning Materials	
Recommended Readings	*Edoardo A.C. Costantini, Manual of methods for Soil and Land Evaluation. Science publishers (2009).* *Van Diepen, C. A., Van Keulen, H., Wolf, J., and Brekhout, J.A.A. (1991). Land Evaluation: from intuition to quantification, Advances in soil sciences. New York, Springer*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Case study.
CLO 2	Visual, Auditory and Kinesthetic[d]	
CLO 3	Visual and Auditory	
CLO 4	Visual and Auditory	
CLO 5	Visual and Auditory	
CLO 6	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Optional Courses (for Water Science focal area)

Course Code: SWE 521	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Water Pollution

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: This course is design for a basic theoretical understanding of general water chemistry and chemical equilibrium in natural waters. Water Pollution concepts; water quality parameters; potable water quality parameters, guidelines of uses and management. Water pollution management of surface and groundwater for sustainable aquatic systems. Fate of water pollutants in aquatic systems; monitoring and control of water pollutants. Furthermore, water quality management in ponds, lakes, watersheds and rivers.

Course Objectives: The objective of this course is to provide students a comprehensive knowledge of basic water chemistry, water pollution, causes/sources, measurements, data interpretation, and recommendations for a sustainable aquatic system considering all physico-chemical water quality parameters.

Mapping with SDG: This course is relevant to achieve SDG 4 and 14**.**

Course Learning Outcomes (CLOs) and Mapping with PLOs		
Upon completion of this course the students will be able to learn:		**PLOs covered**
CLO 1	General properties of water and chemical processes maintaining equilibrium in natural waters.	PLO 1 & 2
CLO 2	Water Pollution concepts, sources, types, water sampling techniques, sample processing for laboratory analyses, water quality parameters measurements in the laboratory, data interpretation, and recommendation. Potable water quality parameters, guidelines for uses and management.	PLO 4, 5 & 6
CLO 3	Management of surface and groundwater for sustainable aquatic environment.	PLO 7 & 8
CLO 4	Eutrophication, Oil Pollution, Fate and Movements of pollutants in aquatic environment.	PLO 7 & 8
CLO 5	Groundwater Pollution concepts.	PLO 7 & 8
CLO 6	Monitoring and Control of water pollutants in aquatic systems. Furthermore, water quality management in ponds, lakes, watersheds and rivers.	PLO 7 & 8

Course Contents			
Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	General properties of water. Water resources, Chemical equilibrium in natural water.	3	CLO 1

2	Water quality parameters: sources, impacts, measurement, standards and uses. Water quality standards, and water quality requirements. Potable water: criteria, standards and management. Analysis of water quality parameters and pollutants. Data interpretation.	7	CLO 2
3	Water pollution: sources, types, classification and control. Oil Pollution: causes, effects and control. Dissolved oxygen, dissolved oxygen sag curve.	7	CLO 3 & 4
4	Eutrophication: causes, effects and control.	3	CLO 4
5	Ground water pollution, causes, effects and control.	5	CLO 5
6	Water quality management: in ponds, lakes, and rivers. Water sampling.	5	CLO 5 & 6

Learning Materials	
Recommended Readings	*V. P. Kudesia. 2002.Water Pollution. Pragati Prakashani.* *Water Pollution (Causes, Effects and Control) - P.K. Goel*
Supplementary Readings	*P N Prasad, T R Amarnath. 2010. Environmental Water Pollution: Causes, Effects And Control. Crescent Publishing Corporation.* *Sudhakar Srivastava (Editor). 2010.* Arsenic in Drinking Water and Food. *Springer.* *Arvind Kumer. Water Pollution. APH Publishing Corporation. New Delhi.* *Soil and Groundwater Pollution - Alexander J.B. Zehnder* *Water quality handbook - McGraw-Hill.* *Water resources handbook - McGraw-Hill.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual, Auditory and Kinesthetic[d]	
CLO 3	Visual and Auditory	
CLO 4	Visual and Auditory	
CLO 5	Visual and Auditory	
CLO 6	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 522	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Water Treatment Technology

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: Water Treatment Technology course is designed to provide knowledge about the general concept of sources of impurities in water, and techniques or treatment processes for potable, industrial, waste water, sewage and their reuse. This course also involves the study of sludge dewatering and disposal.

Objectives: The objective of this course is to:

- gather knowledge about the general concept and techniques of water treatment.
- illustrate knowledge about the impurities in water.
- develop and understanding of the purification processes of soluble particles, organics, inorganics, particulate organic matter, hardness and other scale forming substances, corrosive substances, dissolved gases, taste, odour and colour, radioactive materials, toxic substances and oils.
- achieve knowledge on the treatment for potable, industrial and waste water.
- familiar of the different purification processes like membrane, filtration and disinfection of water.
- acquire knowledge about the reuse of waste-water and sewage.
- understand the natural water treatment processes like oxidation ponds or lagoon.
- comprehend common ideas about sludge dewatering and disposal.

Mapping with SDG: This course is relevant to achieve SDG 4 and 14.

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course the students will be able to:		**PLOs covered**
CLO 1	know the general ideas about the concept and techniques of water treatment	PLO 1, 2 & 3
CLO 2	comprehend common knowledge about the impurities in water like dissolved and suspended matter; and volumes, composition, characterization and flow of waste-water,	PLO 4 & 5
CLO 3	acquire knowledge about different processes of purifying water like removal of different water pollutants,	PLO 2, 3, 5 & 6
CLO 4	understand processes like membrane, filtration and disinfection of water,	PLO 5 & 6
CLO 5	understand different filtration processes, demonstrate water disinfection processes; understand the treatment of water for different industries.	PLO 5, 6 & 7
CLO 6	illustrate ideas about purification of water for drinking and domestic use; municipal water treatment,	PLO 6, 7 & 8
CLO 7	gather knowledge on primary, secondary and tertiary treatment of biological and non-biological wastes; treatment of some industrial effluents (Electroplating, Steel, Sugar cane, Paper and pulp, etc); reuse of waste-water; on sewage treatment; use of oxidation ponds or lagoon for natural water treatment processes; and on sludge dewatering and disposal.	PLO 6, 7 & 8

Course Contents			
Sl. No	**Topic**	**Class Hours**	**CLOs covered**
1	**General concept** and techniques of water treatment.	3	CLO 1
2	**Impurities in water:** Dissolved matter, Suspended matter, Biological impurities, Amount of impurities in water. Waste-Water flows, Volumes, Composition and characterization.	4	CLO 2
3	**Purification Processes:** Removal of soluble particles, Removal of Organics, Removal of inorganics, Removal of particulate organic matter, Removal of hardness and other scale forming substances, Removal of corrosive substances, Removal of dissolved gases, Removal of taste, odour and colour, Removal of radioactive materials, Removal of toxic substances, Removal of oils.	6	CLO 3
4	**Membrane Processes:** Microfiltration, Ultrafiltration, Reverse osmosis, Electrodialysis	2	CLO 4
5	**Filtration Processes:** Slow sand filters, Rapid Sand filters, Pressure filters, Gravity filters.	2	CLO 5
6	**Water Disinfection:** Chlorination, Ozonation, Chlorinedioxide, Ultraviolet Radiation.	2	CLO 6
7	**Treatment for Potable Water:** Purification of water for drinking and domestic use. Municipal water treatment.	3	CLO 7
8	**Treatment of water for Industry:** Food and drink, Boiler feed and, Pharmacy and Medicine, Electronics.	3	COL 8
9	**Waste Water Treatment:** Primary, secondary and tertiary treatment of biological and non-biological wastes. Treatment of some industrial effluents (Electroplating, Steel, Sugar cane, Paper and pulp, etc). Reuse of waste-water. Sewage treatment, Oxidation ponds for natural water treatment processes. Sludge dewatering and disposal.	5	COL 9

Learning Materials	
Recommended Readings	*Chemistry of Water Treatment –Samuel D. Faust, Osman M. Aly* *Handbook of Water Purification - Editor: Walter Lorch*
Supplementary Readings	*Water Treatment and Purification Technology –W. J. Ryan* *Environmental Science and Technology - Stanley E. Manahan* *The Environment - Chris Park* *Soil and Groundwater Pollution - Alexander J.B. Zehnder* *Environmental Chemistry - B.K. Sharma*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1 to 5	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level
CLO 6	Visual, Auditory and Kinesthetic[d]	
CLO 7	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 523	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Surface and Ground Water Management

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: This course (SWE-523) is aimed at giving ideas on water resources & its management practices and surface & ground water hydrology involved to fulfill those practices. In addition to that policies and transboundary water treaties will also be discussed.

Course Objectives: The objective of this course is to provide students encompassing knowledge include planning, design and surface & ground water hydrology on water resources management, management practices on the basis of hydrologic condition in an area and possible sources of pollution and mitigate the challenges on the basis of water resources policies in Bangladesh and sharing formula of water distribution in bordering rivers.

Mapping with SDG: The course is relevant to achieve SDG goal No. 4 and 14.

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course the students will be able to-		**PLOs covered**
CLO 1	acquire a brief idea on water resources and its global distribution.	PLO 1&2
CLO 2	get the ideas on how to assess a water resource plan in its time scale and use of its data after completing the projects.	PLO 8
CLO 3	learn management practices on the basis of hydrologic condition in an area and possible sources of pollution on the interface of surface and ground water.	PLO 6 & 7
CLO 4	design water resources projects.	PLO 9 & 10
CLO 5	know the policies of water resources in Bangladesh.	PLO 3 & 4
CLO 6	know how different countries of the world are sharing the waters from bordering rivers for their mutual benefits.	PLO 5

Course Contents

Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Water resources:** Actual and potential. Global water resources. Water stress. Water stress factors. Distribution of fresh water and saline water in global water balance.	3	CLO 1
2	**Water resources planning:** objectives, assessment of water resources plan. Application of water resources management.	6	CLO 2
3	**Surface water hydrology of water resources management:** Watershed management, overland flow, rivers and lakes. Solid and chemical waste management on the basis of disposal zone in surface and ground water.	6	CLO 3

4	**Streamflow analysis:** Water level, measurement of water level, discharge measurement, floods, causes of floods, danger level, flood measurement, flood frequency analysis, Flood hydrograph, Stage-Discharge relationships	5	CLO 4
5	**Water policy and water planning in Bangladesh:** National water policy in Bangladesh, Water planning- Role of Bangladesh Water Organization in water resources management, Flood Action Plan (FAP), National water management plan.	6	CLO 5
6	**Transboundary water resources:** Shared river basins, conflict potential, legal umbrella, International water resources treaties.	4	CLO 6

Learning Materials	
Recommended Readings	*V. P. Kudesia. 2002.Water Pollution. Pragati Prakashani.* *Water Pollution (Causes, Effects and Control) - P.K. Goel*
Supplementary Readings	*P N Prasad, T R Amarnath. 2010. Environmental Water Pollution: Causes, Effects And Control. Crescent Publishing Corporation.* *Sudhakar Srivastava (Editor). 2010.* Arsenic in Drinking Water and Food. *Springer.* *Arvind Kumer. Water Pollution. APH Publishing Corporation. New Delhi.* *Soil and Groundwater Pollution - Alexander J.B. Zehnder* *Water quality handbook - McGraw-Hill.* *Water resources handbook - McGraw-Hill.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	Lecture and team teaching	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2 to 5	Problem-based learning and presentation: Visual, Auditory and Kinesthetic[d]	
CLO 6	Lecture and Group Discussion: Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 524	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Marine Ecosystem

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: SWE 524 (Marine Ecosystem) is designed to provide the M.S. students a comprehensive knowledge on the nature, characteristics and importance of marine environment. This course focuses the depth, extent and distribution of world oceans; ecological zones of the oceans; marine resources; blue economy; marine organisms; and the dynamic interactions between human and sea. It will also discuss the nature and characteristics of different marine and estuarine ecosystems, and the sources, impacts, and prevention measures of marine pollution.

Course Objectives: The major objective of this course is to provide knowledge and experience of understanding the nature and properties of marine environments and their importance. In addition, the successful completion of the course will ensure and enable the students to practically apply their learnings into diverse sectors of oceanic study and research. Moreover, they will be more pragmatic in relating the sustainable use of marine resources for the development of the nation.

Mapping with SDG: This course is relevant to achieve SDG 14 (Life Below Water).

Course Learning Outcomes (CLOs) and Mapping with PLOs		
Upon completion of this course the students will be able to-		**PLOs covered**
CLO 1	learn about the nature and characteristics of marine environment, importance of ocean, depth and extent of different regions of the world oceans, ecological zones of the oceans, marine resources, blue economy, and the dynamic interactions between human and sea.	PLO 1, 3 & 7
CLO 2	understand the different physical and chemical characteristics of the oceans; interrelationships of salinity, temperature, pressure and density of ocean water; the nature, formation and classifications of waves and tides; oceanic currents, thermohaline circulation, and factors regulating the pattern and distribution of the currents.	PLO 1, 2, 8 & 10
CLO 3	know about the marine biological environment, organisms living in marine habitats, different types of phytoplankton and zooplankton, and the decomposers of marine ecosystems.	PLO 3
CLO 4	understand the nature and characteristics of different marine and estuarine ecosystems, coastal and estuarine ecosystems of Bangladesh, productivity and importance of estuaries.	PLO 1, 2 & 3
CLO 5	know about the sources and impacts of marine pollution, measures for prevention of marine pollution, impacts of climate changes on the marine ecosystems, and conservation of marine and estuarine resources.	PLO 2, 4, 5

Course Contents			
Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Marine Environment:** Study of the ocean and its inhabitants, Fundamentals of marine ecology, Classification of marine environment, Importance of oceans.	7	CLO 1 & 4

	Distribution of land and sea on the earth's surface, Ocean basins, Zones of the ocean, Ocean floor, Mapping the ocean floor, Plate tectonics. Nature of ocean water, Marine animals and plants, Major ecological zones, Marine resources, Blue economy, Human and sea interactions.		
2	**Physical and Chemical Properties of the Ocean:** Physical and chemical characteristics of the marine environment; Composition of ocean water; Salinity; Temperature; Pressure; Density; Salinity-temperature-density relationship; Nutrient uptake and gas exchange; Buoyancy; Waves – Formation and classification of waves; Tides – Nature and classification of tides; Oceanic currents – Surface currents, Coriolis effect, Gyres, Thermohaline circulation, Factors regulating the pattern and distribution of currents.	9	CLO 2 & 3
3	**Marine Organisms:** Marine biology, Types of organisms living in marine habitats, Classifications of phytoplankton and zooplankton, Marine microbes.	5	CLO 3
4	**Marine Ecosystems:** Marine ecology, Estuaries, Characteristics of Estuaries, Classification of estuaries, Estuarine productivity, Importance of estuaries, Coastal and estuarine areas of Bangladesh, The Bay of Bengal, The Bengal Fan, Inter-tidal communities, Salt marshes, Coral reef communities, Hydrothermal vents.	5	CLO 4
5	**Marine Pollution:** Pollution of the marine environment, Sources and impacts of marine pollution, Fate of pollutants, Prevention of marine pollution, Coastal problems, Ocean acidification, Impacts of climate changes on the marine ecosystems, Desalination of sea water, Conservation of marine and estuarine resources.	4	CLO 1 & 5

Learning Materials	
Recommended Readings	*G. Karleskint, R. Turner, J.W. Small (2010). Introduction to Marine Biology. Brooks/Cole, Cengage Learning.* *A. H. Arias, M. C. Menendez (2014). Marine Ecology in a Changing World. CRC Press, Taylor & Francis Group.* *A. Mitra, S. Zaman (2016). Basics of Marine and Estuarine Ecology. Springer, India.*
Supplementary Readings	*J. L. Sumich (1992). Introduction to the Biology of Marine Life. Dubuque, IA: Wm. C. Brown Publishers, USA.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	Visual[b] and Auditory[c]	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual and Auditory	
CLO 3 & 4	Visual, Auditory and Kinesthetic[d]	
CLO 5	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 525	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Maritime Law and Conventions

Prerequisite(s): B .S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: SWE 525 (Maritime Law and Conventions) is designed for graduate students of the department so that they get a theoretical understanding of the law related to maritime activities on rivers, seas, and oceans. The course focuses on the United Nations Convention on the Law of the Sea and various international maritime organization's conventions related to the prevention of maritime pollution. In addition, the course is designed to discuss the maritime administration and legal system of Bangladesh.

Course Objectives: The objective of the course is to provide students with a comprehensive knowledge of maritime law, UNCLOS, and international maritime conventions in relation to maritime pollution including the maritime administration and admiralty court to prevent and control marine pollution at sea.

Mapping with SDG: The course is relevant to achieving SDG goals 3 (Good health and well-being), 4 (Quality education), 6 (Clean water and sanitation), 10 (Reduced inequality), 13 (Climate action), 14 (Life below water), and 16 (Peace, justice and strong institutions).

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course, the students will be able to		**PLOs covered**
CLO 1	understand the basic principles of maritime law within the wider context of law and legal systems	PLO 3
CLO 2	understand the basics of public international law, including the law of the sea and the law of treaties	PLO 8
CLO 3	understand the liability regime in case of marine pollution and the role of the admiralty court in taking action against the claims	PLO 8
CLO 4	understand the pollution prevention regulation by ships at sea	PLO 2
CLO 5	understand various IMO conventions related to the marine environment	PLO 8
CLO 6	understand the civil and criminal liability of environmental pollution including the impact on the sea environment by marine pollution	PLO 2 & PLO 8
CLO 7	understand Bangladesh's local law on maritime administration related to the prevention of marine pollution	PLO 8

Course Contents

Sl. No	**Topic**	**Class Hours**	**CLOs covered**
1	**Introduction to Maritime Law:** Law and legal systems, principles of public international law, international maritime organization, maritime administration.	3	CLO 1
2	**Law of the Sea:** conventions on the law of the sea, territorial sea, and the contiguous zone, international straits, exclusive economic zone and continental shelf, high seas, protection and preservation of the marine environment	3	CLO 2

3	**Marine Environment Pollution & MARPOL Convention:** basic causes; common pollutants, the international convention on the prevention of pollution by marine environment 1973/78 (MARPOL); pollution by oil, chemicals, hazardous substances, garbage, and sewage.	4	CLO 3
4	**Marine Pollution by Microorganisms:** Anti-fouling convention, ballast water management convention, convention of the prevention of marine pollution by dumping of wastes and other matter (London dumping convention).	4	CLO 4
5	**IMO – the International Maritime Organization** – is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. Member States, Intergovernmental Organizations (IGOs), Non-Governmental Organizations (NGOs).	3	CLO 5
6	**Liabilities & Preparedness on Marine Pollution:** Liability against marine pollution, clearing process, and materials used to recover the pollution damage, shore reception facility, emergency oil pollution preparedness, and response, international convention relating to intervention on the high seas in cases of oil pollution casualties 1969, limitation of liability, criminal liabilities for breach of statutes or breach of duty, and civil liabilities for negligence causing damage.	4	CLO 6
7	**Maritime Administration and Admiralty Court of Bangladesh:** Ministry of shipping, department of shipping, mercantile marine office, Bangladesh merchant shipping ordinance, inland shipping ordinance, admiralty court act.	3	CLO 7

Learning Materials	
Recommended Readings	*Thomas J. Schoenbaum. (2019). Admiralty and Maritime Law, 6th edition. West Academic Publishing.* *Johnson, L.S. (2004). Coastal State Regulation of International Shipping. Oceana TM.*
Supplementary Readings	*Robert Force. (2004). Admiralty and Maritime Law. University of Michigan Library.*

Mapping CLOs with the Teaching-Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	Visual[b] and Auditory[c]and Kinesthetic[d]	Class attendance, in-course exam, assignment, final theory and practical exam, field level
CLO 2 to 6	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 526	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Marine Meteorology and Research

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: The proposed contents for a 30-hour lecture series on 'Marine Meteorology and Research' are appropriate for a course at the Master's level. The topics cover a wide range of fundamental principles, advanced concepts, and practical applications relevant to the field of marine meteorology. The content is structured to provide students with a comprehensive understanding of key meteorological phenomena, observational techniques, data analysis methods, and research approaches specific to marine environments.

Course Objectives: At the Master's level, students are expected to delve deeper into complex topics, engage in critical analysis, and potentially conduct independent research. Therefore, the course content should be designed to challenge students intellectually, encourage critical thinking, and foster advanced research skills. The suggested topics provide a solid foundation for achieving these learning objectives and can be supplemented with additional readings, case studies, research projects, and practical exercises to enhance the educational experience.

Overall, the proposed course content aligns well with the expectations for a Master's level course in Marine Meteorology and Research and can serve as a basis for further curriculum development and refinement based on the specific goals and objectives of the academic program.

Mapping with SDG: The course is relevant to achieving SDG goals 4 (Quality education), 13 (Climate action), and 14 (Life below water).

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course, the students will be able to-		**PLOs covered**
CLO 1	outline the scopes and importance of atmospheric conditions and interactions on maritime operations	PLO 1, PLO 2 & PLO 3
CLO 2	understand the atmospheric composition, structure, and effects of energy balance on global marine weather	PLO 1 & PLO 2
CLO 3	understand the operational principles and uses of meteorological instruments in the measurement of atmospheric parameters in the ocean	PLO 1, PLO 2 & PLO 3
CLO 4	understand the formation and effects of extreme events on ocean climate	PLO 1
CLO 5	understand the effects of ENSO, NAO, and PDO on marine climate and the trends of marine environments	PLO 3
CLO 6	use the numerical prediction models to forecast the marine weather	PLO 10
CLO 7	understand the remote sensing techniques for observing marine weather and climate	PLO 7
CLO 8	use statistical tools to analyze and interpret marine meteorological data	PLO 10
CLO 9	design and conduct marine meteorology research	PLO 6, PLO 7 & PLO 8
CLO 10	appreciate the trends, challenges, and prospects in marine meteorological research	PLO 10

Course Contents			
Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Introduction to Marine Meteorology** Characterization and scope of marine meteorology; Significance of marine meteorology in maritime operations, marine safety, and climate studies; Indication of atmospheric and oceanic interactions	2	CLO 1
2	**Basic Meteorological Principles** Atmospheric composition and structure; Solar radiation and energy balance; Atmospheric circulation patterns and global wind systems; Oceanographic processes influencing marine weather	4	CLO 2
3	**Meteorological Instruments and Observations** Overview of meteorological instruments used in marine research; Measurement of atmospheric parameters: temperature, humidity, pressure, wind speed and direction; Oceanographic instruments for measuring sea surface temperature, salinity, and currents	3	CLO 3
4	**Weather Systems and Phenomena** Tropical cyclones: formation, structure, and forecasting; Extratropical cyclones and associated weather patterns; Sea breezes, coastal fronts, and fog formation; Marine fog, mist, and haze	5	CLO 4
5	**Marine Climate Variability** El Niño-Southern Oscillation (ENSO) and its impacts on marine weather; North Atlantic Oscillation (NAO) and Pacific Decadal Oscillation (PDO); Long-term climate trends and projections in marine environments	4	CLO 5
6	**Numerical Weather Prediction Models** Introduction to numerical weather prediction (NWP) models; Types of NWP models: global, regional, and mesoscale; Applications of NWP in marine meteorology and forecasting	4	CLO 6
7	**Remote Sensing Applications** Remote sensing techniques for observing marine weather and climate; Satellite data products for monitoring sea surface temperature, ocean currents, and atmospheric conditions; Integration of remote sensing data with meteorological models	3	CLO 7
8	**Marine Meteorological Data Analysis** Data analysis techniques for marine meteorological datasets; Statistical methods for analyzing trends, variability, and extremes in marine weather; Case studies and practical exercises using real-world datasets	3	CLO 8
9	**Research Methods in Marine Meteorology** Overview of research methodologies and approaches in marine meteorology; Designing and conducting marine meteorology research projects; Ethical considerations and data management in marine research	2	CLO 9
10	**Future Directions and Emerging Trends** Current challenges and opportunities in marine meteorology research; Emerging technologies and methodologies in marine weather forecasting and research; Collaborative efforts and interdisciplinary approaches for advancing marine meteorology	2	CLO 10

Learning Materials	
Recommended Readings	*"Marine Meteorology" by Mark A. Bourassa, Stephen P. Anderson, and Russell L. Elsberry, Academic Press, 2012* *"Principles of Meteorological Analysis" by Roland Stull, Cambridge University Press, 2015* *"Remote Sensing of the Environment: An Earth Resource Perspective" by John R. Jensen, Pearson, 2006* *"Numerical Weather and Climate Prediction" by Thomas Tomkins Warner, Cambridge University Press, 2011*
Supplementary Readings	*"Introduction to Marine Biology" by George Karleskint, Richard Turner, and James Small, Cengage Learning, 2013*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	Visual[b] and Auditory[c]	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual and Auditory	
CLO 3	Visual and Auditory and Kinesthetic	
CLO 4	Visual and Auditory	
CLO 5	Visual and Auditory	
CLO 6 to 10	Visual and Auditory and Kinesthetic	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 527	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Integrated Water Resource Management

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: SWE 527 (IWRM) introduces students to Integrated Water Resources Management. The purpose of this course is to give the students a wider understanding of IWRM and the procedures and tools available for its implementation. Enhance student's capacity to plan water resource development · This course will provide an understanding of principles of catchment management including policies, strategies and institutional arrangements for IWRM and also introduce measures to protect water resources including laws and regulations governing water resources.

Course Objectives: The objectives of this course are to provide a basic knowledge on principles and practice of IWRM, analysis of the functions of natural and anthropogenic factors in water resources management, to create an appreciation of water conservation and management interactions, to introduce transboundary issues in water resources management, and to create an understanding of water as a social and economic good. ·

Mapping with SDG: SDG 5, SDG 6, SDG 10, and SDG 11

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course the students will be able to-		**PLOs covered**
CLO 1	understand IWRM concept and SDGs related to IWRM	PLO 2 and 6
CLO 2	explain different water sources and the physical, chemical and biotic nature of these water sources	PLO 3
CLO 3	address water quality, water pollution, different laws to protect water quality, and the National Water Policy	PLO 5
CLO 4	explain the effects of climate change on the water resources	PLO 8
CLO 5	understand relationship between gender issues and IWRM	PLO 5
CLO 6	address National and transboundary policies and strategies for IWRM	PLO 6

Course Contents

Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	Introduction: Integrated Water Resources Management (IWRM) Concept; Sustainable Development Goals related to IWRM.	2	CLO 1
2	Surface and Groundwater sources. The nature and characteristics of groundwater, surface water, river, and wetland water resources (the physical, chemical and biotic nature of water sources)	4	CLO 2
3	Factors that affect the use of water resources (demand, availability, quality, quantity), Water pollution and impact on water quality and health (point and diffuse pollution sources, natural and anthropogenic pollution, nature of pollution, effects on water sources and water uses) The threats to the quality of water resources, the identification of risk and the measures taken to protect them (water conservation, water treatment and wastewater treatment. Laws, standards and their implementation), National Water Policy.	7	CLO 3

4	Climate change and water resources (explain the impact of climate change on water resources)	3	CLO 4
5	Gender approaches and strategies for mainstreaming gender in IWRM; Gender – IWRM relationship; Gender and effective water governance; Benefits of a gender-sensitive approach to water supply solutions.	4	CLO 5
6	Policies, goals, strategies and institutional arrangement for IWRM (National and transboundary considerations),	4	CLO 5 and 3

Learning Materials	
Recommended Readings	*Mark Smith and Torkil Jønch Clausen. Integrated Water Resource Management: A New Way Forward. A Discussion Paper of the World Water Council Task Force on IWRM https://www.worldwatercouncil.org › files › IWRM* *Integrated Water Resources Management, Technical Advisory Committee Background Paper No. 4, (Stockholm, Global Water Partnership, 2000). Available from www.gwp.org/The-Challenge/What-is-IWRM/.* *Integrated Water Resources Management (IWRM) and Water Efficiency Plans by 2005: Why, What and How? Technical Advisory Committee Background Paper No. 10. (Stockholm, Global Water Partnership, 2004). Available from http://cap-net.org/sites/cap-net.org/files/TEC%2010.pdf.* *CAP-NET, GWA 2014. Why Gender Matters in IWRM: a tutorial for water managers.*
Supplementary Readings	

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	Visual[b] and Auditory[c]and Kinesthetic[d]	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual and Auditory	
CLO 3	Visual and Auditory	
CLO 4	Visual and Auditory	
CLO 5	Visual and Auditory	
CLO 6	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Optional Courses (for Environmental Science focal area)

Course Code: SWE 531	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Environmental Microbiology

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: Environmental microbiology is the study of microbes in natural environments such as soil, water and air and focuses on microbial distribution, diversity, physiology, biochemistry, function and ecology along with commonly employed microbial methods. The subject explains the role of microorganisms in the biogeochemical processes, beneficial and harmful effects on crops and human and animal health, adaptation of microorganisms to extreme environmental changes, microbiological contamination and biotechnologies for remediation.

Course Objectives: The course is designed to give of an understanding of diversified microbial habitats, the basic microbiological principles, the methods in microbial ecology and their theoretical and practical use. The course will prepare the students to address pressing environmental challenges by developing a fundamental understanding of the microbial communities and processes in natural and built environments. The students will gain skills to recognize the ecological problems and critical evaluation of the human impacts on pollution, climate changes and as well as environmental protection.

Mapping with SDG: This course is relevant to achieve SDG 4 and 15

Course Learning Outcomes (CLOs) and Mapping with PLOs		
Upon completion of this course the students will be able to:		**PLOs covered**
CLO 1	Know about the microbial population, communities, community dynamics, succession within the community and effects of environmental factors.	PLO 1, 7
CLO 2	Understand how soil environment supports microbial growth and how microorganisms support formation and development of soils. Also learn about the shift in microbial communities, their metabolism and transformation of chemical species under submergence.	PLO 7, 8
CLO 3	Understand the processes of exchange of atmospheric gases to and from the terrestrial ecosystem, in particular, soils and how these are affecting microorganisms and environment. The students will also learn about how the atmosphere can be a dispersal medium and a habitat for microorganisms.	PLO 4, 5, 7
CLO 4	Learn about aquatic habitats, in particular fresh water habitat for the microbial communities-their distribution, diversity and adaptation to changes. They will also understand the wastewater microbiology in this session.	PLO 5, 7, 8
CLO 5	Know about the marine ecosystem and microbes in the marine environment-their distribution, diversity and activities.	PLO 5, 7
CLO 6	Understand extreme environments for the microorganisms and explain the mechanisms by which they adapt with the environment.	PLO 8
CLO 7	Understanding waste management, microbial application in waste management and xenobiotic compound transformation	PLO 4, 10

Course Contents			
Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	Forms of life on the Earth: The three domains of life. Comparison between Bacteria, Archaea and Eucarya. Their ecology, diversity, and metabolism. Environmental components as habitat for micro-organisms. Microbial community dynamics, population, selection	6	CLO 1

	within the communities and succession. Influence of environmental factors on the growth of microorganisms.		
2	Terrestrial ecosystem (Soil Environment) for Microbial growth and Metabolism: Soil as an important component of the terrestrial ecosystem and a habitat for microorganisms. Involvement of microorganisms in the formation and development of soils and transformation of materials under submergence	6	CLO 2
3	Atmo-Ecosphere: Atmosphere as habitat and medium for microbial dispersal; Soil microorganisms and the atmosphere.	3	CLO 3
4	Hydro-Ecosphere: Freshwater habitats; Ponds, Lakes, Rivers; Composition, adaptation and activities of freshwater microbial communities. Wastewater microbiology.	4	CLO 4
5	Marine Habitats: Marine ecosystem, Composition, adaptation and activities of marine microbial communities.	2	CLO 5
6	Extreme environment for the Microorganisms: Extreme environments, Characteristics, composition, adaptations, and functions of microbial communities.	3	CLO 6
7	Involvement of microorganisms in waste management: Waste management definition. Persistence and biomagnifications of Xenobiotic compounds. Mechanisms of microbial transformation. Degradation of recalcitrant halocarbons, polychlorinated biphenyls (PCBs), alkyl-benzyl-sulphonates, petroleum compounds and synthetic polymers. Novel microbiological products.	9	CLO 7

Learning Materials	
Recommended Readings	*Michael J. Pelczar, Jr. E. C. S. Chan Noel K. Krieg 1988. Microbiology. (5th ed.) McGraw-Hill Book Co., Singapore.* *Microbiology: An Introduction- G.J.Tortora, B.R.Funke and C.L.Case; Pearson, Boston* *Bergersen, F. J. Methods for Evaluating Biological Nitrogen Fixation. Jhon Willy & Sons.* *Rahman et al. Biological Nitrogen Fixation associated with Rice Production. Kluver Acad. Pub.* *Rao, N. S. S. Soil Microbiology. Oxford & Ibh Publishing Co. Pvt Ltd.* *Stanier, R. Y. General Microbiology. The Macmillan Press Ltd.*
Supplementary Readings	*Alexander, M. 1977. Introduction to soil microbiology. (2nd ed.) Wiley, USA.* *Kathleen, P. T. and B. Chess. 2014. Foundations in Microbiology. (9th ed.) McGraw-Hill Book Co. Singapore.* *Jeffrey C. Pommerville. 2011. Alcamo's Fundamentals of Microbiology. (7th ed.) Jones and Bartlett Publishers, USA.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual, Auditory and Kinesthetic[d]	
CLO 3 to 7	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 532	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Environmental Quality

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: This course is designed for the Graduate students to extend scientific knowledge and understanding about a wide range of environmental issues. This would enable the students to assess the dimension of pollution and to consider strategies for the environmental quality improvement and management towards ecosystem balancing.

Course Objectives: The objective of this course is to improve student's capacity to identify environmental issues and pollution sources; and to acquire the necessary knowledge and skills for the environmental quality improvement through different techniques, regulations and socio-economic tools.

Mapping with SDG: This course is relevant to achieve SDG 4.

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course the students will be able to:		**PLOs covered**
CLO 1	learn basic concepts of environmental quality, equity related to environmental issues, indicators, standards and criteria setting.	PLO 1, 2
CLO 2	work on urban and industrial air pollution sites, and do emission inventories and air pollution modeling for air quality management.	PLO 1, 2
CLO 3	understand water quality monitoring and planning to meet desired uses.	PLO 1, 2
CLO 4	explain agricultural pollution sources, potential of environmental pollution, and management of pollution control techniques and strategies.	PLO 7, 8
CLO 5	understand waste minimization techniques and management strategies.	PLO 7, 8
CLO 6	comprehend human health and ecological risk assessment as well as environment risk management.	PLO 5, 7
COL 7	understand factors influencing environmental decision and regulations for controlling environmental pollution.	PLO 1, 2

Course Contents

Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Basic concepts of environmental quality and environmental equity**: environmental issues and priorities; environmental standards and criteria setting; environmental indicators and indices.	2	CLO 1
2	**Developing an effective framework for air quality management**: air quality monitoring networks – objectives of monitoring, monitoring sites and network density; urban and industrial pollution emission inventories; basic concepts in air pollution modeling; clean air act.	5	CLO 2
3	**Water quality monitoring and planning**: to meet quality needs and regulatory requirements; water pollution control act; clean water act; safe drinking water act.	2	CLO 3
4	**Agricultural pollution control**: Waste production on agricultural farms; pollution potential of farm wastes; nutrient losses from		CLO 4

	farms; obstacles of agricultural pollution control; agricultural pollution control principles; agricultural pollution control techniques and strategies; codes of practice for land application of fertilizers, pesticides, fungicides, animal and other wastes	5	
5	**Waste minimization and clean technology**: Material flow in society and waste generation; life cycle assessment of product; waste minimization hierarchy; waste minimization techniques; waste minimization audit; management tools of waste minimization strategies; adoption of clean technologies; waste management act.	6	CLO 5
6	**Environmental risk assessment**: Qualitative and quantitative approaches of risk assessment; human health risk assessment and ecological risk assessment; ecological risk characterization; risk monitoring; principal steps of environmental risk assessment; legal requirements for environmental risk assessment; environmental risk management.	4	CLO 6
7	**Environmental decision and pollution control strategies**: Environmental decision, factors influencing environmental decision; eco-centric and human approaches to environmental management; environmental organization; regulations for controlling environmental pollution – direct regulation, services and subsidies; using economics to control environmental quality.	6	CLO 7

Learning Materials	
Recommended Readings	*Jeff Kuo, 2018. Air Pollution Control Engineering for Environmental Engineers, CRC Press* *Kiely, G. 1998. Environmental engineering. Irwin McGraw-Hill, Boston, USA* *Peavy, et al. 1985. Environmental engineering. McGraw-Hill Book Company, NY.* *Arcadio, P.A and A.S. Gregoria. 2008. Environmental Engineering. Prentice-Hall, Inc, USA.*
Supplementary Readings	

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 2	Visual, Auditory and Kinesthetic[d]	
CLO 3	Visual and Auditory	
CLO 4	Visual and Auditory	
CLO 5	Visual and Auditory	
CLO 6	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 533	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Environmental Impact Assessment

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: SWE 533 (Environmental Impact Assessment) course primarily focuses on understanding the basics of environmental impact assessment (EIA) and standard procedures to conduct EIA abiding by local and international specifications with case studies.

Course Objectives: This course aims to create knowledge about the environmental impacts of natural and human activities as it concerns the healthy existence of humans on earth. The course will also help the SWE graduates to efficiently quantify the environmental impacts, and systematically prepare the assessment report to meet global standards, while safeguarding the environment from anticipated deteriorations.

Mapping with SDG: The course is relevant to achieve SDG goal Nos. **3 (**Good Health and Well Being**), 8 (**Decent Work and Economic Growth**), 9 (**Industry Innovation and Infrastructure**), 11 (**Sustainable Cities and Communities**), 12 (**Responsible Consumption and Production**), 16 (**Peace, Justice and Strong Institutions**)** and **17 (**Partnerships for the Goals**).**

Course Learning Outcomes (CLOs) and Mapping with PLOs		
After the successful completion of the course students will be able to:		**PLOs covered**
CLO 1	understand the basic concepts, objectives and terminologies of EIA	PLO 2
CLO 2	explain the different categories of the projects and apply for the clearance certificate as required by the specification.	PLO 4
CLO 3	explain the parameters of EIA quantification and structure of the EIA report	PLO 6
CLO 4	explain and understanding of the required laws and issues	PLO 6
CLO 5	explain standards for different environmental parameters and different mitigation measures	PLO 2
CLO 6	calculate environmental impacts of different projects and learn EIA report writing abiding by the govt. policies	PLO 8
CLO 7	familiar with different EIA studies which will strengthen the knowledge about EIA	PLO 8

Course Contents			
Sl. No	**Topic**	**Class Hours**	**CLOs covered**
1	Definitions of: IEE, EIA, EMP, EMS, ETP, Sustainable development, Stakeholders, Screening, EQS, Structure and functions of DoE	4	1
2	Categorization of projects according to Bangladesh, World Bank, and Asian Development Bank. Steps in getting clearance certificate for existing and proposed industries from GoB. Waste management and the importance of ETP.	7	2
3	Parameters to be considered in EIA/IEE studies. Structures of EIA/IEE Report according to WB and ADB. Criteria for getting WB, ADB, and Local Bank Loans for a project.	4	3
4	Policies and Legislations. ECA 1995, ECR 1997, and other related laws and issues. Responsibilities of the industries.	2	4

5	Standards for environmental quality parameters and mitigation measures for environmental management.	4	5
6	Detailed EIA Report writing: EIA for different projects, EIV, relative importance of Environmental components and EIV calculations.	5	6
7	EIA: Case study (Gupta Khali - Baakh Khali - Boalia Irrigation, Maowa Bridge, and Ruppur Reactor Projects; Jamuna Bridge).	4	7

Learning Materials	
Recommended Readings	*Laws Regulating Environment in Bangladesh- Mohiuddin Farooque and S. Rezwana Hasan* *Handbook: Environmental Procedures and Guidelines*
Supplementary Readings	*Guidelines on Environmental Issues Related to Physical Planning* *Environmental Impact Assessment For Changing World- Dr Subrota Kumar Saha*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLOs 1, 3 to 6	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLOs 2 and 7	Visual, Auditory and Kinesthetic[d]	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 534	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Environmental Ecology

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: Consequences of interactions among Ecology, Ecosystem, Environment, their manipulations and adaptation of biotechnologies have prime importance globally. Accordingly, the course is designed to acquire knowledge on greenhouse and biogenic trace gases, their exchange, fluxes, impact on ecosystems and global climate, and Techniques for reducing these gases.

Course Objectives: Guide the students to gain knowledge on (i) Ecology, Ecosystem, Environment, and Manipulation of soil ecology and soil biotechnology; (ii) Greenhouse, anthropogenic and biogenic trace - gases; (iii) Contribution of terrestrial ecosystems to global climate change and vice versa; (iv) Gas exchange and their impact on ecosystem; (v) Fluxes of CO_2, N_2O and CH_4; (vi) Techniques for reducing greenhouse gases, C-sequestration; and (vii) Types of general circulation models and their use in measurement of gas fluxes.

Mapping with SDG: The course is relevant to achieve SDG goal Nos. 4 (Quality Education), 13 (Climate action) and 15 (Life on land).

Course Learning Outcomes (CLOs) and Mapping with PLOs

The students will be able to-		**PLOs covered**
CLO 1	Define/Distinguish among Ecology, Ecosystem, Environment and their interactions regarding soil as a habitat for organisms.	PLO 2
CLO 2	Explain, how the manipulation of soil ecology and soil biotechnology works.	PLO 2
CLO 3	Learn the processes and properties of soils involved in the production-consumptions, sources and sinks of greenhouse gases.	PLO 3
CLO 4	Aware of the photo-chemistry of biogenic gases and their consequences on global warming/lives on Earth.	PLO 5
CLO 5	Acquire knowledge on terrestrial ecosystems, global warming potential of greenhouse gases and be able to fore-cast regarding their future directions and consequences.	PLO 4, 5
CLO 6	Gain knowledge on gas exchange and their impacts on soil-plant-water-air.	PLO 8
CLO 7	Know the dimensions of fluxes of CO_2 and their consequences on specially forestry and global warming.	PLO 7
CLO 8	Assume regarding methane fluxes from different terrestrial ecosystems and the factors regulating methane production.	PLO 7
CLO 9	Infer knowledge regarding nitrous oxide fluxes from various ecosystems and the factors controlling of nitrous oxide production, consequences of nitrification and denitrification on environment.	PLO 7, 8
CLO 10	Understand the ways and means for the reductions of greenhouse gases from different agro-ecosystems and forestry.	PLO 8
CLO 11	Use the different types of general circulation models regarding measurement of gas fluxes and be able to predict their magnitudes.	PLO 8, 10

Course Contents			
Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	Course objectives, Ecology and ecosystem. Soil as a habitat for organisms.	3	1
2	Manipulation of soil ecology and soil biotechnology.	3	2
3	Soil processes and properties involved in production of greenhouse gases. Sources and sinks of greenhouse gases.	3	3
4	Atmospheric chemistry of biogenic trace gases.	3	4
5	Contribution of terrestrial ecosystems to global climate change and vice versa. Global warming potential of greenhouse and anthropogenic gases, life time and CO_2- equivalent.	3	5
6	Gas exchange and their impacts on ecosystem.	2	6
7	Fluxes of carbon dioxide: emission from terrestrial ecosystems, effects of deforestation and afforestation. Consequences of carbon dioxide emission.	3	7
8	Fluxes of Methane: Rice paddies and natural wetlands, methane consumption in terrestrial ecosystem, factors regulation methane production.	3	8
9	Fluxes of nitrous oxide: Processes of nitrous oxide formation in soils, environmental and agricultural control of nitrous oxide production, factors affecting nitrous oxide production, emission of nitrous oxide from various ecosystems, Environ. consequences of nitrification and denitrification.	4	9
10	Techniques for reducing greenhouse gases, C-sequestration. C-Sequestration potential in different agricultural and forest ecosystems.	2	10
11	Types of general circulation models and their use in measurement of gas fluxes.	1	11

Learning Materials	
Recommended Readings	*ECOLOGY from Individuals to Ecosystems. Michael Begon, Colin R. Townsend and John L. Harper (4th edn. 2006).* *The greenhouse effect, climate change and Ecosystems. Bert Bolin, Bo R. Döös, Jill Jäger and Richard A. Warrick (1986).*
Supplementary Readings	*Ecology – Concepts and Application. Manuel C. Molles Jr. (2001).* *Ecology - Theories and Application. Peter Stiling (2001).* *Soil Ecology – Ken Killham. (2016).* *World Inventory of Soil Emissions. Batjes, N. H. and E. M. Bridges (1992).* *Climate change and Agriculture, ASA Spec.Publ. No. 59.* *Towards sustainable landuse (Vol. I & II) Blume et al., 1998.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLOs 1 to 6	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLOs 7 to 11	Visual, Auditory and Kinesthetic[d]	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 535	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Environmental Biotechnology

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the Course: This course is designed for postgraduate students of the department so that they get a theoretical basis for understanding current applications of biotechnology to environmental quality evaluation, monitoring, remediation, and mitigation of contaminated environments. These provide a foundation for following discussions of microbial removal and degradation of organics, phytoremediation of soil and water contaminated with toxic metals and radionuclides, wetlands as treatment processes, biofilms/biofilters for vapor-phase wastes, and composting in alignment with sustainable development goals considering climate change.

Course Objectives: The objective of this course is to identify methods to exploit microorganisms for use in applications of biotechnology to improve the quality of the environment, monitor, and remediation of contaminated environments, and enhance energy efficiency. These improvements include treatment of contaminated waters and wastewater, clean-up of industrial waste streams, and remediation of soils contaminated with hazardous and toxic chemicals. One of the main objectives of environmental biotechnology is the conservation of resources by recycling waste materials.

Mapping with SDG: The key sustainable development goals that are best aligned with the master's program in Environmental Biotechnology are: SDG 3, 4, 6, 9, and 11.

Course Learning Outcomes (CLOs) and Mapping with PLOs		
Upon completion of this course, the students will be able to:		**PLOs covered**
CLO 1	acquire an introductory knowledge about the issues and scopes in environmental biotechnology.	PLO 1, 2
CLO 2	understand the microbial processes and the implications of the metabolic processes in the degradation of organic pollutants in wastewater treatment plant ecosystems.	PLO 1, 8
CLO 3	understand the utilization of microbial biofilms in wastewater treatment technologies.	PLO 1, 8
CLO 4	understand the design and working principles of different bioreactors.	PLO 1, 8
CLO 5	understand the mechanism for management of effluent discharged from different industries.	PLO 1, 8
CLO 6	explain biodegradation processes through the microorganisms.	PLO 3
CLO 7	understand scientific and engineering management of solid, liquid and gaseous waste (medical and general waste).	PLO 1, 7
CLO 8	understand the removal of heavy metals from liquid wastes by utilization of microbes.	PLO 7
CLO 9	understand the role of microorganisms for production of petroleum, ethanol, natural resources etc.	PLO 8

Course Contents			
Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Issues and Scope of Environmental Biotechnology**.	2	CLO 1
2	**Bacterial Metabolism in Wastewater Treatment Systems:** Decomposition of organic carbon compounds in bioreactor ecosystems; Mass, and energy balance of aerobic and anaerobic biopolymer degradation; Estimating oxygen requirements from stoichiometry; Nitrogen removal during wastewater treatment; Enhanced biological phosphate removal.	3	CLO 2

3	**Microbial Biofilm:** Development of microbial biofilm; Affecting parameters of biofilm development; Microbial biofilm in wastewater treatment; Biofilm kinetics; Numerical modeling of biofilms.	4	CLO 3
4	**Reactor Characteristics and Kinetics:** Suspended growth bioreactors; Biofilm reactors; Important factors in the engineering design of reactors.	4	CLO 4
5	**Industrial Wastewater Sources and Treatment Strategies:** Sugar factory; Dairy industry; Fruit juice and beverage industries; Vegetable oil industries.	4	CLO 5
6	**Biodegradation of Organic Pollutants:** Remediation strategies, microbial degradation, different types of biodegradable organic pollutants, principle of aerobic biodegradation of hydrocarbons, biodegradation of plastics, bioattenuation, biostimulation, bioaugmentation, factors affecting organic pollutant biodegradation, genetically engineered microorganisms.	3	CLO 6
7	**Biotechnology for Solid Waste Management:** General composition of urban solid waste, waste disposal by sanitary landfilling, solid waste composting, vermiculite, feedstock for anaerobic digestion, stages of anaerobic digestion, biogas generation, factors affecting the anaerobic digestion process and biogas production, comparison of aerobic and anaerobic solid waste treatment, treatment of hazardous waste, biomedical waste management.	4	CLO 7
8	**Microbial Biosorption of Heavy Metals:** Mechanism of metal microbial biosorption, Microbes as biosorbents, Immobilization, desorption, and regeneration of biosorbents for bioreactors, Kinetic and modeling of biosorption processes.	3	CLO 8
9	**Bioleaching and Biomining for Recovery of Resources**: Microbes in bioleaching process, bioleaching of copper & uranium, microbial extraction of petroleum, microbial production of ethanol.	3	CLO 9

Learning Materials	
Recommended Readings	*Jördening, H. J., & Winter, J. (Eds.). (2005). Environmental biotechnology: concepts and applications. WILEY-VCH Verlag GmbH.* *Rittmann, B. E., & McCarty, P. L. (2020). Environmental biotechnology: principles and applications. 2nd edition. McGraw-Hill Education.* *Kotrba, P., Mackova, M., & Macek, T. (Eds.). (2011). Microbial Biosorption of Metals. Springer Netherlands.* *Maier, R. M., Pepper, I. L., & Gerba, C. P. (2009). Environmental microbiology (Vol. 397). Academic press.* *Derco, J., & Vrana, B. (Eds.). (2018). Biosorption. InTech.*
Supplementary Readings	*Tchobanoglous, G., Stensel, H. D., Tsuchihashi, R., & Burton, F. (2014). Wastewater Engineering Treatment and Resource Recovery. 5th edition. McGraw-Hill.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLOs 1- 4; 6 - 9	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.
CLO 5	Visual, Auditory and Kinesthetic[d]	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 536	**Credits**: 2 (50 Marks)	**Course Type**: Optional course

Course Title: Environmental Law

Prerequisite(s): B. S. (Honors) Degree in Soil, Water and Environment

Rationale of the course: This course comprises the laws for protecting endangered species, controlling pollution, managing hazardous waste, and planning land use, etc. with special reference to Bangladesh. This course will train the students on different local, domestic, and international environmental laws, their applications, limitations relating to sustainability, conservation, and environmental protection.

Course Objectives: The objective of the course is to provide a basic level understanding of the legislative framework of environmental regulation, its implementation. This course is also aimed to a) introduce the students with the historical development of environmental law b) discuss various major national and international environmental laws c) focus on sector wise main environmental issues in Bangladesh and its different legal mechanisms d) study the relation of ethical concepts to Environmental Law.

Mapping with SDGs: This course is relevant to SDGs 13, 14 and 15

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course, the students will:		**PLOs covered**
CLO 1	acquire an introductory knowledge of different concepts related to environmental law and policy.	PLO 1, 2
CLO 2	find a brief idea about the history and development of environmental law and policy in Bangladesh.	PLO 2
CLO 3	detect constitutional obligation and institutional framework for environmental protection in Bangladesh.	PLO 3
CLO 4	learn various major national and international environmental laws.	PLO 5, 6
CLO 5	gain an understanding of Bangladesh's Environmental Policy.	PLO 7
CLO 6	be able to explain sector-wise main environmental issues in Bangladesh and its legal mechanisms.	PLO 5, 6, 7
CLO 7	become capable to relate Environmental Laws to Ethics.	PLO 1

Course Contents

Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Basic concepts** of Environmental Law, Policy, Protocol, Treaty, Convention, Regulation, Rules, Statute, Right, and Justice; Objectives and importance of Environmental law.	2	CLO 1
2	**History and Development** of Environmental Law and Policy: Environmental Law and Policy in –Ancient Bengal (From early to 1204), -Medieval Bengal (1204-1757), -British Era (1757-1947), Pakistan Era (1947-1971), and Post-Independence in Bangladesh.	2	CLO 2
3	**Constitutional Obligation and Institutional Framework** for Environmental Protection in Bangladesh: Constitutional Provisions, State's Duties, Status of Articles 18, 18A, 23, 23A, 24 and 25; Role of Higher Judiciary, GoB, Local Govt., NGO's in the protection of Environment.	2	CLO 3

4	**Major International Environmental Laws**, Sources & Evolution; Major UN Conferences Regarding Environment: Stockholm Declaration 1972, Agenda 21, Rio Declaration, Kyoto Protocol, Basel Convention, Convention on Biological Diversity and Laws of Sea and other recent Conventions	4	CLO 4
5	**Bangladesh's Environmental Policy**: Objectives, Legal Status, Legal Framework, Institutional Arrangement; Industrial Policy, National Water Policy, National Forest Policy, National Health Policy; Proposed NEP 2013 and Its Objectives and sectors/issues coverage; Major Strategies and Action Plans.	4	CLO 5
6	**Major Environmental laws in Bangladesh**: Forest Act 1927, ECA 1995, ECR 1997, Environmental Court Act 2010, CC Trust Act 2010, Biodiversity Act 2012 and 2017, Bangladesh Water Act 2010, Formalin Control Act 2015, etc.	6	CLO 4
7	**Sector Wise Main Environmental Issues in Bangladesh and Its Legal Mechanisms**: Agrochemical, Soil, Air, Water, Sound and Noise, Industrial, Radiation, Coastal and Ship Breaking pollutions; Biodiversity Degradation, SWM, Deforestation and Desertification, Riverbank Erosion and Siltation, Human Physiological Problems, etc. and their Controlling Laws in Bangladesh.	8	CLO 6
8	**Ethical concepts**: relation of Environmental Laws to Ethics and Ethical Issues; Some Case Studies	2	CLO 7

Learning Materials	
Recommended Readings	*Ershadul Karim, M. (2022). Environmental Law in Bangladesh. Netherlands: Wolters Kluwer.* *Woolley, David et al (ed), Environmental Ław, 2nd ed., Oxford University Press, London (2009).* *Hasan, Gazi Saiful. (2016). Outlines of Environmental Law: Bangladesh Perspective.*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1	[b]Visual and [c]Auditory	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Case study.
CLO 2	Visual, Auditory and Kinesthetic[d]	
CLO 3	Visual and Auditory	
CLO 4	Visual and Auditory	
CLO 5	Visual and Auditory	
CLO 6	Visual and Auditory	

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.

Course Code: SWE 537	**Credits:** 2 (50 Marks)	**Course Type:** Optional course

Course Title: Agricultural Environment and Ecosystem Services

Prerequisite(s): B. S. (Honors) in Soil, Water and Environment

Rationale of the Course: Agricultural ecosystems provide humans with food, forage, bioenergy, and pharmaceuticals and are essential to human well-being. These systems rely on ecosystem services provided by natural ecosystems, including pollination, biological pest control, maintenance of soil structure and fertility, nutrient cycling, and hydrological services. Preliminary assessments indicate that the value of these ecosystem services to agriculture is enormous and often underappreciated. Agroecosystems also produce a variety of ecosystem services, such as regulation of soil and water quality, carbon sequestration, support for biodiversity, and cultural services. Depending on management practices, agriculture can also be the source of numerous disservices, including loss of wildlife habitat, nutrient runoff, sedimentation of waterways, greenhouse gas emissions, and pesticide poisoning of humans and non-target species. The tradeoffs that may occur between provisioning services and other ecosystem services and disservices should be evaluated in terms of spatial scale, temporal scale, and reversibility.

Course Objectives: Guide the students to gain knowledge and tackle problems on i) Agricultural and Environment, ii) Soil-Plant-Water-Air continuum (SPWAC) quality, iii) Conservation and environmental management strategies, iv) Climate change and Agriculture, v) Agricultural and Ecosystem services, vi) Current issues in modern agriculture, vii) Sustainable agriculture and food systems.

Mapping with SDG: The course is relevant to achieving SDG goals 2 (zero hunger), 3 (Good health and well-being), 4 (Quality education), and 15 (Life on land).

Course Learning Outcomes (CLOs) and Mapping with PLOs

Upon completion of this course, the students will be able to-		**PLOs covered**
CLO 1	get a basic understanding of the agricultural environment and ecosystem services	PLO 1, 2, 3
CLO 2	manage and protect the Soil-Plant-Water-Air continuum (SPWAC) quality	PLO 1, 7
CLO 3	understand the conservative and environmental management strategies for agricultural land degradation and forest conservation	PLO 3
CLO 4	understand the photochemistry of the atmosphere and gas fluxes to the atmosphere	PLO 1, 2
CLO 5	appreciate the effects of climate change on agriculture and agricultural contribution to climate change	PLO 2
CLO 6	understand the effects of agricultural advancements and technologies on the ecosystem services	PLO 3
CLO 7	understand the social impacts on food security	PLO 4, 5
CLO 8	appreciate the environmental consequences of modern agricultural practices	PLO 3
CLO 9	understand the prospect of the development of sustainable food systems	PLO 3

Course Contents

Sl. No.	**Topic**	**Class Hours**	**CLOs covered**
1	**Basics of agricultural environment and ecosystem services:** Introduction to agricultural environment and ecosystem services; Enhancing the experience of agricultural environment and ecosystem services; Environmental conditions necessary for life.	2	CLO 1

2	**Soil-Plant-Water-Air continuum (SPWAC) quality:** Soil environment and soil quality; Measurement, management, and protection strategies for SPWAC quality.	4	CLO 2
3	**Conservation and environmental management strategies:** Conservation and management strategies for wildlife and environment; Forest resource and sustainable forest management.	3	CLO 3
4	**Photochemistry, ozone layer, and greenhouse fluxes:** Photochemistry of biogenic trace gases; Formation and depletion of ozone layers; Fluxes of greenhouse gases and their impacts on the environment.	5	CLO 4
5	**Climate change and agriculture:** Climate change plan for future; Long-term and short-term goals of climate change; Agricultural contribution to global climate change.	4	CLO 5
6	**Agricultural technologies and ecosystem services:** Impacts of intensive cropping; Impacts of inputs associated with intensification; Impacts of intensive rice systems; Impacts of industrial crop processing.	4	CLO 6
7	**Social issues in modern agriculture:** Agriculture and food system structure; Social consequences of food system.	3	CLO 7
8	**Environmental issues in modern agriculture:** Technological innovations; Alternative to conventional agriculture.	3	CLO 8
9	**Sustainable agriculture and sustainable food systems:** Resistance to modernization; Imaging alternatives.	2	CLO 9

Learning Materials	
Recommended Readings	*Environmental Science – Botkin and Keller* *Environmental Chemistry – Manahan and Stanley* *Ecology – concept and application – Molles Jr.* *The greenhouse effect, climate change and ecosystems – Bolin et al. 1986* *Climate change and Agriculture – ASA Spec. Publ. No. 59.* *Towards sustainable land use (Vol. I & II) – Blume et al. 1998.*
Supplementary Readings	*Dictionary of Environmental Science & Technology 3rd edn., Andrew Porteous*

Mapping CLOs with the Teaching- Learning and Assessment Strategy (*VAK)		
CLOs	Teaching- Learning Strategy[a]	Assessment Strategy
CLO 1 to 9	Visual[b] and Auditory[c]	Class attendance, In-course Exam, Assignment, Final theory and practical Exam, Field level assessment.

Visiting hours: 10 am to 12 noon, and 3 to 5 pm on the working days *(if available)*.