KYAMBOGO UNIVERSITY

FACULTY OF SCIENCE

DEPARTMENT OF ENVIRONMENTAL SCIENCE

MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

(MSc. ES)

JUNE 2023

KYAMBOGO UNIVERSITY

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DEPARTMENT OF ENVIRONMENTAL SCIENCE

CURRICULUM FOR THE NEW MSc. ENVIRONMENTAL SCIENCE PROGRAM

Introduction

The Department of Environmental Science, Kyambogo University is in the process of writing a Master of Science in Environmental Science (MSc. ES) curriculum. A copy of this curriculum is attached for you to review. This review process is aimed at strengthening this program and enabling us to produce graduates whose knowledge and skills are in tandem with the requirements of the employers, academia world, industry and other related fields in general. This particular questionnaire seeks to establish your assessment of the content of the current curriculum and how it matches knowledge and skills requirements for a graduate fellow of Environmental Science background. This survey will help generate consensus on the areas and depths of the training that should be given.

You are, therefore, requested, as a key stakeholder, to spare some time to respond to this questionnaire. Your responses shall be used in strict confidentiality, and shall not be attributed to you without your permission.

SECTION A: GENERAL INFORMATION

No.	Question	Response
1	Name	
2	Name of your company/ organization	
3	Position in the company/ organization	

SECTION B: CONTENT REVIEW

Please score each of the areas below using the scale: *Scale: 1=Strongly disagree, 2=Somewhat disagree, 3=Neither disagree nor agree, 4= Somewhat agree, 5=Strongly agree.* Also suggest areas of improvement.

#	Area	Score	Comments/Suggestions for improvement with a rationale stated
1	The introduction and objectives of the program are clearly explained		
2	The entry requirements for the program are adequate and relevant		
3	Program is well structured in terms of hierarchy of knowledge acquisition/ sequence of course units		
4	The program has specialized courses focusing on specific areas of food safety and quality management		
5	Program has course units that address emerging issues in food safety and quality management, such as food fraud, allergen management, or new foodborne pathogens		
6	Program is aligned with industry standards, best practices, and regulatory requirements in food safety and quality management		

Please give any other suggestions of how the program can be improved.

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Thank you for your Participation

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Head of Department

Department of Environmental Science

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1. NAME OF THE GRADUATE PROGRAMME

The name of the programme shall be Master of Science in Environmental Science (MSc.ES). It is a two-year programme offered only during the day and evening sessions of learning.

2.0 BACKGROUND

The East African region is undergoing rapid growth in all segments including demographic, socioeconomic, industrial, infrastructural and others. The exploration and mining of minerals and fossil fuels coupled with ongoing industrialization in the region requires more professional environmental scientists to address environmental issues, challenges and oversites in planning.

The unprecedented growth exerts pressure and immeasurable demand on the natural resources with consequential resource degradation, contamination, pollution and overexploitation which requires urgent and continuous interventions of skilled graduate experts within environmental science. The program of Master of Science in Environmental Science is a new postgraduate degree programme in the Department of Environmental Science, Faculty of Science, Kyambogo University. The programme aspires to train world leaders in environmental sector, as it aims to attract top performing and ambitious graduates in the country, East Africa and beyond. Upon completion of this programme the students will knowledgeably innovate solutions to complex environmental issues in tandem with the changing times. Furthermore, the students will be capable of undertaking innovations and technologies that would support environmental formulation, implementation and reviews that will be research-based demonstrating knowledge, practical skills and high level of competencies that will be proportionate with emerging environmental challenges and issues. The trained graduates will offer skilled human resource and expertise in the environmental sector in various local and international organizations, both public and private such as ministries, non-governmental organizations and private sector. Career prospects for graduates both in East Africa and abroad include the manufacturing and production industry, environmental management jobs, research institutions, environmental consultancy firms, universities and institutions of higher learning.

This curriculum will address current challenges concerning assessment of environmental problems, how companies and public authorities address environmental issues and challenges, how different categories of environmental players impact and regulate environmental monitoring, environmental pollution and remediation, risk assessment and environmental quality management, planning, innovations and measures engaged in driving positive change. The Master of Science in Environmental Science (MSc.ES) will equip graduates with the theoretical and practical expertise to stimulate development through research and innovative approaches responding to national and global environmental issues and challenges. The MSc.ES is focused on producing graduates who are independent and critical thinkers.

The programme has been aligned to the National development policies: Uganda's Vision 2040, National Development Plan III, Uganda National Environment Management Policy (1995), Uganda Green Growth Development Strategy (UGGDS 2017/18 –2029/30), and guided by the global Sustainable Development Goals (SDGs); Good Health and Wellbeing (SDG No. 2), Quality Education (SDG No. 4), Clean Water and Sanitation (SDG No. 6), Affordable and Clean Energy (SDG No. 7), Industry, Innovation and Infrastructure (SDG No. 9), Sustainable Cities and Communities (SDG No. 11), Responsible Consumption and Production (SDG No. 12), Climate Change (SDG No. 13), Life Below Water (SDG No. 14), Life On Land (SDG No. 15), as well as Strengthen the means of implementation and revitalize the global partnership for sustainable development (SDG No. 17).

2.1 Stakeholders consulted

Internal Stakeholders	
1	Department of Chemistry, Kyambogo University
2	Department of Biological Sciences, Kyambogo University
3	Department of Mining, Chemical and Petroleum Engineering, Kyambogo University
4	Department of Textile and Leather Technology, Kyambogo University
External Stakeholders	
1	Ministry of Environment and Natural Resources
2	Uganda Industrial Research Institute
3	Department of Environmental Studies, Makerere University
4	National Water and Sewerage Corporation
5	National Environmental Management Authority
6	Kyambogo University BESTM Alumni

2.2 Justification

The Master of Science in Environmental Science (MSc.ES) programme of has been compiled as one of the postgraduate programmes of Kyambogo University offered in the Department of Environmental Science to provide response to the rapidly growing skills needs of graduates craving for further education and training in Environmental Science.

This programme has been blended on interdisciplinary pillars to enrich its foundations in critical thinking, analytical tools and models, scientific innovations and initiatives, research and practical laboratory skills. The programme will equip learners with soft and hard skills as change agents and opinion leaders in environmental science issues of the 21st century. It will enable graduates acclimatize to current and future careers and opportunities directly and indirectly concerned with

the environment. The exposure to local and global environmental science, technology and engineering issues and challenges, will shape the graduates into internationally recognized environmental science experts and academicians with diversified perspectives.

The graduates will address predicted and forecast existing and emerging environmental issues, oversites, lapses and challenges with environmentally sound solutions for sustainability.

The programme will equip learners with specialized training and expertise with emphasis on the development of critical attitude, analytical and problem-solving skills, and deeper knowledge of a wide range of environmental science issues that will enable them to work out sustainable solutions independently and expertly.

2.3 Target group

The Master of Science in Environmental Science programme will target graduates with Honours Bachelor's Degrees (First class; 1.1 or Second class 2.1 and 2.2) or with postgraduate diplomas in the following fields of study and categories:

2.3.1 Environmental Science, Environmental Engineering, Environmental Science Technology and Management, Environmental Management, Environmental Studies, Environmental, Forestry, Agriculture, Fisheries and Aquaculture, Environmental Health, Occupational Safety, Science with Education (Chemistry/Mathematics, Chemistry/Biology, Chemistry/Physics), Science Technology (Chemistry, Biology), Laboratory Technology, Industrial Chemistry, Chemical Engineering, Oil and Gas, Conservation Sciences, Textiles and Clothing Technology, Leather Tanning Technology, Botany, Zoology, Natural Resources, Mining, Geology and Geosciences, Oceanology, Earth Studies/Sciences, Civil and Building Engineering, Land and Water Resources Engineering, Water Engineering, Water Resource Management, Laws, Urban Planning, Public Health, Biostatistics, Demography, Wildlife and antiquities,

2.3.2 Other recognized Environmental related fields of expertise as the Higher Degrees Committee may deem eligible and relevant.

2.3.3 Candidates who haven't yet graduated but hold testimonials or partial transcripts or evidence of completion of the Bachelor's Degrees with First class; 1.1 or Second class 2.1 and 2.2 divisions, of the categories as outlined in 2.3.1 and 2.3.2 above shall be eligible for admission to this programme.

3. RESOURCES

3.1 Staffing

The programme will be hosted and administered by the existing academic and technical staff in the Department of Environmental Science with assistance from the academic staff from the Department of Chemistry, the Department of Biological Sciences, Department of Mathematics and Statistics, and Part-time academicians from public and private sectors with specialized expertise. The current staff are shown in Appendix A.

3.2 Facilities

In the Faculty of Science facility as well as the Central Lecture Block facility there are several lecture rooms that will be used for lectures. The faculty has several spacious equipped laboratories that will be used to conduct practical works. There are other facilities at collaborating educational and research Institutions, and industries where experiments will be conducted. A planned Environmental Resource Centre shall be unveiled at Kyambogo University to cater for specialized environmental research activities.

3.3 Funding

The funding shall come from privately sponsored students of both local and international background, other internally generated revenue, and grants and donations from collaborative agencies. The Departmental staff will continuously be engaged in research and funds generated will also partly benefit the post-graduate programme. The programme shall largely depend on scholastic materials available in the University and utilize the physical infrastructures and facilities available in collaborative institutions and industries that will facilitate teaching and learning.

4. OBJECTIVES

4.1 General Objective

The overall objective of the programme is to equip graduates with the theoretical and practical knowledge and expertise needed to inspire and drive change and development through formulation, design and implementation of innovative technologies to solve national and global environmental science challenges and issues.

4.2.1 Specific Objectives

The specific objectives of the programme shall be to:

1. Train graduates who employ scientific research-based approaches to innovate solutions to the problems facing society through rigorous training on research evidence-based environmental solutions.
2. Train competent researchers who can undertake cutting-edge research in the field of environment to solve key problems facing the society.
3. Train skilled and independent researchers who can write award-winning grant proposals to fund research projects that address the needs of the society.
4. Train environmental scientists who can effectively communicate and translate scientific results to the public to promote good environmental governance at local and global level.
5. Build capacities and equip the environmental science professionals with expertise of international standard for the best outputs.
6. To culture and nurture graduates with environmental ethics and sound knowledge that promotes and enhances use of modern and efficient technologies to achieve environmental sustainability.

4.2.2 Learning Outcomes

By the end of this programme, students should be able to:

1. Apply hands-on practical skills to analyze a range of environmental samples for various research or regulatory objectives to solve current and emerging environmental issues and challenges, and set-up sound sustainable mitigation and conservation measures.
2. Independently carry out cutting-edge research within the environmental science discipline to address environmental issues and challenges resulting from overexploitation, degradation, contamination and pollution of the environmental.
3. Develop remediation strategies and monitoring programs for management of environmental pollution.
4. Use research data to formulate evidence-based solutions to environmental issues and challenges to realize sustainable environmental practices.
5. Assess and provide critical review of environmental strategies, innovations and practices.

6. Write and disseminate or communicate research findings through high-quality research articles for publication in international journals or through conferences and conventions.

5.0 Matrix for Achievement of the Programme Objectives

GMSE	Research-based approaches	Competent Teamwork	Environmental scientific knowledge	Effective scientific communication	Responsible environmental governance	Capacities, & leadership development	Culture, ethics, sustainability
7111 ETX	✓	✓	✓	✓	✓	✓	✓
7112 EHE	✓	✓	✓	✓	✓	✓	✓
7113 ERS	✓	✓	✓	✓	✓	✓	✓
7114 EEC	✓	✓	✓	✓	✓	✓	✓
7115 ERT	✓	✓	✓	✓	✓	✓	✓
7116 EMS	✓	✓	✓	✓	✓	✓	✓
7121 EIA	✓	✓	✓	✓	✓	✓	✓
7122 AEX	✓	✓	✓	✓	✓	✓	✓
7123 RMC	✓	✓	✓	✓	✓	✓	✓
7124 CCM	✓	✓	✓	✓	✓	✓	✓
7125 PWM	✓	✓	✓	✓	✓	✓	✓
7126 AEB	✓	✓	✓	✓	✓	✓	✓
7127 ASA	✓	✓	✓	✓	✓	✓	✓
7128 SDM	✓	✓	✓	✓	✓	✓	✓
7211 RES	✓	✓	✓	✓	✓	✓	✓

6. GENERAL REGULATIONS

6.0 Eligibility for Admission

Admission to the Master of Science in Environmental Science (MSc. ES) programme shall be governed by the general Admission Regulations and procedures that govern the postgraduate studies' programmes of Kyambogo University. The guidelines and regulations from the Uganda National Council for Higher Education shall also be applied.

7. ADMISSION REQUIREMENTS

7.1 Minimum Requirements

In addition to the general University requirements, a candidate shall have at least an honours degree (First class; 1.0 or Second class; 2.1 and 2.2) from a recognized and accredited University or Institution of Higher learning. Alternative qualifications other than those specified below shall require equivalency by the Uganda National Council for Higher Education. Candidates shall be selected for admission according to their performance in their first degree or in addition to their postgraduate diploma in the specified fields of study. Candidate due for graduation or graduates holding Bachelor's Degrees and/or Postgraduate Diplomas in the areas or disciplines of study described in Section 2.3 are eligible for admission to the Master of Science in Environmental Science (MSc.ES) programme.

8. DURATION OF THE PROGRAMME

The Master of Science in Environmental Science (MSc. ES) programme is a full-time undertaking, lasting four (4) semesters, or the equivalent of two (2) Academic Years. Each semester shall have seventeen (17) weeks with fifteen (15) weeks of teaching/learning and two (2) weeks for examinations.

9. PROGRAMME STRUCTURE

The Master of Science in Environmental Science (MSc. ES) programme is divided into two parts: coursework and dissertation. The First Year will be spent attending lectures, doing coursework and examinations during which the learners will study ten core courses and two elective courses: one in environmental management and another in environmental analysis as indicated in the table below. The Second Year will be spent on research proposal writing and presentations, field work, laboratory work and seminars, and dissertation writing, presentation and a viva voce examination. During the first year, the learners will study ten core courses and two elective courses in management and two elective courses in policy as given in the table overleaf:

Year 1 Semester 1					
COURSE CODE	**COURSE NAME**	**L**	**P/F**	**CH**	**CU**
GMSE 7111	Advanced Ecotoxicology (ETX)	30	30	45	3
GMSE 7112	Environmental Health	30	30	45	3
GMSE 7113	Ecological Restoration	30	30	45	3
GMSE 7114	Environmental Economics	30	30	45	3
GMSE 7115	Environmental Remediation Technologies	45	30	60	4
GMSE 7116	Environmental Modeling & Simulation	45	30	60	4
		Semester 1 Load = 20 CU			
Year 1 Semester 2					
COURSE CODE	**COURSE NAME**	**L**	**P/F**	**CH**	**CU**
GMSE 7121	Environmental Impact Assessment & Monitoring	30	30	45	3
GMSE 7122	Advanced Environmetrics	30	30	45	3
GMSE 7123	Research Methods and Communication	45	30	60	4
GMSE 7124	Climate Change Mitigation & Adaptation	45	30	60	4
ELECTIVE COURSES A: ENVIRONMENTAL MANAGEMENT AND TECHNOLOGY					
GMSE 7125	Petroleum Waste Management	30	30	45	3
GMSE 7126	Advanced Environmental Biotechnology	30	30	45	3
ELECTIVE COURSES B: ENVIRONMENTAL ANALYSIS AND DISASTERS MANAGEMENT					
GMSE 7127	Applied Spatial Analysis	30	30	45	3
GMSE 7128	Sustainability & Disaster Management	30	30	45	3
		Semester 2 Load = 20 CU			
	Total Year 1 Load = 40 CU				
Year 2 Semester 1					
GMSE 7211	Research proposal writing and presentations,		960	120	8
	Field work, Laboratory work and Seminars		960	120	8
		Semester 1 Load = 16 CU			
Year 2 Semester 2					
GMSE 7211	Dissertation writing, Presentation		960	120	8
	Research Communication (Manuscript writing)		960	120	8
	Viva voce examination		960	120	8
		Semester 2 Load = 24 CU			
	Total Year 2 Load = 40 CU				
	Overall Programme Load = 80 CU				

10. PROGRAMME LOAD

To qualify for the award of the Master of Science in Environmental Science, a candidate must obtain a minimum load of **80 Credit Units** distributed as follows:

Year & Semester of Study	**Credit Units**
Year One Semester One	20
Year One Semester Two	20
Year Two Semester One & Two	40
Total Graduation Load	**80**

11. ASSESSMENT AND GRADING

11.1 Assessments of courses

Each course shall be assessed through:

a) Progressive/ Coursework assessment
b) Practical work
c) Graduate Seminars and presentations
d) Written tests and final semester Examinations
e) Research Project
f) Viva voce Examination

11.2 Progressive Assessment

(a) Each course shall be assessed on the basis of 100% total marks as follows:

Course work assessment	:	40%
Final Examination	:	60%
Total	**:**	**100%**

(b) Course work assessment shall consist of practical work (laboratory work, Workshop practice, field work, group work, presentations and internship) and progressive assessment (assignments and tests) and shall be assessed as follows:

(i) For a course without practical work:

Assignments	:	15%
Tests	:	25%

(ii) For a course with practical work:

Assignments	:	5%
Tests	:	10%
Practical Work	:	25%

11.3 Written Examinations

There shall be a written examination for each course covered during the First Year Semester One and Two will be marked out of 100% and converted to score out of 60.

11.4 Research Project

The Research Project shall be assessed out of a maximum of 100 marks as follows:

Dissertations will be marked by;

a.	Two Internal Examiners	(Average)	100%
b.	One External Examiner		100%
c.	Viva Voce Examination	(Average)	100%
	Average Score in the Research Project		**100%**

11.5 Research Project

There shall be Advanced Environmetrics, and Research Methodology and Communication Courses offered prior to performing the research project. Students shall carry out their research work starting from the beginning of year two. They will present their proposals and do fieldwork and laboratory work, data analyses, presentations of progress reports, and dissertation writeup before submitting their research report for examination during semester II of year two. Students shall carry out research in various areas of environmental science and technology related disciplines. Assessment shall be based on the Oral Presentations and Seminars series (40%), and

Research Report Examination and Viva Voce Examination (60%). The pass mark for the Research Reports and Viva Voce Examination shall be 60%.

11.7 Grading of Courses

(a) Each Course shall be graded out of a maximum of 100 marks and assigned appropriate letter grades and grade points as follow:

Marks (%)	Letter Grade	Grade Point (GP)
80 – 100	A	5.0
75 – 79	B+	4.5
70 – 74	B	4.0
65 – 69	C+	3.5
60 – 64	C	3.0
0.0 – 59	F	0.0

(b) The following additional letters shall be used as appropriate:
W = Withdrawal, when a candidate withdraws from a course;
I = Incomplete, when a candidate does not complete a course;
AUD = Audited Course, when a candidate offers a course, whose credits shall not contribute to the Cumulative Grade Point Average (CGPA).

(c) The pass grade for each course is 3.0. No credit shall be awarded for any course in which a student fails.

11.8 Progression

Progression of a student shall be classified as Normal or Probationary.

11.9. Normal Progression

Normal progress (NP) in which a student passes each course taken with a minimum grade point of 3.0.

11.10 Probationary Progress (PP)

Probationary progress (PP), which is a warning, stages and occurs if a student:

(i) Fails a core course

(ii) Obtains Cumulative Grade Point Average (CGPA) of less than 3.0.

Probation is removed when the conditions no longer hold.

11.11 Retaking a Course

A student may retake any course of the programme when it is offered again in order to:

(a) Pass it if the student had failed it before;

(b) Improve the grade if the first pass grade was below.

A student who does not wish to retake a failed Elective Course shall be allowed to take a substitute Elective Course.

11.12 Discontinuation

Discontinuation from the programme occurs if a student:

(a) Fails a course three times

(b) Accumulates CGPA less than 3.0 for three consecutive semesters

(c) Involves in examination malpractices

12. AWARD AND CLASSIFICATION

12.1 Degree Award

On successful completion of the programme the candidates shall be awarded a **Master of Science in Environmental Science** of Kyambogo University.

12.2 Classification

The degree of Master of Science in Environmental Science shall be not be classified.

12.3 Obtaining the Cumulative Grade Point Average (CGPA)

The CGPA shall be obtained by:

(a) Multiplying the grade point (GP) obtained by the credit units assigned to the course to arrive at the weighted score for the course,

(b) Adding together the weighted scores for all courses taken up to the time;

(c) Dividing the total weighed score by the total number of credit units taken up to the time.

12.4 Course Codes

The Course Codes that will be used for courses under the Master of Science in Environmental Science will be tagged GMSE. **GMSE represents Graduate studies at Masters level programme in Environment Science.**

YEAR 1; SEMESTER 1

COURSE NAME: Advanced Ecotoxicology

COURSE CODE: GMSE 7111

COURSE LEVEL: YEAR I SEMESTER I

CREDIT UNITS: 3

Brief Course Description

General introduction to ecotoxicology and environmental toxicology. Metals in the environments, Organic pollutants, sources and global transport. Emerging pollutants, Biological and biochemical effects of pollutants. Biomarkers and biomonitoring. Endocrine disrupting chemicals, Toxicokinetics, Genotoxicity, Effects on individuals and populations, Changes in communities and ecosystems. Factors affecting toxicity, mixtures and climate change, Plastic pollution, Oil pollution, and Ecological risk assessment. Bioaccumulation and biomagnification. Effects in different species and animal groups. Ecotoxicology and ecological risk assessment. Combined effects of pollutants and other anthropogenic environmental factors. Environmental chemistry. Different chemical groups of anthropogenic origin in the environment. Focus is on their sources and fates in the environment. Effects of anthropogenic chemicals on different biological organization levels (cell, organ, organism, population, ecosystem) with focus on mechanisms. Hazard assessment: Evaluation of toxicological information from different sources for classification and labelling of chemicals. Individual projects on classification and labelling of chemicals using EU guidelines. Environmental risk assessment of chemicals. Major classes of contaminants. Routes by which contaminants enter ecosystems. Effects of contaminants on populations and communities. Population level effects and population dynamics. Evolutionary responses to environmental stressors. Community and ecosystem level effects. Ecological risk assessment and environmental management.

Course Objectives

Upon successful completion of the course learners will be able to:

1. Discuss the sources and fate of chemicals in the environment

2. Present and explain mechanisms for adverse effects of chemicals; Bioaccumulation and bio magnification of persistent chemicals
3. Estimate the risk of adverse effects of a chemical on different biological organization levels based on knowledge about the toxicity, degradability, and bioavailability of the chemical
4. Evaluate toxicological information from different sources; Toxicokinetic and biotransformation in relation to differences in toxicity
5. Discuss the Speciation of metals in soil and water and the Sorption and biodegradation of organic chemicals.
6. Discuss environmental/ecological risk assessment and (international) legislation of chemicals

Learning outcomes

At the end of this course learners should be able to:

1. Demonstrate advanced knowledge within ecotoxicology.
2. Predict how pollutants affect organisms, species, populations and ecosystems.
3. Apply knowledge of ecotoxicological theory to new environmental situations;
4. Evaluate the risk for adverse toxicity effects of chemicals on ecosystems.
5. Interpret, summarize, validate and critique ecotoxicological data from the scientific literature.

Detailed Course Description

SN	Course Content	Duration
		CH
1	**Introduction** to ecotoxicology; knowledge of exposure and effects of environmental pollutants on natural biological systems (molecules, cells, organisms, species, populations and ecosystems: Skills in form of ability to apply acquired knowledge to understand how pollutants are spread in the nature, and how they affect biological systems in nature. Definition of, and differences between environmental toxicology and ecotoxicology. Ecological risk assessment; measurement of chemical transport and fate, and exposure of organisms in ecotoxicologic testing. Description of ecotoxicologic methods and procedures. Ecotoxicologic testing; integration of knowledge from the laboratory with the actual field conditions. Aquatic and terrestrial ecotoxicology.	**8**

2	**Chemical movement, fate, and exposure**. Chemodynamics; single phase chemical behaviour, chemical transport between phases, chemical behaviour and bioavailability. **Biomarkers**; Biomarkers of exposure, effect, susceptibility, and interpretation. Biomonitoring.	**7**
3	**Endocrine and development disruptors**. Mechanisms of Endocrine toxicity and sensitive life stages. Timing of exposure. Hormone regulation and feedback control. Species-dependent sex determination. The ability to apply acquired knowledge to reduce or hinder harmful effects of pollutants on biological systems and bioresources. It as well provides basic knowledge on how different groups of contaminants are spread in the nature, taken up and excreted by the organisms, and the toxic and ecotoxic effects on pollutants on biological systems and bioresources and have basic knowledge on ecological risk assessment.	**8**
4	**Terrestrial and aquatic ecotoxicology**. Toxicity tests. Sublethal effects. Population and community effects. Chemical interactions and natural stressors. Trophic-level transfer of contaminants. Genotoxicity. Terrestrial Ecotoxicology; acute and chronic toxicity testing, and Field testing. Aquatic ecotoxicology; acute and chronic toxicity testing, Sublethal effects, and Field testing. Good laboratory practices in terrestrial and aquatic ecotoxicology.	**8**
5	**Modeling and Geographic Information Systems.** Types of Models; Individual-based versus Aggregated Models, Stochastic versus Deterministic Models. Spatially Distributed versus Lumped Models. Modeling Exposure. Modeling Effects. Linking Models to Geographical Information Systems; Mapping Exposure and Effects.	**7**
6	**Ecological Risk Assessmen**t. Problem formulation, analysis, Risk Assessment and Risk Management. Probabilistic Risk Assessment; Overlapping Distributions, Stochastic Simulation. Environmental Toxicology and Human Health. Link between wildlife and human health; the challenges and concerns in the extrapolation of wildlife data to humans. Risk Assessment steps; hazard identification, dose-response assessment, exposure assessment, and risk characterization. The interconnection between ecological health and human health.	**7**

Mode of delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are as below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Study Materials

1. Bhattacharya, A., Sahu, K.S., and Sarkar, F., (2013) *Ecotoxicity of Pesticides*. (1st Ed.). LAP LAMBERT Academic Publishing
2. Green, J.W., Springer, T.A., and Holbech, H., (2018) *Statistical Analysis of Ecotoxicity Studies*. (1st Ed.). Wiley
3. Cohen, G.M., (2020) *Target Organ Toxicity.* Vol. 1 (1st Ed.). CRC Press
4. Gupta P.K., (2018) *Illustrated Toxicology.* (1st Ed.). Academic Press
5. Gupta R.C., (2015) *Handbook of Toxicology of Chemical Warfare Agents.* (2nd Ed.). Academic Press
6. Houck, M.M., (ed) (2018) *Forensic Toxicology.* Academic Press
7. Simon, T.W., (2019) *Environmental Risk Assessment.* (2nd Ed.). CRC Press
8. Stanley, L., (2014) *Molecular and Cellular Toxicology.* (1st Ed.). Wiley
9. Razzaghi, M., (2020) *Statistical Models in Toxicology.* (1st Ed.). CRC Press
10. Ritz, C., Jensen, S.M., Gerhard, D., and Streibig, J.C., (2019) *Dose-Response Anaysis Using R.* (1st Ed.). CRC Press
11. Wooley, D., and Wooley, A., (2017) *Practical Toxicology.* (3rd Ed.). CRC Press

COURSE NAME: ENVIRONMENTAL HEALTH

COURSE CODE: GMSE 7112

COURSE LEVEL: YEAR I SEMESTER I

CREDIT UNITS: 3

Brief Course Description

Examines health issues, scientific understanding of causes, and possible future approaches to control of the major environmental health problems in industrialized and developing countries. Topics include how the body reacts to environmental pollutants; physical, chemical, and biological agents of environmental contamination; vectors for dissemination (air, water, soil); solid and hazardous waste; susceptible populations; biomarkers and risk analysis; the scientific basis for policy decisions; and emerging global environmental health problems.

Course objectives

Upon successful completion of the course learners will be able to:

1. Describe ways in which environmental factors in community, occupational and residential settings impact health;
2. Establish the relationship between population growth and dissemination of environmental pollutants.
3. Explain the pertinent scientific principles associated with the major environmental health program areas;
4. Explain the factors, such as community perceptions, public health law, traditions, socioeconomic conditions, politics and interpersonal communications, may influence the practice of environmental health;
5. Describe the benefits and limitations of the various methodologies through which society attempts to minimize negative environmental health impacts;
6. Assessment of personal contributions to environmental degradation and their potential health consequences;
7. Analyze at least one environmental health topic for its impact on health and propose solutions based on what is known about the challenges/barriers.

Learning Outcomes

Upon successful completion of the course learners should be able to:

1. Discuss the history and definition of environmental health.
2. Discuss the association between population growth and dissemination of environmental pollutants.
3. Describe methods used in epidemiology and toxicology to assess environmental exposures and hazards.
4. Describe policies that have been developed to manage health risks associated with exposures to environmental hazards.
5. Identify chemical, physical, and microbial agents that originate in the environment and can impact human health.
6. Describe specific applications of environmental health concepts to fields such as water quality control, food safety, and occupational health

Detailed course description

SN	Course Content	Duration
		CH
1	**Introduction** to environmental health; knowledge of the potential environmental hazards, action and effects of the environment on human health. Course overview and introduction to environmental health concepts	**8**
2	**Environmental health issues** Health issues, scientific understanding of causes, and possible future approaches to control of the major environmental health problems in industrialized and developing countries. Characteristics of healthy environments. Major sources of environmental health risks and hazards-chemical, physical, microbial, emerging agents, and the resulting effects Methods of monitoring and control of environment health hazards	**10**

	Environment health practices and standards, public health policy, community and other public health legislation. Agencies involved in environmental health and protection of the public.	
3	**Reactions to environmental pollutants:** Reactions of the body to environmental pollutants; physical, chemical, and biological agents of environmental contamination; vectors for dissemination (air, water, soil); solid and hazardous waste; susceptible populations; biomarkers and risk analysis; the scientific basis for policy decisions; and emerging global environmental health problems.	**6**
4	**Regulatory Programmes**. Federal and state regulatory programs, guidelines and authorities that control environmental health issues, General mechanisms of toxicity in eliciting a human health effect after exposure to environments. Community perceptions, public health law, traditions, socioeconomic conditions, politics and interpersonal communications, may influence the practice of environmental health	**7**
5	**Toxicity.** General mechanisms of toxicity in eliciting a human health effect after exposure to environments. Toxicology-fundamental principles, methodologies and approaches, the critical pathways of the pollutants/toxicants. Water, sanitation and hygiene Emerging infectious diseases. Food safety-sources of contamination and control.	**7**
6	**Risk Managemen**t. Risk management and risk communication approaches in relation to issues of environmental justice and equity. Environmental factors in community, occupational and residential settings impact health; list the major agencies and organizations involved in environmental health protection and explain their basic responsibilities, programs and problems.	**7**

Mode of delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are as below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Study Materials

1. Battersby, S. (Ed.). (2022). *Clay's Handbook of Environmental Health* (22nd ed.). Routledge. https://doi.org/10.1201/9781003035640
2. Johnson, B.L., and Lichtveld, M.Y. (2022). *Environmental Policy and Public Health: Principal Health Hazards and Mitigation, Volume 1* (3rd ed.). CRC Press. https://doi.org/10.1201/9781003253358
3. Johnson, B.L., and Lichtveld, M.Y. (2022). *Environmental Policy and Public Health: Emerging Health Hazards and Mitigation, Volume 2* (3rd ed.). CRC Press. https://doi.org/10.1201/9781003212621
4. Johnson, B.L., and Lichtveld, M.Y. (2017). *Environmental Policy and Public Health* (2nd ed.). CRC Press. https://doi.org/10.1201/9781351228473
5. Koren, H. (2017). *Best Practices for Environmental Health: Environmental Pollution, Protection, Quality and Sustainability* (1st ed.). Routledge. https://doi.org/10.1201/9781315119274
6. Robson, M.G., Toscano, W.A., Meng, Q., and Kaden, D.A. (Eds.). (2022). *Risk Assessment for Environmental Health* (2nd ed.). CRC Press. https://doi.org/10.1201/9780429291722

7. Stewart, J., and Lynch, Z. (2018). *Environmental Health and Housing: Issues for Public Health* (2nd ed.). Routledge. https://doi.org/10.1201/9781315109077
8. Zölzer, F., and Meskens, G. (Eds.). (2021). *Research Ethics for Environmental Health* (1st ed.). Routledge. https://doi.org/10.4324/9780429318436
9. Zölzer, F., and Meskens, G. (Eds.). (2019). *Environmental Health Risks: Ethical Aspects* (1st ed.). Routledge. https://doi.org/10.4324/9781351273367
10. Zölzer, F., and Meskens, G. (Eds.). (2017). *Ethics of Environmental Health* (1st ed.). Routledge. https://doi.org/10.4324/9781315643724

COURSE NAME: ECOLOGICAL RESTORATION
COURSE CODE: GMSE 7113
COURSE LEVEL: YEAR I SEMESTER I
CREDIT UNITS: 3

Brief Course Description

The field of Ecological Restoration is a complex interdisciplinary field that is becoming more important in a world that depends on increasingly degraded ecosystems to support growing human societies. The United Nations General assembly declared 2021 – 2030 as the UN Decade on Ecosystem Restoration and that restoration is fundamental to sustainable development, mitigating and adapting to climate change, enhancing food security as well as water and biodiversity conservation. Further, restoration will continue to be a critical aspect in environmental management for as long as human infrastructural development continues to occur. Ongoing human disturbances associated with urbanization, energy development, climate change, poor land management, and pollution create the need for professionals that can restore services to degraded ecosystems. Restoration of degraded ecosystems benefits society by improving biodiversity conservation, improving human livelihoods, empowering local people, and improving ecosystem productivity. This course is intended to provide students with an understanding of the process of assisting in the recovery of damaged, degraded or destroyed ecosystems.

Course Objectives

Upon successful completion of the course learners should be able to:

1. Describe the physical, biotic and human issues of restoration of natural ecosystems
2. Demonstrate the critical role of scientific description and analyses (biophysical sciences) and the importance of the integration of scientific data, models and approaches with human needs and attitudes (social sciences) for successful restoration.
3. Demonstrate the importance of communication for the successful development and management of a restoration project, and introduce you to selected skills.
4. Demonstrate the basic tools for carrying out restoration projects.
5. Demonstrate restoration activities in the community and to others carrying out restoration in the province of British Columbia.
6. Describe a solid introduction to your further study of courses in the Restoration of Natural Systems Program.

Learning Outcomes

Upon successful completion of the course learners will be able to:

1. Explain the meaning of ecological restoration, and how it defers from rehabilitation
2. Articulate the historical development of restoration concepts and the role that restoration can serve in the future stewardship of natural resources,
3. Describe the major ecological principles underlying the successful restoration of ecosystems including concepts of disturbance and succession,
4. Use ecological and management principles and select appropriate methods and tools for designing and conducting restoration projects,
5. Discern elements of successful versus failed restoration projects

Detailed Course Outline

SN	Course Content	Duration
		CH
1	**Introduction to Restoration**: An Introduction Definition of restoration, discussion of the current need and human impacts on the natural environment. Outline of the scope of practical ecological restoration. Exploration of the elements of a restoration project. Basic skills and tools required to conduct a restoration project.	**6**
2	**Characteristics of Natural Systems:** An examination of the components and processes of ecosystems before focusing on the concept of Essential Ecosystem Characteristics. Particular to climate change and its potential impact on ecosystems, and the work of ecological restoration. The importance of biological diversity and current threats to it. How to obtain and evaluate information on rare and endangered ecosystems and species. Introduction of the key concepts in soil description and hydrology as they apply to restoration.	**6**
3	**Philosophy, Ethics, and Legislation:** Exploration of the human dimension of restoration from two perspectives. The role and importance of human perceptions and values in restoration. Professional ethics for the practitioner of restoration. Overview of public policy and legislation pertinent to restoration. Topics range from international conventions to understanding the role of municipal and other forms of local government.	**6**
4	**The Restoration Project**: This module takes the reader through the stages of planning and carrying out a restoration project—from developing initial project objectives, through information gathering, then implementation, to post-project monitoring.	**10**
5	**Restoration of Wetlands, Forests, Streams, and Marine Ecosystems**: Examination of the three major areas of restoration activity practiced in British Columbia: wetlands, streams, forests, and briefly marine ecosystems. In each case we consider the importance of ecosystem type and essential ER311 Course Outline characteristics, as well as the restoration strategies and issues particular to that ecosystem type. Restoration examples and issues are described or covered in readings.	**7**
6	**Restoration and People**: Sustainability, Traditional Ecological Knowledge, Agroecology This module begins with a discussion of the concept of sustainability and follows with a description of methods for	**4**

	measuring and monitoring the sustainability of natural systems and of restoration projects. A demonstrates the value of traditional ecological knowledge as it applies to restoration. We conclude with an introduction to the developing field of agroecology.	
7	**Public Involvement, Urban Restoration, and Restoration in a Global Context**: An examination of the critical importance of public involvement in the success of restoration project, and lists strategies for engaging and gaining public involvement and support. A discussion of public involvement and public perceptions of restoration in an urban context. The course concludes with a case study from Asia (Iraq) that highlights several of the themes and principles developed throughout ER311 in the context of the political realities of the globe.	**6**

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Reading List

1. Hobbs, R. J., Hallett, L. M., Ehrlich, P.R., and Mooney, H. A., (2011). *Intervention ecology: Applying ecological science in the twenty-first century.* Bioscience 61:442-450.
2. Funk, J.L., and McDaniel S., (2010). *Altering light availability to restore invaded forest: The predictive role of plant traits.* Restoration Ecology 18 (6): 865-872.
3. Wong, T. M., and Ticktin, T., (2015). *Using population dynamics modelling to evaluate potential success of restoration: a case study of a Hawaiian vine in a changing climate*. Environmental Conservation 42:20-30.
4. Collinge, S.K., Ray, C., and Marty, J.T., (2013). *A long-term comparison of hydrology and plant community composition in constructed versus naturally occurring vernal pools.* Restoration Ecology 21:704-712.
5. Stainback, G.A., Lai, J.H., Pienaar, E.F., Adam, D.C., Wiederholt, R., and Vorseth, C., (2020). *Public preferences for ecological indicators used in Everglades restoration*. PLOS ONE 15, e0234051. https://doi.org/10.1371/journal.pone.0234051
6. Kettenring, K. M., and Adams, C. R., (2011). *Lessons learned from invasive plant control experiments: a systematic review and meta-analysis.* Journal of Applied Ecology. 48:970-979.

COURSE NAME: ENVIRONMENTAL ECONOMICS

COURSE CODE: GMSE 7114

COURSE LEVEL: YEAR I SEMESTER I

CREDIT UNITS: 3

Brief Course Description

Environmental Economics: Two – way linkages between Ecological and Economic systems: Environment – Development handoffs. Eco – Industrial development, Eco – labeling.

Theories of externality and public goods: Pigou and Coase; property rights and transaction costs, market failures and corrective actions. Pollution: optimal level, definition, types of pollution. Environmental damages / benefit, social cost, benefit analyses, valuation methods.

Controlling environment with economics: Environmental Standards, subsidies, taxes, marketable permits, trading systems.

Energy Audit: Energy – Efficient Terminology. End – use technologies: such as lighting, HVAC, refrigeration & motors. Energy efficiency measures. Energy audit components: such as utility billing analysis, auditing strategies

Course Objectives

1. Discuss the advanced theories and models of Environmental Economics.
2. Describe the environment-economic linkages.
3. Apply the environmental models to research and policy issues in the area of environmental economics with specific reference to Sub-Saharan Africa
4. Discuss the implications of the dynamics of global environment for development in Sub-Saharan Africa

Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

1. Explain the basic concepts in environmental economics.
2. Discuss the factors that govern environmental economics.
3. Describe the advanced theories and models of Environmental Economics.
4. Explain the linkages between ecological and environmental-economical systems

5. Describe and distinguish between environmental valuation and accounting

Detailed Course Outline

SN	Course Content	Duration
		CH
1	**Introduction** to Basic concepts in Environmental Economics. Market Failures: Public Goods, Externalities, Property Rights, Imperfect Information and Non-Convexity. Environment, Economic Growth, Poverty and Population Linkages. Ethics, Discounting, Sustainable Development, Green Economy. Optimal Exploitation and Management of Natural Resources; Exhaustible (Non-Renewable) Resources, Renewable Resources, Economics of Biodiversity.	**10**
2	**Pollution**. Theory, Policy and Case Studies; Efficient Level of Pollution, Least Cost Theorem: Derivation of Efficiency Conditions of Market Based Policy Instruments, Derivation of Policy Instruments from Pareto-Optimality with Externality, Environmental Policy Instruments. Two – way linkages between Ecological and Economic systems: Environment – Development handoffs. Eco – Industrial development, Eco – labeling.	**9**
3	**Environmental Valuation;** Types of Economic Values, Welfare Foundations of Environmental Valuation, Revealed Preference (RP) Methods, Stated Preference (SP) Methods, Combined RP and SP Methods, Benefit Transfer Method. Environmental Evaluation; Environmental Cost-Benefit Analysis (Methods for Environmental CBA, Discounting and the future, Equity and CBA, Uncertainty and irreversibility, Criticisms of CBA), Cost-Effectiveness Analysis, Environmental Impact Assessment and Analysis, Multiple Criteria Analysis.	**10**
4	**Environmental Accounting;** Theory of Environmental Accounting and Environmental accounting in Practice. International Environmental Issues; Trade and Environment, International Environmental Externalities, International Environmental Convention, and the Economics of Climate Change. Theories of externality and public goods: Pigou and Coase; property rights and transaction costs, market failures and corrective actions. Pollution:	**9**

	optimal level, definition, types of pollution. Environmental damages / benefit, social cost, benefit analyses, valuation methods.	
5	**Energy Audit:** Energy – Efficient Terminology. End – use technologies: such as lighting, HVAC, refrigeration & motors. Energy efficiency measures. Energy audit components: such as utility billing analysis, auditing strategies.	**7**

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	15%
Tests	25%
Final examination	60%
Total	**100%**

Reading List:

1. Anderson, D.A. (2019). *Environmental Economics and Natural Resource Management* (5th ed.). Routledge. https://doi.org/10.4324/9781351121477
2. Hussen, A. (2018). *Principles of Environmental Economics and Sustainability: An Integrated Economic and Ecological Approach* (4th ed.). Routledge. https://doi.org/10.4324/9781351109116
3. Lewis, L., and Tietenberg, T. (2019). *Environmental Economics and Policy* (7th ed.). Routledge. https://doi.org/10.4324/9780429503849

4. Managi, S., and Kuriyama, K. (2016). *Environmental Economics* (1st ed.). Routledge. https://doi.org/10.4324/9781315467337
5. Nguyen, B., and Wait, A. (2015). *Essentials of Microeconomics* (1st ed.). Routledge. https://doi.org/10.4324/9781315690339
6. Shogren, J.F. (Ed.). (2003). *Experiments in Environmental Economics: Volume 1* (1st ed.). Routledge. https://doi.org/10.4324/9781315196350
7. Smith, V.K. (1988). *Environmental Resources and Applied Welfare Economics: Essays in Honor of John V. Krutilla* (1st ed.). Routledge. https://doi.org/10.4324/9781315677446
8. Squires, G. (2012). *Urban and Environmental Economics: An Introduction* (1st ed.). Routledge. https://doi.org/10.4324/9780203825990
9. Tietenberg, T., and Lewis, L. (2019). *Environmental Economics: The Essentials* (1st ed.). Routledge. https://doi.org/10.4324/9780429299292
10. Tietenberg, T., and Lewis, L. (2023). *Environmental and Natural Resource Economics* (12th ed.). Routledge. https://doi.org/10.4324/9781003213734

COURSE NAME: ENVIRONMENTAL REMEDIATION TECHNOLOGIES

COURSE CODE: GMSE 7115

COURSE LEVEL: YEAR I SEMESTER I

CREDIT UNIT: 4

Brief Course Outline

Contamination of soil and water may result from a variety of human activities, for example urban, industrial, mining and agriculture. The potential and actual impacts of contamination from these activities on natural ecosystems, and the resultant need for remediation are in many cases well documented. This course will introduce the subject of soil and water pollution from a wide range of sources and examine the mobility of contaminant constituents in soil and water ecosystems. Different remediation technologies and strategies to overcome the resultant environmental problems will be examined in relation to degraded urban, agricultural and industrial landscapes.

This course will discuss environmental remediation topics including, but not limited to, using plants, microorganisms and substrates (e.g., soil and engineered materials) to improve air, water and soil quality. For example, this course will explore the current sciences and technologies of living walls to improve indoor air quality, green roofs to manage storm water and air pollutants, and constructed wetlands to treat wastewater. Environmental remediation is, by nature, multidisciplinary, involving chemistry, physics, biology, engineering, landscape design, etc.

Course Objectives:

By the end of this course, learners should be able to:

1. Identify and characterize novel environmental pollutants in order to develop remediation strategies
2. Design and apply green infrastructures for environmental remediation based on the theories and principles
3. Identify new research directions and design an experiment to study a chosen topic
4. Discuss various remediation options, their limitations and how they can be selected to suit the different pollution scenarios.

Learning Outcomes

Upon successful completion of this course, learners will be able to:

1. Describe various mass transport models of contaminants in subsurface such as soil and groundwater.
2. Explain various contaminant retardation processes such as sorption, degradation, volatilization, precipitations, and redox reactions
3. Describe the various types of bioremediations: intrinsic bioremediation, in situ bioremediation, and ex situ bioremediation;
4. Explain phytoremediation and describe its application and limitation in remediation of environmental contamination
5. Explain photodegradation and describe its application and limitation in environmental remediation
6. Describe the various remediation technological options for various contaminated sites
7. Plan and design remediation option for various environmental contamination scenarios

Detailed Course Outline:

SN	Course Content	Duration
		CH
1	This course will introduce the subject of soil and water pollution from a wide range of sources and examine the mobility of contaminant constituents in soil and water ecosystems. Different remediation technologies and strategies to overcome the resultant environmental problems will be examined in relation to degraded urban, agricultural and industrial landscapes.	**10**
2	Soil and groundwater pollution from different types of development and their behaviour and transport pathways in the environment will be examined. The remediation and treatment of contaminated land forms a major part of this course along with the issues associated with the treatment, reuse and land application of liquid and solid wastes.	**10**

3	Pollution control methodologies will be examined and various treatment and remediation technologies covered. Material presented will also deal with the measurement and interpretation of a range of biological, chemical and microbiological pollutants. Mining in different environments will be examined and issues such as siting of mine infrastructure, disposal and storage of overburden and topsoil, tailings disposal and site rehabilitation will be discussed.	**10**
4	Advanced geomorphic techniques will be used to develop mine site rehabilitation plans. The chemical, petroleum and minerals processing industries and the effects that they have on soil and water contamination will be examined as well as methods of rehabilitating and remediating former industrial and mining sites.	**10**
5	Contamination of soil and water may result from a variety of human activities, for example urban, industrial, mining and agriculture. The potential and actual impacts of contamination from these activities on natural ecosystems, and the resultant need for remediation are in many cases well documented.	**10**
6	Environmental remediation topics including, but not limited to, using plants, microorganisms and substrates (e.g., soil and engineered materials) to improve air, water and soil quality. For example, this course will explore the current sciences and technologies of living walls to improve indoor air quality, green roofs to manage storm water and air pollutants, and constructed wetlands to treat wastewater. Environmental remediation is, by nature, multidisciplinary, involving chemistry, physics, biology, engineering, landscape design.	**10**

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Reading List

1. Asante-Duah, K. (2019). *Management of Contaminated Site Problems, Second Edition* (2nd ed.). CRC Press. https://doi.org/10.1201/9780429198021
2. Eslamian, S. (Ed.). (2015). *Urban Water Reuse Handbook* (1st ed.). CRC Press. https://doi.org/10.1201/b19646
3. Gupta, A. (2020). *Heavy Metal and Metalloid Contamination of Surface and Underground Water: Environmental, Policy and Ethical Issues* (1st ed.). CRC Press. https://doi.org/10.1201/9780429198373
4. Ok, Y.S., Rinklebe, J., Hou, D., Tsang, D.C.W., and Tack, F.M.G. (Eds.). (2020). *Soil and Groundwater Remediation Technologies: A Practical Guide* (1st ed.). CRC Press. https://doi.org/10.1201/9780429322563
5. Rakshit, A., Parihar, M., Sarkar, B., Singh, H.B., and Fraceto, L.F. (Eds.). (2021). *Bioremediation Science: From Theory to Practice* (1st ed.). CRC Press. https://doi.org/10.1201/9780429327643
6. Riser-Roberts, E. (1998). *Remediation of Petroleum Contaminated Soils: Biological, Physical, and Chemical Processes* (1st ed.). CRC Press. https://doi.org/10.1201/9780367802547
7. Sellers, K. (1999). *Fundamentals of Hazardous Waste Site Remediation* (1st ed.). Routledge. https://doi.org/10.1201/9780203755273

8. Singh, P., Hussain, C.M., and Sillanpää, M. (Eds.). (2022). *Innovative Bio-Based Technologies for Environmental Remediation* (1st ed.). CRC Press. https://doi.org/10.1201/9781003004684
9. Suthersan, S.S., Horst, J., Schnobrich, M., Welty, N., and McDonough, J. (2016). *Remediation Engineering: Design Concepts, Second Edition* (2nd ed.). CRC Press. https://doi.org/10.1201/9781315367088
10. Wise, D.L. (2000). *Remediation Engineering of Contaminated Soils* (1st ed.). CRC Press. https://doi.org/10.1201/9781482289930

COURSE NAME: ENVIRONMENTAL MODELING AND SIMULATION
COURSE CODE: GMSE 7116
COURSE LEVEL: YEAR I SEMESTER I
CREDIT UNITS: 4

Brief Course Description

The course addresses the major steps in the development of environmental models, and how they are used for decision-making, with a particular emphasis on water quality and responding to potential climate change impacts. Topics to be covered include one or more of the following: model specification (types of models e.g. process-driven models, artificial neural networks, environmental processes, model complexity, model application), model calibration (different optimization methods, including gradient methods and evolutionary algorithms), model validation (structural, replicative and predictive validity) and stochastic modelling (types of uncertainty, random variables, risk-based performance measures and reliability analysis, including Monte Carlo simulation), environmental decision-making (multi-objective trade-offs, multi-criteria decision analysis). These topics will be explored through a project on managing dissolved oxygen and salinity in a river system under climate and population change

The environmental problems result from a complex interaction of physical, chemical and biological processes, involving land, water, air and energy resources that significantly affect human activities and attitudes. The complex and multidisciplinary nature of environmental

problems requires that they are dealt in an objective and integrated manner. Quantitative tools provide the requisite objectivity in environmental decision-making. These tools help in investigating, understanding, representing the current and predicting the future state of environment and generating 'what-if' scenarios under alternative policy interventions. These are crucial for any integrated environmental assessment and management strategy. This course aims to provide introduction to the fundamental modeling concepts and their applications in simulating the pollutant fate and transport problems in the natural environmental systems.

Course objectives

Upon completion of the course learners will be able to:

1. Discuss the idea, methodology and basic tools of environmental modeling
2. Evaluate the different modeling approaches, their scope and limitations
3. Describe the fate and transport of pollutants
4. Recognize applications of modeling in environmental management and decision making

Learning Outcomes

On successful completion of this course learners should be able to:

1. Critically review and evaluate different model types (e.g., data-driven (machine learning), process-driven).
2. Discuss and evaluate the different steps in the development of models (e.g., model specification, calibration and validation) and the methods used in each of these steps.
3. Develop and validate process-driven dissolved oxygen and data-driven (machine learning) salinity models in river systems.
4. Distinguish between sources and different types of uncertainty, explain their potential origins and discuss how they might impact engineering modelling and decision-making.
5. Discuss different approaches to incorporating uncertainty into engineering modelling and decision-making.
6. Employ models and multi-criteria decision analysis approaches to solve complex engineering problems that examine the trade-offs between economic, environmental and social outcomes in an uncertain environment, including the development of solutions to adapt to climate change impacts.

Detailed Course Outline

SN	Course Content	Duration
		CH
1	**Introduction to Environmental modeling**: scope and problem definition, goals and objectives, definition; modelling approaches– deterministic, stochastic and the physical approach; applications of environmental models; the model building process.	**6**
2	**Elementary concepts, laws, theories and processes The building blocks:** extensive and intensive properties, properties relevant to of environmental systems, the material balance approach; the transport processes–advection, diffusion, dispersion, gravitational settling, transport in porous media; the transformation processes–the non-reactive processes, the reactive processes; simulation of transport and transformation processes– introduction, the completely stirred tank reactor, plug flow reactor, mixed flow reactor models; the general material balance models.	**8**
3	**Environmental modeling applications:** Water quality modeling: surface water quality modeling – lakes and impoundments, rivers and streams, estuaries; ground water pollution modeling. Air quality modeling: the box model, the Gaussian plume model point sources, line sources, area sources; special topics; Gaussian puff model.	**8**
4	**Environmental Modelling and Simulation:** The course addresses the major steps in the development of environmental models, and how they are used for decision-making, with a particular emphasis on water quality and responding to potential climate change impacts. Topics to be covered include one or more of the following: model specification (types of models e.g., process-driven models, artificial neural networks, environmental processes, model complexity, model application)	**10**
5	**Model Calibration and Validation:** Model calibration (different optimization methods, including gradient methods and evolutionary algorithms) Model validation (structural, replicative and predictive validity)	**10**
6	**Modeling and Simulation:** stochastic modeling (types of uncertainty, random variables, risk-based performance measures and reliability analysis, including Monte Carlo simulation), environmental decision-making (multi-objective trade-offs, multi-criteria decision analysis)	**10**

7	**Project work:** Exploration of case study through a project on managing dissolved oxygen and salinity in a river system under climate and population change.	**8**

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Reading List

1. Barnsley, M.J. (2007). *Environmental Modeling: A Practical Introduction* (1st ed.). CRC Press. https://doi.org/10.1201/9781315275970
2. Bundschuh, J., and Zilberbrand, M. (Eds.). (2011). *Geochemical Modeling of Groundwater, Vadose and Geothermal Systems* (1st ed.). CRC Press. https://doi.org/10.1201/b11690
3. Chaturvedi, D.K. (2010). *Modeling and Simulation of Systems Using MATLAB and Simulink* (1st ed.). CRC Press. https://doi.org/10.1201/9781315218335
4. Dubois, G. (2018). *Modeling and Simulation: Challenges and Best Practices for Industry* (1st ed.). CRC Press. https://doi.org/10.1201/9781351241137
5. Dunnivant F.M. and Anders E. (2006) *A Basic Introduction to Pollutant Fate and Transport*, John Wiley & Sons, Inc., New Jersey.

6. Gordon, S.I., and Guilfoos, B. (2017). *Introduction to Modeling and Simulation with MATLAB® and Python* (1st ed.). Chapman and Hall/CRC. https://doi.org/10.1201/9781315151748
7. Kinser, J.M. (2022). *Modeling and Simulation in Python* (1st ed.). Chapman and Hall/CRC. https://doi.org/10.1201/9781003226581
8. Maurya, S.P., Yadav, A.K., and Singh, R. (Eds.). (2022). *Modeling and Simulation of Environmental Systems: A Computation Approach* (1st ed.). CRC Press. https://doi.org/10.1201/9781003203445
9. Smith J. and Smith P. (2007). *Introduction to Environmental Modelling*. Oxford: Oxford University Press. (SRUC Library)
10. Wainer, G.A., and Mosterman, P.J. (Eds.). (2011). *Discrete-Event Modeling and Simulation: Theory and Applications* (1st ed.). CRC Press. https://doi.org/10.1201/9781315218731

YEAR 1; SEMESTER 2

COURSE NAME: ENVIRONMENTAL IMPACT ASSESSMENT & MONITORING
COURSE CODE: GMSE 7121
COURSE LEVEL: YEAR I SEMESTER II
CREDIT UNITS: 3

Brief Course Description

The course introduces students to Environmental Impact Assessment (EIA), hereafter referred to as Environmental and Social Impact Assessment (ESIA). The course is designed to provide a critical overview of the theory and practice of ESIA. The ESIA process is introduced including the history and evolution of ESIA. Policy, laws and ESIA administration. Monitoring environmental ecosystems and carrying out environmental audits. The course includes field trips to selected projects.

Course objectives

By the end of this course learners should be able to:

1. Explain the application and role of Environment and Social Impact Assessment (ESIA) in sustainable development
2. Critically review ESIA of projects, plans and programmes
3. Employ the ESIA procedure and methods in environmental management and conservation
4. Utilize the knowledge and methods for Strategic Environment Assessment (SEA) in a project

Learning Outcome

Upon successful completion of the course, learners should be able to:

1. Explain the origin and the values of ESIA
2. Discuss the principles of ESIAs
3. Describe the different stages of ESIA;
4. Describe the role and purpose of ESIA for decision-making;
5. Explain the use Impact identification and evaluation methods in ESIA and the strengths and limitations of ESIA
6. Explain the format of an ESIA Report and the purpose of monitoring or audits
7. Discuss the role of ESIA and Strategic Environmental Assessments (SEA) in sustainable development
8. Critically review ESIA and SEA reports

Detailed Course Outline

SN	Course Content	Duration
		CH
1	**Introduction** to The ESIA process: definition, objectives, scope and significance. The values, principles and different stages of ESIA. The role and purpose of ESIA for decision-making.	**7**

2	Environmental and Social Impact Assessment (ESIA) as a planning tool and a means of ensuring the inclusion of environmental and social considerations in decision-making	**7**
3	Different ESIA procedures appropriate for inclusion in different types of political and legislative systems with particular emphasis on Uganda Public participation and the links to sustainable development.	**8**
4	Social Impact Assessment (SIA) – Social Investment Programmes; Understanding the social nature of impacts on communities; Benefits of undertaking SIA Environment Management Systems (EMS) and International Standardisation Organisation (ISO) Standards (ISO 14001:1996 for EMS and ISO 9001:2000 for Quality Management system).	**8**
5	Environmental Auditing and monitoring of established projects for environmental compliance Methods of analysis and individual case studies, field studies.	**7**
6	An EIA of a processing factory / Field study	**8**

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Reading List

1. Allard, A., Keskitalo, E.C.H., and Brown, A. (Eds.). (2023). *Monitoring Biodiversity: Combining Environmental and Social Data* (1st ed.). Routledge. https://doi.org/10.4324/9781003179245
2. Bartram, J., and Ballance, R. (Eds.). (1996). *Water Quality Monitoring: A practical guide to the design and implementation of freshwater quality studies and monitoring programmes* (1st ed.). CRC Press. https://doi.org/10.1201/9781003062110
3. Carley, M.J., and Bustelo, E. (1984). *Social Impact Assessment and Monitoring: A Guide To The Literature* (1st ed.). Routledge. https://doi.org/10.4324/9780429306303
4. Glasson, J., Therivel, R. and Chadwick, A. (2012) *Introduction to Environmental Impact Assessment*, (4th ed.), Routledge, London.
5. Manyuchi, M.M., Mbohwa, C., Muzenda, E., and Sukdeo, N. (2020). *Environmental Impact Assessments and Mitigation* (1st ed.). CRC Press. https://doi.org/10.1201/9780429270307
6. Morris, P. and Therivel, R. (eds.) (2009) *Methods of Environmental Impact Assessment*, (3rd ed.) Routledge, London
7. Sanford, R.M., & Holtgrieve, D.G. (2022). *Environmental Impact Assessment in the United States* (1st ed.). Routledge. https://doi.org/10.4324/9781003030713
8. Sengupta, M. (1993). *Environmental Impacts of Mining Monitoring, Restoration, and Control* (1st ed.). Routledge. https://doi.org/10.1201/9780203757062

9. Thenkabail, P.D. (Ed.). (2015). *Land Resources Monitoring, Modeling, and Mapping with Remote Sensing* (1st ed.). CRC Press. https://doi.org/10.1201/b19322
10. Therivel, R., and Wood, G. (Eds.). (2017). *Methods of Environmental and Social Impact Assessment* (4th ed.). Routledge. https://doi.org/10.4324/9781315626932
11. Wood, C. (2002). *Environmental Impact Assessment: A Comparative Review* (2nd ed.). Routledge. https://doi.org/10.4324/9781315838953

COURSE NAME: ADVANCED ENVIRONMETRICS
COURSE CODE: GMSE 7122
COURSE LEVEL: YEAR I SEMESTER II
CREDIT UNIT: 3

Brief Course description

As the world gets more crowded and technology continues to develop, environmental problems multiply. There are many aspects of these problems–economic, political, psychological, medical, scientific and technological. Addressing such problems often involves quantitative aspects; in particular, the acquisition and analysis of environmental data. Treating these quantitative problems effectively involves the use of statistics. When one is confronted with a new problem that involves the collection and analysis of data, two crucial questions exist: "How will using statistics help this problem?" and "Which techniques should be used?" The course has been designed and intended to help budding environmental scientists/managers to answer these questions in order to better understand and design systems for environmental protection. The course is about how to extract information from data and how informative data are generated in the first place. Analyzing data is part science, part craft and part art. An effort has been made through this course to provide some useful tools 'to get to the grips' of environmental problems and to encourage the students to develop the necessary craft and art.

Interpretation of data; descriptive data analysis; inferential data analysis; types of samples; parametric tests and non-parametric statistics; regression; multiple regression; curvilinear regression; factor analysis; cluster analysis; optimisation and mathematical statistics; partial and

semi-partial cancellation; variance partitioning; computer applications in environmental sciences; computer models of physical, chemical and biological parameters.

Course Objectives:

Upon completion of the course learners should be able to:

1. Collect, interpret and statistically analyze environmental data
2. Employ basic concepts useful for environmental data analysis
3. Employ statistics on a wide range of issues and challenges in the environment for management and decision making
4. Develop technical skills to use statistical tools and software in environmental data analysis
5. Utilize computer applications in simulation and modelling of environmental data to predict, control and manage challenges and issues
6. Innovate, design and develop systems for environmental protection

Learning Outcomes

Upon successful completion, learners should be able to:

1. Utilize R and a GUI or command line interface to analyze environmental data
2. Manipulate collated environmental data into R and write scripts for statistical analysis
3. Perform summary statistics to give an overview on the structure of the data
4. Explore information on data distribution and structure to resolve on the appropriate statistical models
5. Transform data to meet data quality requirement prior to final model selection;
6. Formulate hypotheses to be tested so as to answer research questions;
7. Conduct hypothesis testing by using parametric and non-parametric tests;
8. Express regression analyses to identify associations between parameters;
9. Prepare complex statistical analyses including multivariate analysis such as distance matrix, constrained and unconstrained ordinations for either chemical or biological dataset;
10. Create high quality data visualizations to be included in research reports such as dissertations and journal publications.

Detailed Course Outline

SN	Course Content	Duration
		CH
1	**Environmetrics**. Give a strong background in the application of statistical methods of data analysis in environmental sciences to enable learners to analyze environmental changes and their impacts on various life forms. Consideration of statistical and mathematical models concerned with biological and ecological applications. The application of statistical and systems methods to the analysis and modelling of environmental data.	**8**
2	**Hypotheses and tests.** Testing of research hypotheses: Introduction to hypotheses, types of hypotheses. Hypothesis evaluation in environmental science Degrees of freedom, level of significance, Type I & Type II errors, Standard deviation.	**8**
3	Parametric and non-parametric tests; t-test, Mann-Whitney U-test, Wilcoxon test, F-test, chi2-test, correlation, linear regression, one-way ANOVA and Kruskall-Wallis test. Chi-square tests, student t-test and F- test (Definitions of these tests and their applications) Hypotheses testing and statistical analysis involving means, correlations, prediction and validation of studies. Designs involving several means, proportions and covariates, including one way and two-way ANOVA. Data analyses using the latest computer statistical packages.	**10**
4	**Correlation studies.** Partial correlation, simple correlation, and multiple correlations. Regression; simple linear regression, method of least squares, and multiple regressions **Variance.** Analysis of variance (ANOVA); Single factor independent measures design, One-way ANOVA; two factor independent measures design two-way ANOVA, and single factor dependent measures design. Multivariate analysis of variance. Error of variance.	**10**

5	**Computer application and Web designing** Computer applications for environmental: Linear, regression, validation and forecasting. Introduction to database, networking, LAN, WAN, Website design. Computer-based modeling: Linear, regression, validation and forecasting. Computer-based modeling for population and population studies.	**9**

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Reading List

1. Acevedo, M.F. (2013). *Data Analysis and Statistics for Geography, Environmental Science, and Engineering* (1st ed.). CRC Press. https://doi.org/10.1201/b13675
2. Bailer, A.J. (1997). *Statistics for Environmental Biology and Toxicology* (1st ed.). Routledge. https://doi.org/10.1201/9780203738504
3. Bilder, C.R., and Loughin, T.M. (2014). *Analysis of Categorical Data with R* (1st ed.). Chapman and Hall/CRC. https://doi.org/10.1201/b17211

4. Harris, R., and Jarvis, C. (2011). *Statistics for Geography and Environmental Science* (1st ed.). Routledge. https://doi.org/10.4324/9781315847610
5. Gelfand, A.E., Fuentes, M., Hoeting, J.A., and Smith, R.L. (Eds.). (2019). *Handbook of Environmental and Ecological Statistics* (1st ed.). Chapman and Hall/CRC. https://doi.org/10.1201/9781315152509
6. Ott, W.R. (1995). *Environmental Statistics and Data Analysis* (1st ed.). Routledge. https://doi.org/10.1201/9780203756843
7. Plant, R.E. (2018). *Spatial Data Analysis in Ecology and Agriculture Using R* (2nd ed.). CRC Press. https://doi.org/10.1201/9781351189910
8. Qian, S.S. (2016). *Environmental and Ecological Statistics with R* (2nd ed.). Chapman and Hall/CRC. https://doi.org/10.1201/9781315370262
9. Qian, S.S., DuFour, M.R., & Alameddine, I. (2022). *Bayesian Applications in Environmental and Ecological Studies with R and Stan* (1st ed.). Chapman and Hall/CRC. https://doi.org/10.1201/9781351018784

COURSE NAME: RESEARCH METHODOLOGY AND COMMUNICATION
COURSE CODE: GMSE 7123
COURSE LEVEL: YEAR I SEMESTER II
CREDIT UNITS: 4

Brief Course Outline

Introduction to research and developing a research concept paper and a proposal. Developing a research instrument for field data collection, especially in surveys. Sampling techniques, data presentation and report writing. The course introduces students to various writing and publishing skills. The course describes scholarly writing in content and style. It gives an insight of writing ethics by avoiding plagiarism and its consequences. The course explains the basic components of an article. It introduces students to the skills of book and article reviews. The course provides guidelines of writing an article manuscript. It covers the skills of presenting an article in a conference before it is ready for publication. The course provides the processes of paper publication in referred journals.

Course Objectives:

The course aims to enable students to:

1. Develop in-depth knowledge of research designs and methodology
2. Critically review scientific literature and write a concept paper and research proposal
3. Conduct research studies in Environmental Science and Technology
4. Apply statistics concepts and principles of advanced linear models, including regression and non-linear associations in data handling.
5. Compile a dissertation and prepare articles for publication in peer review journals.

Learning Outcomes

Upon successful completion of the course, learners should be able to:

1. Explain the process of literature search and writing a research proposal
2. Design, execute, analyze and critique research in Environmental Science and Technology
3. Communicate research results in a scientific paper and research report
4. Critique other authors' academic works in order to compare and contrast differences of opinions in research studies.
5. Competently prepare and execute conference presentations.
6. Publish quality scholarly articles in refereed scientific journals.

Detailed Course Outline:

SN	Course Content	Duration
		CH
1	**Introduction.** Nature, types and functions of research; identifying research problems; statement of the problem; research design; literature search, concept and research proposal development. The use and access to various scientific sources of literature. The identification of current trends in environmental related issues and problems. The art of writing critical scientific reviews of earlier studies reported in journals and books. Citation of works, books, interviews, publications and unpublished works. Ethical issues in research.	**6**

2	**Proposal presentation**. Discussion of a research proposal. Power point presentations of scientific research proposals. Conducting or communicating in a seminar/presentation.	**6**
3	**Research design.** Design and implementation of quantitative and qualitative techniques including case study and precedent studies, surveys, interviews, focus groups, participant observation, textual and media analysis. Designs of experiments, principles of experimental design, randomized block design (RBD), Latin square design (LSD), missing plot technique in RBD and LSD, critical difference (CD), and split plot design. **Research instruments**. The questionnaire; open and closed ended questionnaires, developing a questionnaire and pre-testing a questionnaire.	**8**
4	**Sampling Techniques.** Planning and sampling protocol; concept of population and sampling procedures; fieldwork and laboratory work. Instruments for data collection. common sampling problems; documentation and reporting. **Data collection procedures.** data sources: primary and secondary sources; analysis of data; quality control; dissemination of research findings; ethical issues in research. Data treatment, analysis and data presentation. Graphic and statistical methods of data presentation	**8**
5	**Research dissemination.** Reports. Types of reports. Reports written as monographs and those written with appended publications. Publications. Conference papers. Poster presentations. Manuscripts for submission to Journal publication. Monographs; Title, Abstract, background, research problem, objectives, research questions/hypotheses, justification, literature review, methodology, results and discussions, conclusions and recommendations, references/bibliography.	**8**

6	**Scholarly Writing in content and style. Plagiarism (ethics of writing an academic paper).** Definition of plagiarism, Types of plagiarism (intentional and accidental), Consequences of plagiarism, Plagiarism and similarities. Detecting plagiarism using software. **Types of academic articles:** Research article, Theoretical/conceptual article **Basic components of an academic article:** Abstract, Introduction, Body, Suggestions & recommendations (if required by the journal), Conclusion. **Book or Article reviews:** Purpose of review (for publication, for academic purpose). Critiquing author's arguments, agreeing or disagreeing with the author, adding an idea to the article or subtracting an idea from the article/book. **Writing your article/report manuscript:** Purpose of writing (narrative, persuasive, informative or exposition, inspire), Guidelines of writing academic papers (styles of writing, use of proper language, use of appropriate punctuations, referencing using APA format), sources of writing materials (primary and secondary).	**8**
7	**Presentation of prepared article/report:** Nature of presentation - Oral presentation, Visual presentation; Types of presentation - Tutorial presentation (coursework & research students in the lecture room), Seminar presentation (research students in the department/auditorium), Conference presentation (submitting abstract, considering the conference theme in the abstract, stage/actual presentation, know the size of your audience). Poster presentation (poster designs); Practicing before presentation; Presentation format - Reading short scripted notes as a paper (use handouts), Reading long scripted notes as a paper (use handouts), Using PowerPoint presentation (overhead projectors)	**8**
8	**Scholarly Publication** **Publishing an academic paper/article/book:** Where to publish (book chapters, book reviews, journals, online publication, magazines), Ranking of journals and periodicals **Ranking of Journals:** Impact factor of a journal**,** Journal indexing by Scopus- Citation analysis under Education Research Abstracts- ERA-	**8**

	catalog of a Comprehensive database of selected high-quality abstracts), Journal indexing by Thomson and Reuters (Institute of Scientific Information (ISI) (Citation and measuring the importance of a journal). **Selecting the right and relevant academic journals for publication:** Area coverage and aims of the journal, Understanding Journal requirements and conditions of peer reviewing, Journal instructions and responses from peer review; acceptance, revision or rejection. **Co-authorship/joint publication.** **Online submission of an article for publication:** Stages and processes involved.	

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Reading List

1. Creswell, J. W. (2018) (5th Ed.). *Research design: Qualitative, quantitative and mixed methods approach*. ISBN: 978-1-5063-8670-6
2. Imam, E. (2021). *Basics Of Research Methodology*. NEW INDIA PUBLISHING AGENCY (NIPA).

3. Tan, W. (2017). *Research Methods*. World Scientific Publishing Company.
4. Robinson, E. (2016). *Data Analysis for Scientists and Engineers*. Princeton University Press.
5. Bailey, S. (2015). *The Essentials of Academic Writing for International Students* (1st Ed.). Taylor and Francis.
6. Brynard, D., Hanekom, S., and Brynard, P. (2014). *Introduction to Research 3*. Van Schaik Publishers.
7. Whong, M., and Godfrey, J., [ed]. (2020). *What is Good Academic Writing?* (1st Ed.). Bloomsbury Publishing.
8. Jones, S., Torres, V., and Arminio, J. (2021). *Negotiating the Complexities of Qualitative Research in Higher Education* (3rd Ed.). Taylor and Francis.
9. Harris, D. (2019). *Literature Review and Research Design* (1st Ed.). Taylor and Francis.
10. Williams, M., Wiggins, R., and Vogt, P. (2022). *Beginning Quantitative Research* (1st Ed.). SAGE Publications.

COURSE NAME: CLIMATE CHANGE MITIGATION AND ADAPTATION
COURSE CODE: GMSE 7124
COURSE LEVEL: YEAR I SEMESTER II
CREDIT UNITS: 3

Brief Course Description

Climate change and its effects are a major environmental concern today; this is particularly so for small island developing states in the Caribbean. This course will develop students' understanding of the nature of climate change and the strategies that can be used to mitigate its effects. The course will have two main units; the first will discuss the issues surrounding climate change, primarily the science behind climate change; the mechanisms that underpin the greenhouse effect, energy balances, molecular energy absorption by greenhouse gases, the sources of these gases and the general global effects of the global warming and how this translates into climate change. The consequences of climate change will be discussed, as well as the continuing debate on whether or not global warming/climate change are happening at all, or being caused by rising carbon dioxide

concentrations in the atmosphere. The second unit will introduce the mechanisms that are in use to mitigate the potential hazards of climate change. This will include legislative and technical efforts to reduce greenhouse gas emissions. The course will cover international agreements like the Kyoto Protocol, local and regional legislation, technological solutions, like alternative energy sources and strategies to reduce the current climate change impacts being experienced by some nations. The delivery of course materials would involve a combination of lectures, practicals, tutorials, and web-based materials. Assessments are designed to encourage students to work continuously with the course materials.

Course Objectives:

By the end of the course, learners should be able to:

1. Explain causes of global warming, as well as emission trends and driving forces that are responsible for fossil fuel emissions and deforestation.
2. Identify technological options to reduce emissions, their barriers and costs and co-benefits.
3. Discuss climate policy tools, their theoretical merits and practical experiences
4. Describe the understanding of climate mitigation in difference disciplines and the discipline's contribution to climate mitigation.
5. Distinguish co-benefits, tradeoffs, potentials, and limitations of a wide range of climate change mitigation options, from the energy to the land sector (including negative emission technologies and geoengineering).

Learning Outcomes

Upon successful completion, learners should be able to:

1. Analyse the fundament concepts of climate science and anthropogenic drivers of climate change
2. Synthesize climate change scenarios and their diverse implications
3. Provide guidance on the areas of relevance of the UNFCC and Kyoto protocol and how take advantage of the post-2020 climate change regime
4. Advocate for early preparation, planning and compliance for effective climate change adaptation
5. Undertake climate change adaptation and development planning

6. Justify the choice of international mechanisms for climate change mitigation and low carbon development
7. Advocate for integration of climate change into country planning processes.

Detailed Course Outline:

SN	Course Content	Duration
		CH
1	**Introduction** to climate change. Climate change and its effects are a major environmental concern today; this is particularly so for small island developing states in the Caribbean. The nature of climate change and the strategies that can be used to mitigate its effects. the issues surrounding climate change, primarily the science behind climate change. The fundament concepts of climate science and anthropogenic drivers of climate change	**10**
2	**Greenhouse effect.** The mechanisms that underpin the greenhouse effect, energy balances, molecular energy absorption by greenhouse gases, the sources of these gases and the general global effects of the global warming and how this translates into climate change.	**10**
3	**Issues of Climate change**. The issues surrounding climate change, primarily the science behind climate change; the mechanisms that underpin the greenhouse effect, energy balances, molecular energy absorption by greenhouse gases, the sources of these gases and the general global effects of the global warming and how this translates into climate change. Synthesize climate change scenarios and their diverse implications	**10**
4	**Consequences of climate change.** The consequences of climate change. The continuing debate on whether or not global warming/climate change are happening at all, or being caused by rising carbon dioxide concentrations in the atmosphere.	**10**

5	**Mechanisms in mitigation.** Introduce the mechanisms that are in use to mitigate the potential hazards of climate change. This will include legislative and technical efforts to reduce greenhouse gas emissions. The international agreements like the Kyoto Protocol, local and regional legislation, technological solutions, like alternative energy sources and strategies to reduce the current climate change impacts being experienced by some nations. The delivery of course materials would involve a combination of lectures, practicals, tutorials, and web-based materials. Assessments are designed to encourage students to work continuously with the course materials.	**10**
6	**Climate change adaptation.** Preparation, planning and compliance for effective climate change adaptation. Climate change adaptation and development planning The choice of international mechanisms for climate change mitigation and low carbon development. Integration of climate change into country planning processes.	**10**

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Reading List

1. Adger, W. N. (Ed.). (2006). *Fairness in adaptation to climate change*. MIT press.
2. Albanese, J.A.F., and Ruiz, M.P. (Eds.). (2015). *Climate Change Mitigation: Greenhouse Gas Reduction and Biochemicals* (1st ed.). Apple Academic Press. https://doi.org/10.1201/b18711
3. Craig, R. K. (2010). *Stationarity is Dead-Long Live Transformation: Five Principles for Climate Change Adaptation Law*. *Harv. Envtl. L. Rev.*, *34*, 9.
4. Eriksen, S., Aldunce, P., Bahinipati, C. S., Martins, R. D. A., Molefe, J. I., Nhemachena, C., and Ulsrud, K. (2011). *When not every response to climate change is a good one: Identifying principles for sustainable adaptation*. *Climate and Development*, *3*(1), 7-20.
5. Karl, T. R., and Trenberth, K. E. (2003). *Modern global climate change. science*, *302*(5651), 1719-1723.
6. Lemmen, D. S., and Warren, F. J. (2004). *Climate change impacts and adaptation:* a Canadian perspective.
7. Seinfeld, J. H., and Pandis, S. N. (2012). *Atmospheric chemistry and physics: from air pollution to climate change*. John Wiley & Sons.
8. Wilson, E., and Piper, J. (2010). *Spatial planning and climate change* (p. 445). London: Routledge.

YEAR 1; SEMESTER 2

ELECTIVES A. ENVIRONMENTAL MANAGEMENT AND TECHNOLOGY

COURSE NAME: Petroleum Waste Management

COURSE CODE: GMSE 7125

COURSE LEVEL: YEAR I SEMESTER II

CREDIT UNITS: 3

Brief Course Description

Petroleum is an energy source essential commodity that powers the ever-expanding global economy. However, petroleum exploration and production produce wastes which should be managed wisely so as to minimize environmental impacts that may be regional or global in scale, including air, water and soil pollution, global climate change, and oil spills. The petroleum reserves in Uganda are located in ecologically sensitive areas, raising concerns about the environmental impacts of generated wastes. Management of exploration and production wastes should occur in a manner that prevents releases of hazardous constituents to the environment, particularly releases that may impact groundwater and surface water resources. The major goal of this course is to equip students with skills to assess and manage wastes emanating from petroleum exploration.

Course Objectives

By the end of this course, learners should be able to:

1. Explain the role of petroleum in in economic development of a given country
2. Examine the impacts related to oil and exploitation and use on the environment (socio-economic and bio-physical)
3. Discuss the assessment and monitoring of wastes from exploration and use of petroleum
4. Review and infer the best-case scenarios for sustainable exploitation and use of energy sources

Learning Outcomes

Upon completion of this course, learners should be able to:

1. Explain processes involved in petroleum exploration and associated wastes
2. Discuss the impacts associated with petroleum exploration in Uganda and their mitigation

3. Discuss sustainable petroleum exploration and environmental management practices
4. Discuss best practices of managing petroleum wastes and how they can be replicated and up-scaled.
5. Explain the impacts of petroleum exploration and their use on the global climate

Detailed Course Outline

SN	Course Content	Duration
		CH
1	**Introduction** Petroleum is an energy source. It is an essential commodity that powers the ever-expanding global economy. Petroleum exploration conventional methods. The role of petroleum in economic development.	**8**
2	**Petroleum wastes.** Petroleum exploration and production and associated wastes. The environmental impacts of the petroleum wastes at regional or global scale; air, water and soil pollution. Association of global climate change and petroleum spills and usage. Environmental impacts associated with petroleum exploration in Uganda and how they can be enhanced or mitigated	**8**
3	**Environmental Impacts** Petroleum exploration and environmental management. The best practices of managing petroleum wastes and their replication and up-scaling. Environmental impacts of petroleum exploration and use on global climate	**9**
4	The petroleum reserves in Uganda are located in ecologically sensitive areas, raising concerns of the environmental impacts of generated wastes. Management of exploration and production of wastes. Reduction of the release of hazardous constituents to the environment.	**9**

5	Valuation of the environmental impacts of petroleum wastes release on soils, groundwater and surface water resources. Assessment of and management of oil and gas wastes due to petroleum exploration. Scientific management of oil and gas wastes.	**10**

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Reading List

1. EPA (2008). *An Assessment of the Environmental Implications of Oil and Gas Production: A Regional Case Study*. September 2008 Working Draft. U.S. Environmental Protection Agency
2. Ministry of Energy and Mineral Development (2011). *A National Communication Strategy for the Oil and Gas Sector in Uganda*. Kampala Uganda
3. Norwegian Ministry of Environment - The Oil for Development Programme, (2009). *Environmental Manual for petroleum activities*. Norad Petrad
4. Republic of Uganda (2011). *Environmental Management in Uganda's Oil and Gas Sector*
5. FAO (2011). *Environmental Impact Assessment: Guidelines for FAO Field Projects*. Rome Italy

6. Environmental Alert (2011). *Oil and gas laws in Uganda: A legislators' guide*. Oil Discussion Paper No. 1.
7. Ministry of Energy and Mineral Development (2008). *National Oil and Gas Policy for Uganda.* Kampala Uganda
8. NEMA (2006). *The National Environment (Audit) Regulations*, 2006 Statutory Instruments 2006 No. 12.
9. NEMA (2012). *The Environmental Monitoring Plan for the Albertine Graben 2012-2017*. Kampala National Environment Management Authority

COURSE NAME: ADVANCED ENVIRONMENTAL BIOTECHNOLOGY
COURSE CODE: GMSE 7126
COURSE LEVEL: YEAR I SEMESTER II
CREDIT UNIT: 3

Brief Course Outline

Basic techniques in genetic engineering: Nucleic acid hybridization and polymerase chain reaction as sensitive detention methods, Introduction of clone genes into new hosts using plasmid and phage vector systems. Expression of genes in new host, Use of micro-organisms in waste treatment and methane production, Production of microbial enzymes: cellulase, proteases, amylases, Alcohol and acetic acid production. Microbial leaching of low-grade mineral ores Molecular probes for organisms in mines and mine-tailings. Biodegradation of petroleum pollutants, Biofiltration technologies for pollution abatement, genetically engineered microbes and environmental risk
This course covers the application of biological processes in wastewater treatment and (to a lesser degree) drinking water treatment. This will include the different types of aerobic, anoxic and anaerobic biological processes that are used in wastewater treatments plants (WWTPs), how microbial populations contribute to the processes and the tools available to track these microbial populations. Students will learn how to use models to design wastewater treatment processes and will be introduced to new and upcoming aspects of sustainable WWTP design, such as resource

and energy recovery from sewage. There will also be an introduction to biological drinking water treatment, where microbial populations are utilized to produce potable water.

Course Objectives:

By the end of this course, learners should be able to:

1. Explain the importance of microbial physiology in bioreactor design;
2. Describe the major wastewater treatment process configurations for the removal of carbon, nitrogen and phosphorous from sewage;
3. Discuss the usage of activated sludge models for the design of aerobic processes in wastewater treatment;
4. Describe the potential of wastewater as a source of resources and energy;
5. Explain the use of biological processes for drinking water treatment.

Learning Outcomes

Upon successful completion, learners should be able to:

1. Describe the steps involved in DNA amplification during a PCR reaction;
2. Explain the application of molecular probes such as FISH in detecting biotechnologically relevant microbial taxa in environmental samples;
3. Explain the various processes through which biotechnologically relevant genes are introduced into a microbial species;
4. Describe how stable isotope probing can be applied to study biodegradation or biogeochemical processes in situ;
5. Describe how advanced sequencing technologies such as metagenomics, meta transcriptomics and proteomics can be used to elucidate microbial processes in environmental systems;
6. Explain the use of microorganisms in bioleaching as an eco-friendly metal extraction strategy;
7. Describe the various sources of enzymes such as laccases, monooxygenases, dioxygenases, peroxidases etc., used in bioremediation

Detailed Course Outline

SN	Course Content	Duration
		CH
1	**Introduction.** Environmental Biotechnology and Biotechnological Methods. Basic techniques in genetic engineering: Nucleic acid hybridization and polymerase chain reaction as sensitive detention methods, Introduction of clone genes into new hosts using plasmid and phage vector systems. Environment and Microbial forms (Algae, Fungi, Bacteria, Virus, Protozoa, worms and larvae). Lichens as biological monitoring agents. Biotechnological methods of pollution detection based on microbes, plants, animal, and molecular systems, biosensors. Biotechnological methods in pollution abatement, removal of phosphorus, metals with plants and microbes, cell immobilization in waste treatment, mutants for specific Waste Water. Introduction to Metagenome and Metaproteome.	**8**
2	**Expression of genes.** Expression of genes in new host, Use of micro-organisms in waste treatment and methane production. Techniques used in Genetic Engineering and GM organisms. Polymerase Chain Reaction (PCR) and Nucleic acid hybridization. Genetically modified organisms in biological treatment. Genetically modified crops – cotton, maize, paddy, brinjal. Use of Nucleic Acid waste and immunological methods for detection of specific groups of microorganism and genes. Production of microbial enzymes: cellulase, proteases, amylases, Alcohol and acetic acid production, Microbial leaching of low-grade mineral ores Molecular probes for organisms in mines and mine tailings,	**8**
3	Biodegradation of pollutants. Biodegradation of petroleum pollutants, Biofiltration technologies for pollution abatement, genetically engineered microbes and environmental risk. Genetically Engineered organisms in Biodegradation of Pollutants and ecofriendly bioproducts. Application of extremophiles (thermophiles, alkalophiles; acidophiles, halophiles and	**9**

	psychrophiles) in pollution studies. Production of enzymes like cellulase, proteases amylases in varied environmental conditions. Biotechnology in biodegradation, Bioremediation, Case studies for Bio-remediation with specific pollutant/compound.	
4	**Application of biological processes.** Application of biological processes in wastewater treatment and (to a lesser degree) drinking water treatment. The different types of aerobic, anoxic and anaerobic biological processes that are used in wastewater treatments plants (WWTPs). How microbial populations contribute to the processes and the tools available to track these microbial populations. Industrial applications of relevant aspects of biochemistry, plant and animal biotechnology; structural and molecular biology in biotechnology, microbial physiology, medical biotechnology and use of more economically significant processes like in pharmaceutical industry, fermentations and food production and processing.	**10**
5	**Modeling wastewater treatment processes.** Use models to design wastewater treatment processes and will be introduced to new and upcoming aspects of sustainable WWTP design, such as resource and energy recovery from sewage. There will also be an introduction to biological drinking water treatment, where microbial populations are utilized to produce potable water. Advanced biotechnological methods for Safe Environment, Genetically Engineered Microbes in Biotreatment of wastes, biosafety. Ecofriendly bio-products: Biopesticides, Biofertilizers Biodegradable Plastics. Biofuels: source and production technology of alcohols & biodiesel	**10**

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
	60%
Total	**100%**

Reading List

1. Centanni, J.M., and Roy, M.J. (2016). *Biotechnology Operations: Principles and Practices, Second Edition* (2nd ed.). CRC Press. https://doi.org/10.1201/9781315367750
2. Fowle, J.R. (Ed.). (1987). *Application Of Biotechnology: Environmental and Policy Issues* (1st ed.). Routledge. https://doi.org/10.4324/9780429042850
3. Fulekar, M.H. (2010). *Environmental Biotechnology* (1st ed.). CRC Press. https://doi.org/10.1201/b15412
4. Khan, F.A. (2016). *Biotechnology Fundamentals* (2nd ed.). CRC Press. https://doi.org/10.1201/9781315370767
5. Kumar, A., & Ram, C. (Eds.). (2021). *Nanobiotechnology for Green Environment* (1st ed.). CRC Press. https://doi.org/10.1201/9780367461362
6. Mondal, S., Pratap Singh, S., & Kumar Lahir, Y. (Eds.). (2022). *Emerging Trends in Environmental Biotechnology* (1st ed.). CRC Press. https://doi.org/10.1201/9781003186304
7. Roychoudhury, A. (Ed.). (2023). *Biology and Biotechnology of Environmental Stress Tolerance in Plants:* Volume 2: Trace Elements in Environmental Stress Tolerance (1st ed.). Apple Academic Press. https://doi.org/10.1201/9781003346203
8. Sanchez, G., and Hernandez, E. (Eds.). (1999). *Environmental Biotechnology and Cleaner Bioprocesses* (1st ed.). CRC Press. https://doi.org/10.1201/9781003417163
9. Sharma, N., Singh Sodhi, A., and Batra, N. (Eds.). (2021). *Basic Concepts in Environmental Biotechnology* (1st ed.). CRC Press. https://doi.org/10.1201/9781003131427

10. Show, P.L., Chai, W.S., and Ling, T.C. (Eds.). (2022). *Microalgae for Environmental Biotechnology: Smart Manufacturing and Industry 4.0 Applications* (1st ed.). CRC Press. https://doi.org/10.1201/9781003202196
11. Sibi, G. (2022). *Environmental Biotechnology: Fundamentals to Modern Techniques* (1st ed.). CRC Press. https://doi.org/10.1201/9781003272618

ELECTIVES B. ENVIRONMENTAL ANALYSIS AND DISASTERS MANAGEMENT

COURSE NAME: APPLIED SPATIAL ANALYSIS
COURSE CODE: GMSE 7127
COURSE LEVEL: YEAR I SEMESTER II
CREDIT UNITS: 3

Brief Course Description

This course is suitable for those with or without previous Geographical Information Systems (GIS) experience. The course is based on spatial (geographic) data, and how it can be utilised within a GIS environment. This includes the input, storage, and management of spatial data; analysing and modelling spatial data; and the various outputs (maps and charts) from a GIS. It illustrates the use of that data to solve real-world problems in a wide variety of applications. The coursework has a strong practical focus, and students will gain experience in field data collection, and the construction, manipulation, and interpretation of data in a GIS environment. Lectures provide the theoretical foundation of the principles behind the fundamental concepts of spatial analysis and mapping within a GIS. This includes the vector and raster data models; projections and coordinate systems; spatial analysis tools and methods; map design and spatial data visualisation techniques; where and how to source spatial data; data quality issues; and how GIS has been used in different industries and fields of research. Practical workshop sessions build on the content covered in lectures, guiding students in the development of increasingly sophisticated spatial analysis capabilities and the creation of high-quality maps, using commercial GIS software. Students will

learn how to interpret and present the results of spatial data analysis through high-quality technical reports. Students with existing skills in GIS analysis are encouraged to develop and apply data analysis techniques to propose, construct and carry out a major research project in an area of their own interest.

Course Objectives:

By the end of this course, learners should be able to:

1. Discuss the concept of GIS, Cartography and spatial analysis techniques and data.
2. Explain the principles of database management and systems planning, map formation and map projection.
3. Discuss the application of analytical functions of GIS software and ArcGIS in spatial data processing.
4. Validate the proficiency in integration of GIS data analysis and statistical analysis

Learning Outcomes

Upon successful completion, learners should be able to:

1. Discuss GIS concepts and spatial analysis techniques in an interdisciplinary setting;
2. Explain and employ source data in evidence-based decision making;
3. Demonstrate application of ArcGIS for spatial data preparation, analysis and visualization with sophisticated skills of vector and raster processing;
4. Demonstrate proficiency in integrating GIS data analysis with simple statistical analysis;
5. Formulate professional-standard GIS reports;
6. Demonstrate the ability to conduct a GIS research project in the area of their choice.

Detailed Course Outline

SN	Course Content	Duration
		CH
1	GIS concepts and spatial analysis techniques in an interdisciplinary setting; Source data in evidence-based decision making;	**8**
2	Application of ArcGIS for spatial data preparation, analysis and visualization with sophisticated skills of vector and raster processing; Geographical Information Systems (GIS). Spatial (geographic) data, and how it can be utilised within a GIS environment.	**9**
3	The input, storage, and management of spatial data; analysing and modelling spatial data; and the various outputs (maps and charts) from a GIS. Use of that data to solve real-world problems in a wide variety of applications. Practical focus and experience in field data collection, and the construction, manipulation, and interpretation of data in a GIS environment.	**9**
4	The theoretical foundation of the principles behind the fundamental concepts of spatial analysis and mapping within a GIS. The vector and raster data models; projections and coordinate systems; spatial analysis tools and methods; map design and spatial data visualisation techniques; where and how to source spatial data; data quality issues; and how GIS has been used in different industries and fields of research.	**9**
5	Practical workshop sessions. Increasingly sophisticated spatial analysis capabilities. Creation of high-quality maps, using commercial GIS software. Interpret and present the results of spatial data analysis through high-quality technical reports. Skills in GIS analysis. Development and application of data analysis techniques to propose, construct and carry out a GIS research project in an area of their own interest. Proficiency in integrating GIS data analysis with simple statistical analysis; Formulate professional-standard GIS reports	**10**

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Reading List

1. Heywood I., Cornelius S., and Carver S., (2011) *An Introduction to Geographic Information Systems* (4th Edition) Pearson Education Limited ISBN-13: 978 0 273 72259 5
2. Delaney J. and Van Niel K. (2007) *Geographical Information Systems* (2nd Edition) Oxford University Press ISBN-13: 978-0-195-55607-0
3. Longley P. A., Goodchild M.F., Maguire D.J. and Rhind D. W. (2015) *Geographic Information Science and Systems* (4th Edition) Wiley ISBN: 978-1-119-03130-7
4. Burrough P.A., McDonnell R., and Lloyd C. D. (2015) *Principles of Geographical Information Systems* (3rd Edition) Oxford UP ISBN: 9780198742845; 0198742843
5. O'Sullivan D. and Unwin D. J. (2010) *Geographic Information Analysis* (2nd edition) Wiley ISBN-13: 978-0-470-28857-3

COURSE NAME: SUSTAINABILITY AND DISASTER MANAGEMENT

COURSE CODE: GMSE 7128

COURSE LEVEL: YEAR I SEMESTER II

CREDIT UNITS: 3

Brief Course Description

Sustainability concept and sustainable development concept and the Sustainable Development Goals. Environmental issues and sustainability goals facing society today. Political, social and economic forces underlying environmental conflicts and exploring concrete approaches to address their causes. Extent and nature of natural hazards, Nature and extent of flood; environmental effects of flooding; flood mitigation methods, Landslides: causes, prevention and correction, Coastal hazards: tropical cyclone and tsunamis; coastal erosion; sea level changes and its impact on coastal areas, hurricanes and tsunami, Earthquakes: causes, intensity and magnitude of earthquakes, geographic distribution of earthquake zones, nature of destruction, protection from earthquake, Volcanism: nature, extent and causes of volcanism, geographic distribution of volcanoes, volcanism and climate, Disaster management Technologies: pre-disaster phase, actual disaster phase, post-disaster phase, Technological assistance for disaster management, Relief camps, organization, camp layout, food requirement, water needs, sanitation, security, information administration, Role of NGOs in disaster management.

Course Objectives:

By the end of this course, learners should be able to:

1. Explain the concepts of sustainable development, sustainability and disaster management
2. Discuss the Environmental management and innovation strategies for sustainable development;
3. Explain the political, social and economic forces underlying environmental conflicts
4. Describe the implications of Environmental Management and WTO regime
5. Discuss the legislations and policies associated with disasters and the tools for environmental management.
6. Discuss the types of disasters, disaster management and disaster management plan
7. Explain preparedness plan and managing natural disasters

Learning outcomes

Upon completion of this course, learners should be able to:

1. Discuss the sustainability concept and sustainable development concept
2. Discuss the Uganda Green Growth Development Strategy and the Sustainable Development Goals and the Environmental issues
3. Explain environmental management and innovation strategies for sustainable development
4. Discuss the causes, prevention and correction of natural disasters
5. Describe the types of disasters, disaster management and disaster management plan
6. Explore preparedness plans and management of natural and industrial disasters

Detailed Course Outline

SN	Course Content	Duration
		CH
1	Sustainability concept and sustainable development concept and the Sustainable Development Goals. Environmental issues and sustainability goals facing society today. Sustainable Development. History of the concept of sustainable development, and the key principles. Environmental degradation, poverty and sustainable development.	**8**
2	Political, social and economic forces underlying environmental conflicts and exploring concrete approaches to address their causes.	**5**
3	Extent and nature of natural hazards. Nature and extent of flood; environmental effects of flooding; flood mitigation methods, Landslides: causes, prevention and correction, Coastal hazards: tropical cyclone and tsunamis; coastal erosion; sea level changes and its impact on coastal areas, hurricanes and tsunami, Earthquakes: causes, intensity and magnitude of earthquakes, geographic distribution of earthquake zones, nature of destruction, protection from earthquake, Volcanism: nature, extent and causes of volcanism, geographic distribution of volcanoes, volcanism and climate.	**8**

4	Disaster management Technologies: pre-disaster phase, actual disaster phase, post-disaster phase, Technological assistance for disaster management, Relief camps, organization, camp layout, food requirement, water needs, sanitation, security, information administration, Role of NGOs in disaster management. Environmental management and innovation strategies for sustainable development. Governance for sustainable development. Policy responses to environmental degradation.	**8**
5	Implications of Environmental Management and WTO regime. WTO and formation of WTO. Tools for Environmental Management. Trade and environment in the WTO regime. Measures taken by WTO in trade affairs and improving environment. Environmental legislations, institutions and policies with special reference to Uganda.	**8**
6	Disaster Management. Disaster and Types of Disasters. Disaster Management and components of Disaster Management Plan – objective, emergencies organization, responsibilities, communication, facilities, action, information. Preparedness Plan – Occupational Health and Safety Review. Managing natural disasters- floods, earthquakes, tsunamis, volcanic eruptions, cyclones, forest fires. Managing Industrial Disasters	**8**

Mode of Delivery

The course is taught under the blended mode of learning by both physical and online lectures, multimedia, discussions, presentations, tutorials, practicals, fieldwork, attachments, conferencing, recordings and assignments.

Assessment

The course is assessed by assignments, tests and final examinations whose contributions are shown below:

Requirements	**Contribution**
Assignments	5%
Tests	10%
Practicals	25%
Final examination	60%
Total	**100%**

Reading List

1. Farley, H.M., and Smith, Z.A. (2020). *Sustainability: If It's Everything, Is It Nothing?* (2nd ed.). Routledge. https://doi.org/10.4324/9781351124928
2. Gopalakrishnan, C. (Ed.). (2016). *Designing Water Disaster Management Policies: Theory and Empirics* (1st ed.). Routledge. https://doi.org/10.4324/9781315680156
3. Jerolleman, A., and Kiefer, J.J. (Eds.). (2012). *Natural Hazard Mitigation* (1st ed.). CRC Press. https://doi.org/10.1201/b13673
4. Jerolleman, A., and Kiefer, J.J. (Eds.). (2015). *The Private Sector's Role in Disasters: Leveraging the Private Sector in Emergency Management* (1st ed.). CRC Press. https://doi.org/10.1201/b19315
5. Kapucu, N., and Boin, A. (Eds.). (2016). *Disaster and Crisis Management: Public Management Perspectives* (1st ed.). Routledge. https://doi.org/10.4324/9781315677545
6. Lindell, M. (Ed.). (2019). *The Routledge Handbook of Urban Disaster Resilience: Integrating Mitigation, Preparedness, and Recovery Planning* (1st ed.). Routledge. https://doi.org/10.4324/9781315714462
7. McNabb, D.E., and Swenson, C.R. (2022). *Disaster Management Policies and Practices: Multi-Sector Collaboration in Emergencies and Disasters* (1st ed.). Routledge. https://doi.org/10.4324/9781003310280
8. Merry, M.K. (2013). *Framing Environmental Disaster: Environmental Advocacy and the Deepwater Horizon Oil Spill* (1st ed.). Routledge. https://doi.org/10.4324/9780203110218

9. Nakanishi, H. (2022). *Disaster Resilience and Sustainability: Japan's Urban Development and Social Capital* (1st ed.). Routledge. https://doi.org/10.4324/9781003150190

YEAR 2; SEMESTERS 1 & 2

COURSE NAME: DISSERTATION
COURSE CODE: GMSE 7211
COURSE LEVEL: YEAR II SEMESTER I & II
CREDIT UNITS: 20

Brief Course Description

Each student shall be required to identify an environmental science related problem and design a simple research project to solve/mitigate it. The project should be simple but clear enough to engage the student in fieldwork, laboratory work, IT engagements and seminars/workshops among others. The course is activity intensive involving Proposal development and writing, Field work and Laboratory work, Data collection, Analysis and Presentation, Report Writing and Research Communication and dissemination of research findings, Viva Voce Examination.

Course Objectives

By the end of the course, learners should be able to:

1. Collaborate with colleagues at various levels of research;
2. Develop and write research proposals for funding;
3. Plan and execute field work to collect quality-assured representative environmental samples;
4. Perform quality-controlled laboratory analysis on either chemical or biological parameters depending on research objectives;
5. Conduct rigorous data analysis and presentation;
6. Disseminate research findings through high quality reports, dissertation, articles, and conference presentations;

7. Lead, supervise, and mentor lower-level students such as undergraduate students or staff at place of work.

Learning Outcomes

Upon completion of the course, learners should be able to:

1. Employ scientific research-based approaches to generate research evidence-based environmental solutions to societal problems.
2. Undertake cutting-edge research in the fields of environment science and technology to innovate technologies to solve environmental issues
3. Write award-wining grant proposals to fund research projects that address pertinent issues
4. Effectively communicate and translate scientific results to the public
5. Promote good environmental governance at local and global level.
6. Show capabilities and expertise in implementation of international standards
7. Illustrate environmental ethics and sound knowledge that promote usage of modern technologies to achieve environmental sustainability.

Detailed Course Outline

SN	Course Content	Duration
		CH
1	Each student shall be required to identify an Environmental Science related problem and design a research project to invent a practical solution through field work, laboratory work, artificial intelligence, information technology, modeling and simulation programmes, and analysis of data	**120**
2	The student shall present a written research proposal then be expected to go through the process of data collection, analysis and discussion.	**120**
3	Plan and execute field work to collect quality-assured representative environmental samples; Perform quality-controlled laboratory analysis on either chemical or biological parameters depending on research objectives;	**120**

	Lead, supervise, and mentor lower-level students such as undergraduate students or staff as research assistants.	
4	Conduct rigorous data analysis and presentation; Data analysis, data interpretation and compiling the final written report of between 5000-7000 words for the Degree. The report shall be submitted two weeks before the end of the second semester	**120**
5	Disseminate research findings through high quality reports, dissertation, articles, and conference presentations; Oral presentation preparation	**120**

Mode of Delivery

Each student has to undertake a supervised individual research project in third year in one of the areas covered in the syllabus. A minimum of five (5) contact hours will be spent on the project each weak for fifteen weeks.

The student will be required to draft a research proposal on a practical problem of interest to a supervisor (lecturer) and the student. The candidate will then embark of the research which will involve experimental design and data collection at the end of which a report is submitted by the student at least two weeks before the end of the second semester of the final academic year.

Assessment

The Research Project shall be assessed out of a maximum of 100 marks as follows:

Dissertations will be marked by;

Two Internal Examiners	(Average)	100%
One External Examiner		100%
Viva Voce Examination	(Average)	100%
Average Score in Research		**100%**

Reading List

1. Billups, F. D. (2019). Qualitative Data Collection Tools: Design, Development, and Applications. SAGE Publications, United States.
2. Creswell, J. W., Creswell, J. D. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE Publications, Germany.
3. Holland, B., Heiberger, R. M. (2013). Statistical Analysis and Data Display: An Intermediate Course with Examples in S-Plus, R, and SAS. Springer New York, United States
4. Mligo, E. S. (2016). Introduction to Research Methods and Report Writing: A Practical Guide for Students and Researchers in Social Sciences and the Humanities. Wipf and Stock Publishers, United Kingdom.
5. Park, K., Wang, G. T. (2016). Student Research and Report Writing: From Topic Selection to the Complete Paper. Wiley, Germany.
6. Weaver, P. F., Weaver, K. F., Dunn, S. L., Morales, V. C., Godde, K. (2017). An Introduction to Statistical Analysis in Research: With Applications in the Biological and Life Sciences. Wiley, United Kingdom.
7. Yanow, D., Schwartz-Shea, P. (2013). Interpretive Research Design: Concepts and Processes. Taylor & Francis, United Kingdom.

APPENDICES

Appendix A: List of Departmental Academic and Technical Staff

Staffing: The programme shall be managed and implemented by the staff of the Department of Environmental Science with the assistance of staff from the other Departments of the University.

LIST OF FULL TIME ACADEMIC STAFF						
SN	**Names**	**Gender**	**Highest Qualification**	**Year of qualification**	**Awarding institution**	**Area of Expertise**
1	Dr. Grace Kizito Bakyayita	M	D. Tech. & PhD	2022 & 2020	KTH and Makerere University	Land and Water Resources Eng. & Environmental Engineering

2	Dr. Alex Barakagira	M	PhD	2018	Nelson Mandela University	Environmental Geography
3	Dr. Mary T. Kaggwa	F	PhD	2013	University of Vienna	Aquatic Ecology
LIST OF PART TIME STAFF FROM OTHER DEPARTMENTS						
1	Dr. Gumula Ivan	M	PhD	2014	University of Nairobi	Natural Products / Organic Chemistry
2	Dr. Twinomuhwezi Hannington	M	PhD	2014	Makerere University	Analytical Chemistry, Natural Products Chemistry
3	Dr. Kodi Phillip	M	PhD	2018	Egerton University, Kenya.	Natural Products / Organic Chemistry
LIST OF PART-TIME STAFF IN THE DEPARTMENT						
1	Dr. Abiriga Daniel	M	PhD,	2021	Sorost Norway	Aquatic Ecology
2	Dr. Were David	M	PhD	2021	World Bank's ACEWM	Aquatic Ecosystem/Water Resources
3	Dr. Kinobe Joel	M	PhD	2015	SLU	Environmental Technology
LIST OF PART TIME TECHNICAL STAFF						
1	Mr. Opedun John	M	Msc	2019	Kyambogo University	Chemistry

Appendix B. Annual Budget Estimates

	Item	Rate	Qty	Frequency	Total
1	**Expected Income**				
	Tuition Fees (30 Students)				
	30 Students	4,000,000	30	2	240,000,000
	Sub Total 1				**240,000,000**

2	**Staff Remuneration**				
	2.1 Teaching Allowances	60,000	20x15 hrs	2	36,000,000
	2.2 Student Supervision	500,000	50	1	25,000,000
	2.3 Industrial Visits & Field Work	12,000,000	1	2	24,000,000
	2.4 Support Staff (Overtime)	50,000	40 hrs	2	4,000,000
	Sub Total 2				**89,000,000**
3	**Seminars, Workshops & Exhibitions**				
	3.1 For Lecturers	1,000,000	4	2	8,000,000
	3.2 For Students	500,000	5	2	5,000,000
	Sub Total 3				**13,000,000**
4	**Meeting Allowances**				
	4.1 Examination Invigilation	1,600,000	1	2	3,200,000
	4.2 Communication & Internet Costs	3,000,000		2	6,000,000
	4.3 Departmental Meetings	1,500,000	1	2	3,000,000
	Sub Total 4				**12,200,000**
5	**Instructional Materials**				
	5.1 Computer & Printer	15,500,000		1	15,500,000
	5.2 Ink Cartridges	400,000	2	2	1,600,000
	5.3 Assorted Stationary	2,000,000		2	4,000,000
	5.4 Consumables	2,000,000		2	4,000,000
	5.5 Apparatus	25,000,000		2	50,000,000
	5.6 Chemicals	15,000,000		2	30,000,000
	Sub Total 5				**105,100,000**
6	**Maintenance of Equipment**	2,500,000		2	5,000,000
	Sub Total 6				**5,000,000**
7	**Computer Software**				
	7.2 Computer Software	3,000,000		2	6,000,000

	Sub Total 7				**6,000,000**
8	**Other Expenses**				
	10.1 Welfare	3,000,000		2	6,000,000
	Sub Total 8				**6,000,000**
	TOTAL EXPENDITURE				**236,300,000**
	Expected Revenue (per annum)				**3,700,000**

APPENDIX C: Equipment List

EQUIPMENT FOR THE ENVIRONMENTAL CHEMISTRY LABORATORY

SNO	Equipment	Qty required	Unit price $ (USD)	Total price $ (USD)
	Weighing balances			
1	Ohaus Adventurer, 410 g, 10 mg resolution	1.0	1067	1067
2	Ohaus Adventurer, 4100 g capacity	1.0	1067	1067
3	Moisture analyser Ohaus MB-35 & MB-45	1.0	3072	3072
4	Centrifuge (Hettich EBA 20)	1.0	1352	1352
5	Minispin Plus Microcentrifuge	1.0	1722	1722
6	Electronic balance	1.0	777	777

	Centrifugation Tubes			
7	Corning centrifuge tubes (15 ml)	500 pcs		242
8	Corning centrifuge tubes (50 ml)	500 pcs		286
9	Microcentrifuge tubes (0.4-0.7 ml)	1000 pcs		41
10	Microcentrifuge tubes (1.0-2.0 ml)	1000 pcs		41
11	Microcentrifuge tubes (5 ml)	1000 pcs		71
12	Plastibrand Centrifuge tubes	50 pcs	12	600
13	Distilled water Unit	1.0	900	900
14	Direct-Q 3, 5, 8 Ultrapure Water	1.0	8320	8320
15	Conductivity meter	1.0	1120	1120
16	pH meters	2.0	1200	2400
17	Refractometer (top bench)	1.0	6486	6486
18	Electrophoresis system	1.0	1540	1540
19	Calorimeter	1.0	1700	1700
20	Density meter	1.0	403	403
21	Dissolved oxygen meter	1.0	1436	1436
22	Magnetic stirrers	1.0	562	562
23	Saccharometers	2.0	58	290
24	Hydrometers	10	58	580
25	Alcoholmeters	10	58	580
26	Melting point apparatus	1.0	1600	1600
27	Bullet stands	20.0	54	1080
28	Viscometer	4.0	400	1600
29	Fridge/freezer thermometer	2.0	5	10
30	Rotary evaporator	1.0	3100	3100
31	Vacuum oven	1.0	5870	5870
32	Muffle furnace	1.0	1912	1912
	Measuring Cylinders			
33	100ml	10.0	33	328
34	250ml	7.0	37	256
35	500ml	7.0	42	294
36	Kjeldhal digestion flasks	20.0	7	136

37	Micro & Macro kjeldhal distillation apparatus	2.0	280	560
38	UV/Visible spectrophotometer HR2000	1.0	12000	12000
	Accessories for the UV/Vis spectrophotometer			
39	Cuvettes (Eppendorf - UVette)	50	Estimate	500
40	Magnetic stirrer (IKA KMO2 basic)	1.0	650	650
41	Ion selective electrode (ISE Cl^-) electrode	1.0	889	889
42	Potentiostat/Galvanostat with EIS analyzer	1.0	18000	18000
43	Standard hydrogen electrodes (SHE)	2.0	87	174
44	Ag/AgCl reference electrodes	2.0	64	128
45	Standard Calomel electrodes (SCE)	2.0	234	468
46	Electrochemical cells	2.0	166	332
47	Glassy carbon electrodes	5.0	261	1305
48	Platinum working electrodes	2.0	750	1500
49	Gold working electrodes	2.0	680	1720
50	Digisim (Simulation of voltammetry)	1.0	2990	2990
51	Bulk electrolysis cell	1.0	1171	1171
52	Platinum auxiliary electrode (coiled)	1.0	434	434
51	Platinum auxiliary electrode (coiled)	1.0	254	254
	TOTAL			**95,916**

EQUIPMENT FOR THE ORGANIC AND INORGANIC LABORATORIES

SNO	**Equipment**	**Qty required**	**Unit price $ (USD)**	**Total price $ (USD)**
1	Plas-labs Basic multi-station glove box	1	11000	11000
2	Anti-static ionizer for Plas-Labs	1	650	650
3	Round bottom flasks with side port	20	60	1200
4	Conical reaction vials with cups	20	95	1900
5	Kjeldahl flasks with glass stopcock on side-arm	20		

	25 ml	10	85	850
	50 ml	10	91	910
	100 ml	10	98	980
6	Aldrich micro sublimation apparatus	5	309	1545
7	Aldrich modified sublimation apparatus	5	561	2805
8	Swiss Boy Lab jacks model 115 + plate	1	396	396
9	Swiss Boy Lab jacks model 116MS + plate	1	4164	4164
10	Swiss Boy Lab jacks model 118 + plate	1	1964	1964
11	Swiss Boy Lab jacks model 122MR	1	7420	7420
12	Vacuum equipment			
13	ACE Manifold with threaded stopcocks	1	3200	3200
14	Ace manifold with fire valve	1	2100	2100
15	Space saver vacuum manifold	1	1300	1300
16	Ace auto-zero Mcleod vacuum gauge	1	650	650
17	Schlaker Reaction Tubes			
	Aldrich-Schlaker reaction tubes – plain			
	Joint	5	141	705
	10 ml	5	146	730
	25 ml	5	158	790
	50 ml	5	161	850
	100 ml	2	182	364
	250 ml			
	Schlaker reaction tubes- screw-thread Joint	5	147	735
	10 ml	5	156	780
	25 ml	5	165	825
	50 ml	5	171	855
	100 ml	2	192	960
	250 ml			
18	Aldrich-reaction tubes (sealed tube reactions)			
	(a) Pyrex	20	47	940
	- 16 cm	20	51	1020
	- 32 cm			

	(b) Quartz - 32 cm	10	144	1440
19	Equipment for Air-Sensitive experiments - Cold trap for isothermic evaporation – female - Three-way adapters; male joints (14/20) female joints (14/20) - Addition funnel with Rotaflo stopcock - Filter funnel with dip-tip & 2 glass stop cocks -Filter funnel with dip-tip & 2 cocked side arms Schlenk-type adapters - 90^{o} bend with stopcock & hose barb, female J - 90^{o} bend with stopcock & hose barb, male J - 4-way adapters for solid transfer vessel male J	 5 5 2 5 5 2 2 2	 132 116 261 167 279 95 131 149	 660 580 522 1335 1395 190 262 298
20	Distillation/refluxing heads	5	206	1030
21	Storage bottles with septum inlet - 125 ml - 250 ml - 1000 ml	 10 5 5	 204 206 204	 2040 1030 1020
22	Deoxygenation apparatus	2	396	792
23	Sure/Stor Flasks - 25 ml (clear glass) - 50 ml (clear glass) - 100 ml (clear glass) - 250 ml (clear glass) - 1000 ml (clear glass) Sure/Stor adapters	 20 10 10 5 2	 266 258 264 324 309	 5320 2580 2640 1620 618

	- size 14/20	5	141	705
	- size 19/22	5	146	730
	- size 24/40	5	146	730
	- size 29/42	5	146	730
24	Balances			
	- Kern 442 series balance	1	134	134
	- Kern ABT analytical balance	1	3600	3600
	- Ohaus Discovery semi-micro analytical balance	1	5500	5500
25	Desiccators	1.0	350	700
26	Refrigerators	2.0	800	1600
27	Deep freezer	1.0	1037	1037
28	Shaking water baths	1.0	2800	2800
29	Oil bath –stainless steel	1.0	899	899
30	Jacketed beakers			
	- 50 ml	1	185	185
	- 100 ml	1	165	165
	- 400 ml	1	204	204
31	Aspirator bottles with tubulation	10	114	1140
32	Bubblers			
	- Ace mineral oil bubblers	5	81	405
	- Check-valve bubblers	5	224	1120
	- Check-valve bubblers + safetybarb	5	206	1030
	- Mini-gas bubblers	5	89	445
	- Mini-gas bubblers with safetybarb	5	81	405
	- In-line bubblers	5	104	520
	- Safety bubblers + safetybarb	5	183	915
	- Reverse-flow bubblers	5	194	970
	- Reverse-flow bubbler + safetybarb	5	170	850
33	CARTS			

	- Folding-handle platform carts - Rubbermaid heavy duty Lab carts	2 2	405 380	810 760
34	General-purpose stopcock	10	72	720
35	Dissolved oxygen meter	1	1200	1200
36	Stuart hotplate stirrers	2	1430	2860
37	IKA ETS temperature controller	2	360	720
38	Microscopes SFC5A (coarse & fine focusing)	10.0	750	7500
39	J-KEM temperature controller	2	1740	3480
40	Eppendorf Thermo-mixer	2	2520	5440
41	Microreactor Explorer kit	1	25050	25050
42	Ultrasonic cleaner (bath)	1	230	230
43	Ultrasonic processor (130 W)	1	4750	4750
44	Ultrasonic homogenizer (Bandelin SONOPULS)	1	6000	6000
45	Microscale glassware kits	5	350	1750
47	ACE gas-collecting tubes	10	330	3300
47	Ehlenmeyer flasks - 125 ml - 250 ml - 500 ml - 1000 ml	 10 10 10 5	 608 648 435 606	 6080 6480 4350 3030
48	Centrifuge (Hettich EBA 20)	1	1352	1352
49	Accessories (centrifugation tubes)	Estimated	2000	1000
50	Volumetric flasks 5ml 10ml 25ml	 100.0 100.0 100.0	 10 10 10	 1,000 1,000 1,000
51	Filter unit	1.0	103	103
52	Laminar flow chamber	1.0	2,500	2,500
53	Pipettes (programmable)	5.0	20	100

54	Flash chromatography assembly + accessories	2	2550	5100
55	TLC chamber + accessories	2	825	1650
56	Chromatography sprayers	5	220	1100
57	Distillation			
	- Air condensers	5	81	405
	- Allihn condensers	2	266	532
	- Coiled condensers –	2	297	594
	unjacketed	2	450	900
	- Coiled condensers - jacketed	2	402	804
	- Concentrator condenser head	2	1320	2640
	- Triple-Jacked coil condenser	2	465	930
	- Modified Davies condenser	2	686	1372
	- Dry ice condenser	2	243	486
	- Friedrich reflux condensers	2	174	348
	- Quick fit (Graham) condensers			
	Distillation heads	2	117	234
	- Quickfit Claisen head	2	239	478
	- Claisen distillation head	2	419	838
	- Fractional distillation head	2	760	1520
	- Water cooled distillation head	2	849	1698
	- Multi-purpose distillation head	2	599	1198
	- Normag reflux boiling spitter	2	1468	2936
	- Normag solvent recirculation	2	1588	3176
	still			
	- Aldrich micro distilling splitter	2	310	620
	head	2	672	1344
	Distillation traps	2	1288	2576
	- Two-piece vacuum trap	2	778	1556
	- Large capacity cold trap	2	943	1886
	- Dry ice chamber condenser-	2	580	1160
	trap	2	424	848
		2	696	1392

	- Cold-finger for high efficiency trap - Dewar for high efficiency cold-trap - Aldrich KOH & cold trap system - Double surface cold-trap - Dry ice condenser trap			
58	Electrophoresis unit + accessories	1	4000	4000
59	Soxhlet extractors + accessories	3	Estimated	4000
60	Liquid-liquid extraction systems + accessories	3	Estimated	6000
61	Rotary evaporator + accessories	2	Estimated	40000
62	Vacuum filtration units + accessories	5	Estimated	4000
63	Durham tubes	20.0	2	200
64	Serial dilution bottles	50.0	141	7,043
65	Anaerobic jars	1.0	1,000	1,000
66	Nicrome wire loops	100	5	500
67	Glass slides	10 sets	10	100
68	Cover slips	10sets	10	100
69	Funnel glass	10.0	2	20
70	Spirit lamp	20.0	5	100
71	Spatula	10.0	5	50
72	Mortar and pestle	10.0	45	145
73	Test tube racks	10.0	19	190
74	Test tubes	25.0	4	100
75	Measuring cylinders			
	10ml	50.0	10	500
	25ml	50.0	10	500
	50ml	50.0	10	500
	100ml	50.0	10	500
76	Wire gauze	10.0	2	20

77	Tripod stands	10.0	7	70
78	Bunsen burners	10.0	34	340
79	Shaker	1.0	954	954
	TOTAL			**309,297**

EQUIPMENT FOR ENVIRONMENTAL MICROBIOLOGY LABORATORY

SNO	**EQUIPMENTS**	**QUANTITY REQUIRED**	**UNIT PRICE IN USD**	**TOTAL PRICE IN USD**
1	Desiccators	1.0	250	250
2	Refrigerator	1.0	400	400
3	Deep freezer	1.0	1,037	1,037
4	Water bath	2.0	200	400
5	Microscopes SFC5A (coarse & fine focusing)	10.0	750	7,500
6	Petridishes	100.0	10	1,019
7	Petri racks	5.0	44	222
8	Petri box	5.0	77	386
	Volumetric flasks			
9	5ml	100.0	10	1,000
10	10ml	100.0	10	1,000
11	25ml	100.0	10	1,000
12	Filter unit	1.0	103	103
13	Laminar flow chamber	1.0	2,500	2,500
14	Pipettes (programmable)	5.0	20	100
15	Colony counter	3.0	100	300
16	Gas cooker	1.0	400	400
17	Durham tubes	20.0	2	200
18	Serial dilution bottles	50.0	141	7,043
19	Anaerobic jars	1.0	1,000	1,000
20	Nicrome wire loops	100	5	500
21	Glass slides	10 sets	10	100

22	Cover slips	10sets	10	100
23	Funnel glass	10.0	2	20
24	Spirit lamp	20.0	5	100
25	Spatula	10.0	5	50
26	Mortar and pestle	10.0	45	145
27	Test tube racks	10.0	19	190
28	Test tubes	25.0	4	100
	Measuring cylinders			
29	10ml	50.0	10	500
30	25ml	50.0	10	500
31	50ml	50.0	10	500
32	100ml	50.0	10	500
33	Wire gauze	10.0	2	20
34	Tripod stands	10.0	7	70
35	Bunsen burners	10.0	34	340
36	Shaker	1.0	954	954
	TOTAL			**30,550**