Far Western University

Faculty of Science and Technology

Course of Study for

MASTER'S DEGREE IN ENVIRONMENTAL SCIENCE AND MANAGEMENT

Prepared by

Curricula Development Task Force

2025

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Prepared by

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2025

Acknowledgements

The Faculty of Science and Technology (FoST), Far Western University (FWU) has prepared the curriculum for the MSc in Environmental Science and Management in accordance with the university's established guidelines and procedures. This achievement is the outcome of the dedicated efforts of the Task Force Committee Members, Prof. Emeritus Dr. P.K. Jha, Prof. Dr. Jiba Raj Pokhrel, Prof. Dr. Narendra Raj Khanal, Dr. Sanjeev Kumar Rai, Dr. Tista Prasai Joshi, Dr. Ramesh Prasad Sapkota and Dr. Ramesh Raj Pant, together with subject experts and teaching faculty with long experience on teaching and research. Their commitment and hard work have been instrumental in shaping the curriculum in this present form. I extend my sincere gratitude to all task force members, faculty colleagues, and subject experts for their unwavering dedication throughout this process. I am also deeply appreciative of the valuable feedback provided by colleagues from Tribhuvan University, the Government of Nepal, and the Nepal Academy of Science and Technology (NAST), whose contributions greatly enriched the curriculum.

My heartfelt thanks go to the Vice-Chancellor, Prof. Dr. Hem Raj Pant; Registrar, Prof. Dr. Binod Lekhak; former Dean, Prof. Dr. Bhawani Chand Thakuri, all the subject committee members (Prof. Dr. Man Dev Bhatta, Dr. Bhoj Raj Pant, Mr. Mahendra Bahadur Chand, Mr. Pushkar Bhatta, Mr. Dipak Singh Thapa, Mr. Prakash Pant, Dr. Ramesh Raj Pant, Mr. Krishna Prasad Pant and Mr. Tark Raj Joshi); Mr. Yagya Raj Joshi (HoD); Mr. Mahesh Prasad Awasthi and other stakeholders of FWU for their continued support. I also acknowledge the insights and recommendations offered by individuals from both government and non-government agencies, which helped ensure that the curriculum addresses contemporary needs in the field. I would also like to acknowledge the contributions of Ms. Rachana Jha and Ms. Rezina Shanker during the curriculum development process. Finally, I would like to recognize the contributions of the expert committee members listed in Annex I of this syllabus.

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Prem Singh Saud, PhD

Dean, FoST

Date:

Introduction

The Faculty of Science and Technology (FoST), Far Western University (FWU) has introduced the MSc in Environmental Science and Management program, to be launched at the Central Campus, Mahendranagar, Kanchanpur, Nepal. This program is designed to produce competent environmental scientists and managers capable of addressing environmental challenges at local, national, and global levels. The curriculum has been prepared in line with the university's guidelines and has incorporated contemporary demands of the environmental sector, ensuring that graduates are equipped with both theoretical knowledge and practical skills.

The MSc in Environmental Science and Management is interdisciplinary in nature. It provides students with a scientific understanding of environmental systems and equips them to contribute effectively in decision-making processes through analytical and integrative approaches. The MSc in Environmental Science and Management program ensures a balanced education that integrates theory, practical, and research. With specialization options in Disaster Risk Management, Natural Resource Management, and Environmental Resilience and Management, the program prepares graduates to address complex environmental challenges through interdisciplinary approaches and to contribute meaningfully to sustainable development.

Program Objectives

- Enhance scientific understanding of contemporary environmental issues.
- Build foundations for research, including field-based learning in environmental data collection and management.
- Develop problem-solving, innovative and decision-making skills to address complex environmental challenges.
- Analyze policy formulation and implementation processes to promote environmental sustainability.

Program Structure

The MSc program spans two academic years (four semesters), with a total of 64 credits and 1,680 lectures/contact hours, evaluated through 1,600 marks. The curriculum combines compulsory and elective courses, practical classes, seminars, internships, and dissertation work.

Semester I (18 credits): Core foundation courses are Ecology and Ecosystem Dynamics, Environmental Earth Sciences, Environmental Chemistry and Toxicology, Meteorology and Hydrology, and Global Environmental Change and Sustainability. Practical modules are integrated with these subjects to provide hands-on field-based learning.

Semester II (18 credits): Advanced courses include Energy, Society and Sustainability, Environmental Economics, Geospatial Analysis, Environmental Assessment and Mitigation, Environmental Policy and Governance, and Research Methodology. Practical modules, seminars, and term papers are included to strengthen applied learning.

Semester III (18 credits): Compulsory courses providing specialized courses are Environmental Modeling, Applied Statistics, Research Proposal and Academic Writing and specialization subjects, including case studies in each specialized course:
Group A: Disaster Risk Management (DRM): Courses on Disaster Types, Preparedness, Response, Reconstruction, and Legal Frameworks.
Group B: Natural Resource Management (NRM): Courses on Biological, Agricultural, Watershed, Land, Soil, and Mineral Resource Management.
Group C: Environmental Resilience and Management (ERM): Courses on Pollution Control, Climate Resilience, Waste Management, and Ecological Restoration.

Each specialization includes theory, practical, and project work.

Semester IV (10 credits): Research-focused courses: The research-focused courses are Internship and Dissertation. The internship fosters professionalism, while the dissertation involves independent research and submission of comprehensive dissertation report.

Course Structure

Papers	Number of Papers					Credit				
	Sem I	Sem II	Sem III	Sem IV	**Total**	Sem I	Sem II	Sem III	Sem IV	**Total**
Theory (Compulsory)	5	6	3	0	**14**	14	12	6	0	**32**
Theory (Specialized)	0	0	4	0	**4**	0	0	8	0	**8**
Practical	4	3	0	0	**7**	4	3	0	0	**7**
Term Paper and Seminar	0	3	0	0	**3**	0	3	0	0	**3**
Case Study	0	0	4	0	**4**	0	0	4	0	**4**
Internship	0	0	0	1	**1**	0	0	0	2	**2**
Dissertation	0	0	0	1	**1**	0	0	0	8	**8**
Grand Total	**9**	**12**	**11**	**2**	**34**	**18**	**18**	**18**	**10**	**64**

Papers	Lecture Hours/ Contact Hours					Full Marks				
	Sem I	Sem II	Sem III	Sem IV	**Total**	Sem I	Sem II	Sem III	Sem IV	**Total**
Theory (Compulsory)	210	180	90	0	**480**	350	300	150	0	**800**
Theory (Specialized)	0	0	120	0	**120**	0	0	200	0	**200**
Practical Application	180	135	0	0	**315**	100	75	0	0	**175**
Term paper and Seminar	0	135	0	0	**135**	0	75	0	0	**75**
Case Study	0	0	180	0	**180**	0	0	100	0	**100**
Internship	0	0	0	90	**90**	0	0	0	50	**50**
Dissertation	0	0	0	360	**360**	0	0	0	200	**200**
Grand Total	**390**	**450**	**570**	**450**	**1680**	**450**	**450**	**450**	**250**	**1600**

Eligibility and Admission Criteria

Candidates seeking admission to the MSc in Environmental Science and Management (ESM) must hold a Bachelor's degree in Environmental Science, Environmental Management, Environmental Engineering, Civil Engineering, Forestry, Agriculture, or a Bachelor of Science in any subject or any other equivalent qualification recognized by FWU. A minimum of second division, or equivalent grade is required for eligibility. All applicants are required to appear and successfully pass the entrance examination conducted by FWU. Admission is granted strictly on a merit basis, ensuring transparency and fairness in the selection process.

Medium of Instruction

English

Duration

Four semesters completed in two academic years.

Hours of Instruction

Working Days : 90 days per semester
Total Credits : 64
Teaching Hours : 1680
Full Marks : 1600

Theory

One credit is equivalent to 15 lecture hours and 25 marks. One theory paper of one credit will have one hour of lecture per week.

Practical/Research Work

One credit is equivalent to 45 lecture hours (laboratory hours or research work including field work) and 25 marks. One practical paper of one credit will have three hours of practical per week.

Evaluation

Students must obtain pass grades in both theory and practical subjects separately to be eligible for the degree. Each semester will include an internal examination carrying 40% of the total marks. The modalities of internal evaluation may include paper reviews, seminar presentations, assignments, field work and report preparation, and/or internal written examinations. Students are required to appear in and secure pass marks in the internal examination to qualify for the final examination. FWU will conduct the final examination, which carries 60% of the total marks. Internal examinations will be administered by the respective departments/campuses, while the final examination will be conducted by the Controller of Examinations, FWU. The grading of students' performance in each subject will be determined in accordance with FWU regulations. At present, the grading system including grades, GPA, and percentage equivalents is as follows:

Grade	GPA	% Equivalent
A	4	90 and above
A^-	3.7	80 to < 90
B^+	3.3	70 to < 80
B	3	60 to < 70
B^-	2.7	50 to < 60
F	0	Below 50

SEMESTER I

Course Title: Global Environmental Change and Sustainability **Credit Hours: 2**

Course Code: ESM 511 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Foundations of Sustainability Science	5
2.	Drivers of Environmental and Economic Change	10
3.	Environmental Communication	5
4.	Key Environmental Movements	5
5.	Policies and Governance	5
Total		30

Course Title: Ecology and Ecosystem Dynamics **Credit Hours: 3**

Course Code: ESM 512 **Lecture Hours: 45**

Nature of Course: Theory (Compulsory) **Full Marks: 75**

SN	Unit	Lecture Hours
1.	Introduction to Ecology	5
2.	Population Ecology	7
3.	Community Ecology	8
4.	Ecosystem Processes and Energy Flow	10
5.	Ecosystem Dynamics and Human Impacts	10
6.	Research Methods and Field Applications	5
Total		45

Course Title: Ecology and Ecosystem Dynamics **Credit Hour: 1**

Course Code: ESM 516 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Course Title: Environmental Earth Science **Credit Hours: 3**

Course Code: ESM 513 **Lecture Hours: 45**

Nature of Course: Theory (Compulsory) **Full Marks: 75**

SN	Unit	Lecture Hours
1.	Atmosphere and Climate Science	10
2.	Hydrological Processes	10
3.	Earth Science and Plate Tectonics	5
4.	Crystallography and Mineralogy	5
5.	Geological Processes	5
6.	Earth Hazards	10
Total		45

Course Title: Environmental Earth Sciences **Credit Hour: 1**

Course Code: ESM 517 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Course Title: Environmental Chemistry and Toxicology **Credit Hours: 3**

Course Code: ESM 514 **Lecture Hours: 45**

Nature of Course: Theory (Compulsory) **Full Marks: 75**

SN	Unit	Lecture Hours
1.	Atmospheric Chemistry	5
2.	Hydrospheric Chemistry	5
3.	Lithospheric Chemistry	5
4.	Biospheric Chemistry	5
5.	Principles of Environmental Toxicology	5
6.	Toxicogenic Pollutants in Environment	5
7.	Environmental Toxins and Human	10
8.	Toxicological Risk Assessment	5
Total		45

Course Title: Environmental Chemistry and Toxicology **Credit Hour: 1**

Course Code: ESM 518 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Course Title: Meteorology and Hydrology **Credit Hours: 3**

Course Code: ESM 515 **Lecture Hours: 45**

Nature of Course: Theory (Compulsory) **Full Marks: 75**

SN	Unit	Lecture Hours
1.	Atmospheric Physics	8
2.	Atmospheric Dynamics, Monsoon and Weather Systems	7
3.	Hydrological Cycle and Watershed Water Balance	5
4.	Precipitation, Snow Processes, and Evapotranspiration	5
5.	Surface and Groundwater Processes and Flood Hydrology	5
Total		30

Course Title: Meteorology and Hydrology **Credit Hour: 1**

Course Code: ESM 519 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

SEMESTER II

Course Title: Energy, Society and Sustainability **Credit Hour: 2**

Course Code: ESM 521 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Introduction to Energy and Society	6
2.	Energy Resources and Technologies	6
3.	Energy, Environment and Climate	6
4.	Energy Economics and Policy	6
5.	Sustainable Energy Transitions and Social Dimensions	6
Total		30

Course Title: Energy, Society and Sustainability	**Credit Hour: 1**
Course Code: ESM 527	**Lecture Hours: 45**
Nature of Course: Term Paper and Seminar (Compulsory)	**Full Marks: 25**

Course Title: Environmental Economics	**Credit Hour: 2**
Course Code: ESM 522	**Lecture Hours: 30**
Nature of Course: Theory (Compulsory)	**Full Marks: 50**

SN	Unit	Lecture Hours
1.	Introduction to Resource Economics	5
2.	Environmental Sustainability	5
3.	Ecosystem Services and Markets	5
4.	Benefit–Cost Analysis (BCA)	5
5.	Economic Valuation of Environmental Goods and Services	10
Total		30

Course Title: Environmental Economics	**Credit Hour: 1**
Course Code: ESM 528	**Lecture Hours: 45**
Nature of Course: Term Paper and Seminar (Compulsory)	**Full Marks: 25**

Course Title: Geospatial Analysis	**Credit Hour: 2**
Course Code: ESM 523	**Lecture Hours: 30**
Nature of Course: Theory (Compulsory)	**Full Marks: 50**

SN	Unit	Lecture Hours
1.	Introduction to Geospatial Science and Technology	8
2.	Geographical Data Source, Creation and Model	8
3.	Geospatial Analysis Techniques and Interpolation	7
4.	Geospatial Data Visualization and Map Output	7
Total		30

Course Title: Geospatial Analysis **Credit Hour: 1**

Course Code: ESM 529 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Course Title: Environmental Assessment and Mitigation **Credit Hour: 2**

Course Code: ESM 524 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Fundamentals of Environmental Assessment	5
2.	Methodologies for Baseline Data Collection and Impact Assessment	8
3.	Environmental Management and Mitigation	7
4.	Monitoring and Auditing	5
5.	Governance, Grievance and Redress Mechanisms	5
Total		30

Course Title: Environmental Assessment and Mitigation **Credit Hour: 1**

Course Code: ESM 530 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Course Title: Environmental Policy and Governance **Credit Hour: 2**

Course Code: ESM 525 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Fundamentals of Public Policy	6
2.	Environmental Policy and Governance in Nepal	6
3.	Global Perspectives on Environmental Governance	6
4.	Environmental Diplomacy and Justice	6
5.	Harmonization and Case Studies	6
Total		30

Course Title: Environmental Policy and Governance	**Credit Hour: 1**
Course Code: ESM 531	**Lecture Hours: 45**
Nature of Course: Term Paper and Seminar	**Full Marks: 25**

Course Title: Research Methodology	**Credit Hour: 2**
Course Code: ESM 526	**Lecture Hours: 30**
Nature of Course: Theory (Compulsory)	**Full Marks: 50**

SN	Unit	Lecture Hours
1.	Scientific reasoning	8
2.	Research Problem Identification	7
3.	Sampling Design	10
4.	Writing Research Report	5
Total		30

Course Title: Research Methodology	**Credit Hour: 1**
Course Code: ESM 532	**Lecture Hours: 45**
Nature of Course: Practical (Compulsory)	**Full Marks: 25**

SEMESTER III

Course Title: Environmental Modeling	**Credit Hour: 2**
Course Code: ESM 631	**Lecture Hours: 30**
Nature of Course: Theory (Compulsory)	**Full Marks: 50**

SN	Unit	Lecture Hours
1.	Hands-on Training with GIS and RS	5
2.	Training in Species Distribution Modeling	5
3.	Land Use and Climate Change Modeling	5
4.	Model Evaluation and Uncertainty Analysis	5
5.	Project Work	10
Total		30

Course Title: Applied Statistics **Credit Hour: 2**

Course Code: ESM 632 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Data and Distributions	5
2.	Sampling and Estimation	5
3.	Hypothesis Testing Methods	10
4.	Correlation and Regression	10
Total		30

Course Title: Research Proposal and Academic Writing **Credit Hour: 2**

Course Code: ESM 633 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Literature Review and Research Idea Framing	5
2.	Research Design and Proposal Writing	15
3.	Manuscript Writing and Publication	5
4.	Seminars	5
Total		30

Group A: Disaster Risk Management (DRM)

Course Title: Disaster Types and Principles of Disaster Risk Management

Credit Hour: 2

Course Code: ESM 634 DT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

SN	Unit	Lecture Hours

1.	Disaster Classification	6
2.	Disaster Terminology and Principles	6
3.	Hazard and Vulnerability	6
4.	Earthquake Vulnerability and Risks	7
5.	Disaster Impact and Resilience	5
Total		30

Course Title: Disaster Types and Principles of Disaster Risk Management

Credit Hour: 1

Course Code: ESM 634 DP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Course Title: Disaster Science and Laboratory **Credit Hour: 2**

Course Code: ESM 635 DT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Earthquake	8
2.	Flood	8
3.	Landslide	6
4.	Fire and Winds	8
Total		30

Course Title: Disaster Science and Laboratory **Credit Hour: 1**

Course Code: ESM 635 DT **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Course Title: Disaster Preparedness and Response **Credit Hour: 2**

Course Code: ESM 636 DT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Fundamentals of Disaster Preparedness	6
2.	Emergency Response Systems	6
3.	Community-Based Disaster Preparedness	6
4.	Resource Mobilization and Coordination	6
5.	Resilience and Sustainable Recovery	6
Total		30

Course Title: Disaster Preparedness and Response **Credit Hour: 1**

Course Code: ESM 636 DP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Course Title: Disaster Reconstruction and Legal Framework **Credit Hour: 2**

Course Code: ESM 637 DT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Concepts of Disaster Reconstruction	6
2.	Legal Frameworks for Disaster Management	6
3.	Institutional Arrangements and Policies	6
4.	Reconstruction Strategies and Practices	6
5.	Challenges and Future Directions	6
Total		30

Course Title: Disaster Reconstruction and Legal Framework **Credit Hour: 1**

Course Code: ESM 637 DP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Group B: Natural Resources Management

Course Title: Natural Resources and Management Systems **Credit Hour: 2**

Course Code: ESM 634 NT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Conceptual Issues and Approaches	6
2.	Classification and Principles of Conservation	6
3.	Human Population and Land Resources	6
4.	Wetlands and their Management	6
5.	Governance and Sustainable Resource Management	6
Total		30

Course Title: Natural Resources and Management Systems **Credit Hour: 1**

Course Code: ESM 634 NP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Course Title: Biological and Agricultural Resources Management **Credit Hour: 2**

Course Code: ESM 635 NT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Biodiversity and Biological Resources	6
2.	Agricultural, Fisheries and Livestock Resources	6
3.	Forest and Wildlife Resources	6
4.	Medicinal, Aromatic and Horticultural Resources	6
5.	Biotechnology, Product Processing and Marketing Strategies	6
Total		30

Course Title: Biological and Agricultural Resources Management **Credit Hour: 1**

Course Code: ESM 635 NP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Course Title: Watershed and Water Resources Management **Credit Hour: 2**

Course Code: ESM 636 NT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Water Resources as a Component of Environment	5
2.	Monitoring, Data Management and Analysis	5
3.	Water Resources Management Approaches	7
4.	Water Security in the Changing Climate	8
5.	Water Resources Governance	5
Total		30

Course Title: Watershed and Water Resources Management **Credit Hour: 1**

Course Code: ESM 636 NP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Course Title: Land and Mineral Resources Management **Credit Hour: 2**

Course Code: ESM 637 NT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Foundations of Land Resource Management	6
2.	Human Impacts and Land Degradation	6
3.	Land Evaluation and Planning Frameworks	6
4.	Sustainable Land and Urban Management	6
5.	Mineral Resources and Sustainable Mining	6
Total		30

Course Title: Land and Mineral Resources Management	**Credit Hour: 1**
Course Code: ESM 637 NP	**Lecture Hours: 45**
Nature of Course: Case study	**Full Marks: 25**

Group C: Environmental Resilience and Management

Course Title: Environmental Pollution and Control	**Credit Hour: 2**
Course Code: ESM 634 ET	**Lecture Hours: 30**
Nature of Course: Theory (Specialization)	**Full Marks: 50**

SN	Unit	Lecture Hours
1.	Air Pollution	7
2.	Water Pollution	8
3.	Soil Pollution	5
4.	Solid Waste Pollution	5
5.	Noise Pollution	5
Total		30

Course Title: Environmental Pollution and Control	**Credit Hour: 1**
Course Code: ESM 634 EP	**Lecture Hours: 45**
Nature of Course: Case study	**Full Marks: 25**

Course Title: Climate Change and Resilience **Credit Hour: 2**

Course Code: ESM 635 ET **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Climate System and Modeling	5
2.	Future Climate Change Scenarios and Projections	5
3.	Climate Resilience and Adaptation Frameworks	5
4.	Mitigation Strategies and Human Dimensions	5
5.	Climate Agriculture Interactions and Hydroclimatic Disasters	5
6.	Climate Change Governance and Policy Frameworks	5
Total		30

Course Title: Climate Change and Resilience **Credit Hour: 1**

Course Code: ESM 635 EP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Course Title: Solid and Hazardous Waste Management **Credit Hour: 2**

Course Code: ESM 636 ET **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

SN	Unit	Lecture Hours
1.	Fundamentals of Waste	5
2.	Municipal Solid Waste	5
3.	Hazardous and Specialized Wastes	5
4.	Waste Management Practices and Technologies	5
5.	Waste Valorization and Sustainable Materials Management	5
6.	Waste Handling Rules and Regulations	5
Total		30

Course Title: Solid and Hazardous Waste Management	**Credit Hour: 1**
Course Code: ESM 636 EP	**Lecture Hours: 45**
Nature of Course: Case study	**Full Marks: 25**

Course Title: Ecosystem Restoration and Resilience	**Credit Hour: 2**
Course Code: ESM 637 ET	**Lecture Hours: 30**
Nature of Course: Theory (Specialization)	**Full Marks: 50**

SN	Unit	Lecture Hours
1.	Fundamentals of Ecosystem Restoration	6
2.	Ecological Attributes	6
3.	Restoration Approaches and Techniques	6
4.	Infrastructure Development and Ecosystem Restoration	6
5.	Global and National Initiatives	6
Total		30

Course Title: Ecosystem Restoration and Resilience	**Credit Hour: 1**
Course Code: ESM 637 EP	**Lecture Hours: 45**
Nature of Course: Case study	**Full Marks: 25**

SEMESTER IV

Course Title: Internship	**Credit Hour: 2**
Course Code: ESM 641	**Lecture Hours: 90**
Nature of Course: Research (Compulsory)	**Full Marks: 50**

Course Title: Dissertation	**Credit Hour: 8**
Course Code: ESM 642	**Lecture Hours: 360**
Nature of Course: Research (Compulsory)	**Full Marks: 200**

SEMESTER I

Fundamental Theory and Practical Courses

Course Title: Global Environmental Change and Sustainability **Credit Hours: 2**

Course Code: ESM 511 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

Introduction

This course is designed to analyze the dynamic relationship between human societies and the changing global environment, with a focus on sustainability as both a scientific and practical pursuit. Sustainability science has emerged as an interdisciplinary field that integrates environmental science, ecology, economics, and social dimensions to address complex challenges such as climate change, biodiversity loss, and resource management. The course emphasizes resilience, systems thinking, and the science–policy interface as guiding principles for sustainable pathways. The course highlights the linkages between human well-being and ecological integrity, recognizing that sustainable futures depend on balancing prosperity with environmental stewardship. Nepal's diverse ecosystems, from the Himalayas to the Terai, offer a unique natural laboratory for understanding the human–nature nexus in a rapidly changing global context. Students will be introduced to the foundations of sustainability science, the drivers of environmental and economic change, and the role of communication, governance, and social movements in shaping sustainable development. Ethical and regulatory frameworks, along with practical tools for assessment and policy integration, will prepare students to critically engage with sustainability challenges and opportunities at local, regional, and global scales.

Objectives

After completion of the course, students will be able to:

- Understand the foundations of sustainability science, global environmental change, resilience, and poverty–environment linkages.
- Analyze drivers of environmental and economic change including population, pollution, technology, land use, climate, and globalization.
- Apply environmental communication skills for stakeholder engagement, media use, message design, and impact assessment.
- Examine key environmental movements globally and in South Asia, and their contributions to sustainability.

- Evaluate policies and governance frameworks, green governance, institutional roles, SDGs integration, and Nepal's commitments.

Unit 1: Foundations of Sustainability Science **5 hrs**

1. Concept of planetary boundaries and Earth system science
2. Concept and trends of global environmental changes
3. Sustainability: Definition, history, current approach, intergenerational equity, resilience, and sustainable development idea
4. Sustainability: Theories, principles, pillars, indicators, and measurements
5. Systems thinking and coupled human–natural systems: Coupled human–environment systems approach
6. Socio-ecological systems (SES): Poverty–Environment linkages, Prosperity-inclusive development and environment degradation/restoration
7. Case studies on sustainability practices and historical milestones

Unit 2: Drivers of Environmental and Economic Changes **10 hrs**

1. Population dynamics and demographic transitions, Urbanization, motorization and land-use change
2. Pollution, consumption pattern and material flows
3. Technological development and industrial transformation
4. Spatial planning infrastructure and transport development
5. Climate change, extreme weather events and disaster risk
6. Biological invasion biodiversity loss, and ecological changes
7. Globalization trade, and local environmental change
8. Economic growth and sustainability
9. Toxic chemicals, pesticide safety and human health linkages
10. Case studies on green practices and technologies

Unit 3: Environmental Communication **5 hrs**

1. Foundation of environmental communication: Concept and definition; historical evolution, and theoretical framework
2. Role of media in environmental sustainability: Mass media, digital and social media; framing and storytelling; barriers to communication
3. Stakeholder engagement: Public participation; policy communication; cross-cultural communication
4. Science communication and impact assessment: Communicating uncertainty, impact assessment and risk perception; ethical responsibility; political polarization; media bias, literacy gaps; trust and credibility
5. Practical skill development: Message design and framing; media engagement techniques; visualization and storytelling; stakeholder dialogue and facilitation; evaluation and impact assessment

Unit 4: Key Environmental Movements **5 hrs**

1. Concept and global evolution trends of environmental movements
2. Early conservation movements: Forest Conservation Campaigns; Wildlife Protection; Soil and Water Conservation
3. Global environmentalism: Environmental laws**;** Anti-pollution campaigns; Environmental Sustainability Movements; Greenpeace Activism Urban Environmental and Anti-Pollution Movements, Anti-Dam and River-Protection Movements; Indigenous Land-Rights and Conservation Struggle, Environmental Justice, and Movements; Biodiversity and Species-Specific Campaigns, Anti-Mining and Anti-Extraction Movements, Mountain, Ocean and Coastal Movements.
4. Climate and Sustainability movements: Climate Justice; Renewable Energy Advocacy; Youth led Movements
5. Case studies on South Asian Environmental Movements: Urban Environmental and Anti-Pollution Movements, Anti-Dam and River-Protection Movements; Indigenous Land-Rights and Conservation Struggles, Environmental Justice, Labor, and Health Movements; Biodiversity and Species-Specific Campaigns, Anti-Mining and Anti-Extraction Movements, Ocean and Coastal Movements, Chipko Movement; Anti-Pollution

Campaigns; Bagmati Conservation Campaign; Kalapathar Meeting; Local Stewardship for Community Forestry

Unit 5: Policies and Governance **5 hrs**

1. Foundations of environmental policy and governance
2. Policy instruments and tools: Policy design, implementation, and Political economy, National and International frameworks for environmental sustainability**;** Multilevel governance and institutions: International environmental governance and transboundary issues, green governance- Principles, Accountability mechanisms, and Pathways for sustainable development
3. Institutions and Partnerships: Roles of government, Civil society, Global partners, and regional cooperation
4. Future Pathways: Community engagement, Mass education, Science–policy interface, and Adaptive governance, Climate finance and investment mechanisms, Technological interventions
5. International Agendas and Agreements and Nepal's commitments: Key Multilateral Environmental Agreements (MEAs; structure and mechanisms such as UNFCCC, CBD, Basel/Stockholm Conventions, Integration of Paris Agreement, Sustainable Development Goals, and integration into the national policies and plans
6. Environmental ethics and world views

Suggested Readings

- **Blewitt, J.** (2018). *Understanding sustainable development*. Routledge.

- **Chapagain, P. S., et al.** (2021). Ecosystem services in Nepal: Policy and practice. *Journal of Forest and Livelihood*.

- **Dutta, V., & Ghosh, P.** (n.d.). *Sustainability science, policy and practice in India*. [Publisher not specified].

- **Folke, C., et al.** (2016). Resilience and social-ecological systems. *Ecology and Society, 21*(3). https://doi.org/10.5751/ES-08748-210344

- **Government of Nepal.** (2024). *National adaptation plan and environmental statistics*. Government of Nepal.

- **Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).** (2019). *Global assessment report on biodiversity and ecosystem services*. IPBES.

- **Joshi, J.** (2006). *Regional strategies for development in Nepal*. Lajmina Joshi Publications.

- **Kates, R. W., et al.** (2001). Sustainability science. *Science, 292*(5517), 641–642. https://doi.org/10.1126/science.1059386

- **Millennium Ecosystem Assessment.** (2005). *Ecosystems and human well-being: Synthesis*. Island Press.

- **Mino, T., & Kudo, S.** (2020). *Framing in sustainability science*. Springer Open.

- **National Planning Commission (NPC) & United Nations Development Programme (UNDP).** (n.d.). *SDG progress reports*. [Publisher details needed].

- **Ramakrishnan, P. S.** (2023). *Ecology and sustainable development*. National Book Trust, India.

- **Rockström, J., et al.** (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society, 14*(2). https://doi.org/10.5751/ES-03180-140232.

- **Pant, R. R., & Thapa, L. B.** (2025). *Ramsar sites in Nepal: Status, research trends, and conservation strategies*. Intellectuals' Book Palace.

- **Pant, R. R., & Pal, K. B.** (2023). *Pioneer environmental chemistry*. Dreamland Publications.
- **Pant, R. R., & Pathak, L.** (2022). *Ecology and environment*. Intellectuals' Book Palace.
- **Pant, R. R., & Acharya, K. P.** (2021). *Teaching environment: Methods and perspectives*. Intellectuals' Book Palace.

Course Title: Ecology and Ecosystem Dynamics **Credit Hours: 3**

Course Code: ESM 512 **Lecture Hours: 45**

Nature of Course: Theory (Compulsory) **Full Marks: 75**

Introduction

Ecology examines how organisms interact with each other and with their environment, shaping patterns of abundance, distribution, and ecosystem processes. This course introduces key ecological concepts across multiple levels; organism, population, community, and ecosystem, highlighting the influence of abiotic and biotic factors and the complexity of ecological interactions. Students will study ecological dynamics under natural and human-induced changes, with emphasis on resilience, succession, and ecosystem services. Alongside theoretical foundations, the course develops practical skills in ecological research. Students will engage with field survey protocols, experimental design, statistical tools, and modern approaches such as remote sensing and GIS for assessing the ecological systems. Case studies and applied exercises connect theory to practice, preparing students to analyze ecological systems, evaluate human impacts, and design strategies for restoration and sustainable management.

Objectives

After completion of the course, students will be able to:

- Analyze ecological patterns and processes across scales

- Apply trait-based and population-level methods in field research
- Evaluate ecosystem dynamics under anthropogenic stress
- Design and implement ecological restoration and monitoring strategies
- Integrate ecological theory into climate-resilient agro ecosystem planning

Unit 1: Introduction to Ecology **5 hrs**

1. Concept of ecology and environment
2. Evolution of ecological thoughts
3. Ecological niche, habitat, and ecotypes
4. Liebig's Law, Shelford's Law of Tolerance
5. Abiotic and biotic factors affecting species distribution

Unit 2: Population Ecology **7 hrs**

1. Population parameters: Density, Dispersion, Age structure
2. Growth models: Exponential, Logistic, and Matrix-based projections
3. r/k selection theory and life history strategies
4. Intraspecific competition and population regulation
5. Demographic techniques and field sampling protocols

Unit 3: Community Ecology **8 hrs**

1. Community structure: Stratification, Keystone species
2. Diversity indices: Shannon –Weiner index, Simpson's index, Beta diversity index
3. Succession theory and disturbance regimes
4. Species interactions
5. Stability, Resilience and Spatial turnover

Unit 4: Ecosystem Processes and Energy Flow **10 h**rs

1. Ecosystem components: Biotic and Abiotic
2. Primary productivity and decomposition pathways
3. Ecological pyramids, food webs, and trophic dynamics

4. Energy flow models and ecological efficiencies
5. Biogeochemical Cycles: Carbon (C), Nitrogen (N), Phosphorus (P), and Sulfur (S) and natural and anthropogenic impact

Unit 5: Ecosystem Dynamics and Human Impacts **10 hrs**

1. Drivers of ecosystem change (land use change, deforestation, environmental pollution)
2. Climate change effects on ecosystem structure and function
3. Ecosystem resilience
4. Ecological networks and ecosystem function
5. Ecosystem modelling and simulation tools
6. Remote sensing and GIS in ecological monitoring
7. Ecosystem services and valuation
8. Restoration ecology and adaptive management
9. Socio-ecological systems
10. Human–environment interactions

Unit 6: Research methods and Field Applications **5 hrs**

1. Field survey protocols and trait-based sampling
2. Experimental design and hypothesis testing; Statistical tools
3. ANOVA, Regression, Ordination
4. Case Studies: Crop Varieties, Biochar Trials, Forest Plots, Species Distributions

Suggested Readings

- Begon, M., Townsend, C. R., & Harper, J. L. (2006). Ecology: Individuals, populations and communities (4th ed.). Blackwell Publishing Ltd.
- Grime, J. P. (2001). Plant strategies, vegetation processes, and ecosystem properties (2nd ed.). John Wiley & Sons.
- Krebs, C. J. (2014). Ecology: The experimental analysis of distribution and abundance (6th ed.). Pearson Education Limited.
- Singh, J. S., Singh, S. P., & Gupta, S. R. (2006). Ecology, environment and resource conservation. Anamaya Publishers.

- Jha, P. K., Tiwari, A., Gaire, N. P., & Shrestha, M. L. (2025). Climate change and forests in the Himalayas. In Himalayan forests in a changing world: Volume II: Climate impacts, biodiversity and human interactions (pp. 67–100). Springer Nature Singapore.
- Subba, D., Jha, P. K., Dhakal, R. P., Devkota, B. D., & Neupane, P. K. (2025). Climate change in Nepal: Impacts, adaptation and mitigation. National Academy of Science and Technology, Nepal.

Course Title: Ecology and Ecosystem Dynamics **Credit Hour: 1**

Course Code: ESM 516 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Introduction

Ecology and Ecosystem Dynamics provide practical exposure to the study of ecological processes, community structures, and ecosystem functions. The course emphasizes hands-on learning through vegetation sampling, diversity analysis, phenological studies, biomass estimation, and carbon stock assessment. Students will also explore aquatic ecosystems, the impacts of invasive species, and ecological modelling using modern tools such as GIS and statistical methods. Field-based assessments of terrestrial and aquatic systems strengthen the connection between biotic and abiotic components, enabling students to critically analyze ecosystem dynamics and apply ecological principles to real-world environmental challenges.

Objectives

After completion of the course, students will be able to:

- Apply ecological sampling and analytical techniques to study vegetation, community structure, and species interactions.
- Assess ecosystem functions and services through biomass estimation, carbon stock analysis, and aquatic ecosystem evaluation.
- Integrate ecological modelling and field-based observations to forecast ecosystem dynamics and prepare structured reports.

A. Practical Work **[10 Practicals × 3 hrs = 30 hrs]**

1. Vegetation Sampling Techniques: Quadrats, Transects, Random/Stratified sampling.
2. Community Structure Analysis: IVI and Diversity indices (Simpson, Shannon–Weiner)
3. Phenological Studies: Seasonal patterns of selected species
4. Biomass and Richness Relationships: Field estimation and analysis
5. Gradient and Aggregation Analysis: Community traits along gradients; Aggregation indices
6. Species Interactions and Similarity: Statistical methods for association and dissimilarity

7. Carbon Stock Assessment: Forest ecosystems and reforested landscapes
8. Invasive Species Impact: Biodiversity effects and control measures.
9. Aquatic Ecosystem Assessment (lentic and lotic): Biotic index, Primary production, Plankton analysis
10. Ecological Modelling and Forecasting**:** Spatial mapping, and ecological modelling integrate QGIS, Regression, Ordination, Cluster, and Predictive forecasting for ecosystem studies

B. Field Work, Data Analysis and Report Writing [15 hrs]

1. Terrestrial Ecosystem Assessment 6 hrs

- Conduct vegetation sampling using quadrats and transects in forest/grassland sites
- Record species composition, abundance, and phenological traits
- Measure biomass and carbon stock estimates
- Relate vegetation patterns to soil physicochemical properties and microclimatic factors

2. Aquatic Ecosystem Assessment 6 hrs

- Assess lentic (standing water) systems using biotic indices, plankton sampling, and primary production methods
- Evaluate lotic (river) systems through macro invertebrate sampling, candidate metrics, and river quality mapping
- Link aquatic community assemblages to abiotic drivers such as flow regime and nutrient status

3. Data Analysis and Report Writing 3 hrs

Each student will prepare concise field reports for both terrestrial and aquatic assessments in the prescribed format after analyzing the data.

Reports must integrate biotic and abiotic observations and include data tables, graphs, and short interpretations.

Suggested Readings

- Gopal, B. (2015). Guidelines for rapid assessment of biodiversity and ecosystem services of wetlands (Version 1.0). Asia-Pacific Network for Global Change Research (APN-GCR) & National Institute of Ecology.
- Gupta, P. K. (2000). Methods in environmental analysis: Water, soil and air. Agrobios (India).
- Kent, M. (2012). Vegetation description and data analysis: A practical approach (2nd ed.). Wiley-Blackwell.
- Kershaw, K. A. (1973). Quantitative and dynamic plant ecology. English Language Book Society.
- Southwood, T. R. E., & Henderson, P. A. (2009). Ecological methods (3rd ed.). Wiley-Blackwell.
- Tachamo Shah, R. D., Shah, D. N., & Sharma, S. (2020). Rivers handbook: A guide to the health of rivers in the Hindu-Kush Himalaya. Aquatic Ecology Center, Kathmandu University.
- Zobel, D. B., Behan, M. J., Jha, P. K., & Yadav, U. K. R. (1987). A practical manual for ecology. Ratna Book Distributors.

Course Title: Environmental Earth Science **Credit Hours: 3**

Course Code: ESM 513 **Lecture Hours: 45**

Nature of Course: Theory (Compulsory) **Full Marks: 75**

Introduction

This course provides a comprehensive exploration of the Earth's atmosphere, hydrosphere, lithosphere, and the dynamic processes that shape them, with particular emphasis on their environmental significance and interconnections. Students will study the fundamental characteristics of these systems, including atmospheric circulation, hydrological cycles, geological structures, and geomorphological processes, while critically examining how they interact to influence the Earth's environment. The course highlights the importance of understanding these natural systems not only in isolation but also as interconnected components of the Earth system, where changes in one sphere often trigger cascading impacts across others. In addition to foundational scientific knowledge, students will engage with applied aspects of environmental earth science, such as the assessment of natural hazards, disaster risk reduction, and sustainable resource management. Special attention will be given to the diverse landscapes of Nepal, from the Himalayan highlands to the river valleys and plains which provide a unique natural laboratory for studying atmospheric variability, hydrological extremes, geological formations, and hazard-prone environments. By integrating global perspectives with Nepal-specific case studies, the course aims to equip students with both theoretical insights and practical skills to analyze, interpret, and address environmental challenges. Ultimately, students will develop the capacity to apply Earth Science knowledge in environmental planning, hazard mitigation, and sustainable development, preparing them to contribute meaningfully to both academic research and policy-oriented practice.

Objectives

After completing the course, students will be able to:

- Understand atmospheric processes and climate dynamics, including precipitation and measurement techniques
- Analyze hydrological processes such as runoff, groundwater, and evapotranspiration
- Discuss geological characteristics of the Earth and identify materials and structures
- Explain geomorphological processes shaping landforms in fluvial, glacial, and desert environments

- Apply Earth Science knowledge to environmental management and hazard mitigation
- Evaluate environmental hazards including floods, landslides, earthquakes, and GLOFs

Unit 1: Atmosphere and Climate Science **10 hrs**

1. Climate-water interactions, circulation systems
2. Energy balance: Solar radiation absorbed/reflected by the atmosphere affects Earth's heat budget, greenhouse effect, and climate-forcing agents
3. Atmospheric stability, cloud formation, precipitation processes
4. Climate system and Nepal's climatic patterns
5. Meteorological extreme events in the Himalayas

Unit 2: Hydrological Processes **10 hrs**

1. Hydrological cycle and Global water budget
2. Infiltration, Evaporation, Evapotranspiration
3. Runoff processes, Hydrograph analysis, Flood estimation
4. Groundwater occurrence, Aquifers, Recharge methods
5. Hydrometry and water resource management in Nepal

Unit 3: Earth Science and Plate Tectonics **5 hrs**

1. Introduction to Earth science and Plate tectonics
2. Composition of the Earth
3. Geology of Nepal Himalayas
4. Regional geological framework
5. Plate tectonics and environmental consequences

Unit 4: Crystallography and Mineralogy **5 hrs**

1. Introduction to geological materials and structure
2. Crystal symmetry and seven crystal systems
3. Rocks, minerals, and soils: Classification and Identification
4. Main rock-forming minerals and their mineralogical and crystallographic properties
5. Geological structures: Folds, Faults, Thrusts, and their environmental significance.

Unit 5: Geological Processes **5 hrs**

1. Geological processes: Endogenic and Exogenic
2. Fluvial systems and Floodplain dynamics
3. Glacial processes and Periglacial features
4. Lake and desert environments, Aeolian processes
5. Geological time scale

Unit 6: Earth Hazards **10 hrs**

1. Concepts of hazard, vulnerability, and risk
2. Landslides: causes, mapping, mitigation
3. Flood hazards and management in Nepal
4. Glacial Lake Outburst Floods (GLOFs)
5. Earthquakes and Tsunamis: Impacts and Mitigation
6. Volcanic hazards and Wildfire risks

Suggested Readings

- Ahrens, C. D. (2014). Essentials of meteorology: An invitation to the atmosphere. Cengage Learning.
- Chow, V. T. (1959). Handbook of applied hydrology. McGraw-Hill.
- Critchfield, H. J. (1974). General climatology. Prentice-Hall.
- Dhital, M. R. (2015). Geology of the Nepal Himalaya: Regional perspective of the classic collided orogen. Springer.
- Fooks, P. G., Lee, E. M., & Griffiths, J. S. (2007). Engineering geomorphology. Whittles Publishing.
- Erickson, J. (2014). Environmental geology: Facing the challenges of our changing earth. Infobase Publishing.
- Garg, S. K. (2002). Hydrology and water resources engineering. Khanna Publishers.
- Chorley, R. J., Schumm, S. A., & Sugden, D. E. (2019). Geomorphology. Routledge.
- Hardy, J. T. (2003). Climate change: Causes, effects, and solutions. John Wiley & Sons.
- Duff, P. McL. D., & Holmes, A. (1993). Holmes' principles of physical geology. Chapman & Hall.

- Deoja, B., Dhital, M., Thapa, B., & Wagner, A. (1991). Mountain risk engineering handbook (Parts I and II). International Centre for Integrated Mountain Development (ICIMOD).
- Ritter, D. F., Kochel, R. C., & Miller, J. R. (1995). Process geomorphology. Wm. C. Brown Publishers.
- Sidle, R. C., & Ochiai, H. (2006). Landslides: Processes, prediction, and land use. American Geophysical Union (AGU).
- Subba, D., Jha, P. K., Dhakal, R. P., Devkota, B. D., & Neupane, P. K. (2025). Climate change in Nepal: Impacts, adaptation and mitigation. National Academy of Science and Technology, Nepal.
- Subramanya, K. (2013). Engineering hydrology

Course Title: Environmental Earth Sciences **Credit Hour: 1**

Course Code: ESM 517 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Introduction

The practical course instills in students essential learning skills by providing hands-on practice in the main aspects of Earth science. The Earth is a dynamic planet, and its surface is continuously changing due to geological processes, solar radiation, and biological, hydrological, and atmospheric interactions. These interactions contribute to the formation and evolution of diverse environments. To understand these relations, it is necessary to grasp the fundamentals of geology and environment. The course introduces plate tectonics, geological processes, crystallography, mineralogy, petrology, and structural geology. It also emphasizes environmental processes, natural hazards, and applied mapping techniques. Students will gain practical exposure to rock and mineral identification, block diagram construction, hazard mapping, and the use of GIS/remote sensing tools. The course highlights the importance of linking geological knowledge with environmental sustainability and hazard mitigation.

Objectives

After completing the course, students should be able to:

- Draw global plate boundaries and tectonic features on maps.
- Distinguish igneous, sedimentary, and metamorphic rocks in hand specimen and outcrops.
- Draw block diagrams of folds, faults, unconformities, igneous bodies, and Himalayan subdivisions.
- Prepare coloured three-dimensional block diagrams of major landforms.
- Apply basic GIS and remote sensing tools for geological and environmental mapping.
- Assess natural hazards (landslides, floods) through practical mapping and interpretation.
- Relate geological structures and processes to environmental sustainability and hazard mitigation.

A. Practical Work **[10 Practical × 3 hrs = 30 hrs]**

1. Interpret raw data, check quality, handle gaps, estimate rainfall (isohyetal, Thiessen) and relate to Earth system.
2. Water balance (Thornthwaite), Basin morphometry, Rating/flow curves, Flow measurement and relate to Earth system.
3. Identify igneous, sedimentary, and metamorphic rocks in hand specimen.
4. Identify rock-forming minerals using hand specimen and diagnostic tools.
5. Study folds, faults, unconformities, and 3D models with environmental implications.
6. Techniques and preparation of maps, emphasizing development and environmental significance.
7. Rock slope failure analysis using discontinuity data.
8. Sieve analysis for soil classification.
9. Prepare and interpret landslide and flood hazard maps, including integrated mapping.
10. Link geological features with environmental processes, hazards, and sustainability.

B. Field Work, Data Analysis and Report Writing **[15 hrs]**

1. Geological Field Assessment **6 hrs**

- Geological mapping exercises in selected terrain.
- Observation of slope failure features and landform analysis.
- Linking geological structures with environmental processes.

2. Hazard Field Assessment **6 hrs**

- Field survey of landslide-prone areas and flood-affected zones.
- Preparation of hazard maps based on field observations.
- Integration of biophysical data with hazard interpretation.

3. Data Analysis and Report Writing **3 hrs**

Each student will prepare concise field reports for geology and hazard assessments in the prescribed format.

Reports must integrate field observations with practical data, including tables, maps, and short interpretations.

Suggested Readings

- Fooks, P. G., Lee, E. M., & Griffiths, J. S. (2007). Engineering geomorphology. Whittles Publishing.
- Dhital, M. R. (2015). Geology of the Nepal Himalaya: Regional perspective of the classic collided orogen. Springer.
- Chorley, R. J., Schumm, S. A., & Sugden, D. E. (2019). Geomorphology. Routledge.
- Duff, P. McL. D., & Holmes, A. (1993). Holmes' principles of physical geology. Chapman & Hall.
- Kent, M. (2012). Vegetation description and data analysis: A practical approach (2nd ed.). Wiley-Blackwell.
- Deoja, B., Dhital, M., Thapa, B., & Wagner, A. (1991). Mountain risk engineering handbook (Parts I and II). International Centre for Integrated Mountain Development (ICIMOD).
- Southwood, T. R. E., & Henderson, P. A. (2009). Ecological methods (3rd ed.). Wiley-Blackwell.
- Tachamo Shah, R. D., Shah, D. N., & Sharma, S. (2020). Rivers handbook: A guide to the health of rivers in the Hindu Kush Himalaya. Aquatic Ecology Center, Kathmandu University.

Course Title: Environmental Chemistry and Toxicology **Credit Hours: 3**

Course Code: ESM 514 **Lecture Hours: 45**

Nature of Course: Theory (Compulsory) **Full Marks: 75**

Introduction

This course provides a comprehensive study of the principles of environmental chemistry and toxicology, focusing on the chemical processes that govern the interactions between pollutants and human health. Students will explore the sources, behavior, and fate of chemical substances in the environment, alongside the mechanisms of toxicity and their implications for human health and ecological integrity. The course emphasizes the dual role of environmental chemistry and toxicology, as scientific disciplines that explain the pathways and impacts of contaminants, and as applied fields that inform risk assessment, regulation, and sustainable management. Key themes include the chemistry of air, water, and soil pollution; the toxicological effects of heavy metals, pesticides, and industrial chemicals; and the global challenges posed by persistent organic pollutants, and emerging contaminants. Nepal's environmental context ranging from urban air pollution to agricultural pesticide use, will serve as a practical case study for understanding local and regional dimensions of chemical risks. By integrating global perspectives with Nepal-specific challenges, the course aims to equip students with the knowledge and skills necessary to evaluate chemical hazards, design preventive measures, and contribute to sustainable solutions in both scientific and policy arenas.

Objectives

After completion of the course, students will be able to:

- Explain atmospheric, hydrospheric, lithospheric, and biospheric chemical processes and their environmental significance
- Identify major pollutants and toxic substances along with their pathways, fate, and ecological impacts
- Apply toxicological principles and dose–response frameworks to assess risks in ecosystems and human health
- Evaluate environmental toxicity through biomarkers, biomonitoring, and testing procedures at local and global scales

- Integrate scientific knowledge into sustainable management and policy strategies for environmental health protection

Unit 1: Atmospheric Chemistry **5 hrs**

1. Structure and composition of the atmosphere
2. Air pollutants: Gases (Carbon monoxide, methane, Sulphur oxides), Particulate pollutants, Aerosols, Free radicals
3. Sources of air pollution: Fossil fuel emissions, Clinker/Lime production, Sulphur residues, Biogenic contributions to atmospheric chemistry
4. Tropospheric Chemistry: Photochemical reactions, Photochemical smog and Acid rain, Oxidation of methane and SO_2
5. Stratospheric chemistry: Ozone and its depletion, Greenhouse gases and global warming
6. Urban atmosphere chemistry

Unit 2: Hydrospheric Chemistry **5 hrs**

1. Availability and quality, environmental significance of freshwater
2. Pollutants in freshwater sources, Acidification and Contamination pathways
3. Microbial mediation of cycles (Sulphur, Carbon, Nitrogen, Phosphorus)
4. Gas solubility, Colloids - occurrence and kinds of colloids
5. Sediment interactions: Solute exchange, Trace metals in suspended matter and sediments

Unit 3: Lithospheric Chemistry **5 hrs**

1. Soil types and properties
2. Minerals and Soil reactions - Ion exchange, Redox, Neutralization reactions
3. Humic substances and nutrients - NPK pathways in soil
4. Soil pollutants – Solid waste interactions, heavy metals and metal interaction, persistence of pesticides and plastics in soil
5. Polymer degradation and fate of additives (BPA, Phthalates, Flame retardants)

Unit 4: Biospheric Chemistry **5 hrs**

1. Concept of biospheric chemistry and its scope, Bioaccumulation and Biomagnification
2. Industrial and agricultural pollutants and their transformation in the biosphere
3. Urbanization, transportation, and solid waste impacts on biospheric chemistry
4. Transboundary pollution: Haze, Acid deposition, and Shared river basin contamination
5. Sustainable management strategies: Cleaner production, Circular economy, Green chemistry

Unit 5: Principles of Environmental Toxicology **5 hrs**

1. Principles of toxicology and ecotoxicology, Toxicokinetic and toxicodynamic
2. Influence of ecological factors on toxicity: biotic and abiotic factors
3. Fate and dispersion of toxic substances
4. Factors affecting the concentration of toxic substances in the environment
5. Exposure pathways of toxic substances

Unit 6: Toxicogenic Pollutants in Environment **5 hrs**

1. Environmental pollutants and their effects
2. Toxic and Hazardous Pollutants **(**Mutagens, Carcinogens, Teratogens, Genotoxic neurotoxic)
3. Endocrine disruption
4. Transport of toxicants in environment
5. Fate of toxicants in environment and human health

Unit 7: Environmental Toxins and Human **10 hrs**

1. Routes of toxicants to the human body
2. ADME – Absorption, Distribution, Metabolism and Excretion
3. Acute and chronic toxicity; Lethal and sub-lethal doses
4. Analysis of NOEL, LD_{50} and MLD
5. Dose Response relationship and Cumulative response
6. Toxicity testing procedures

Unit 8: Toxicological Risk Assessment **5 hrs**

1. Identification of health hazards
2. Toxicological biomarkers and biomonitoring
3. Dose-response relationships (Frequency and cumulative response; Lethal vs. sub-lethal doses)
4. Quantitative toxicology metrics (LD_{50}, LC_{50}, and MLD values)
5. Environmental toxicity and Carcinogenicity testing

Suggested Readings

- Baird, C., & Cann, M. (2005). Environmental chemistry. W. H. Freeman and Company.
- Klaassen, C. D., & Watkins, J. B. (2015). Casarett & Doull's essentials of toxicology (3rd ed.). McGraw-Hill.
- Craddeck, H. A. (2018). Oilfield chemistry and its environmental impact. John Wiley & Sons.
- Crosby, D. G. (1998). Environmental toxicology and chemistry. Oxford University Press.
- European Union (EU). (2011). Plastic waste: Ecological and human health impacts. Science for Environment Policy, European Commission.
- Hodgson, E. (2010). A textbook of modern toxicology (4th ed.). Wiley.
- Manahan, S. E. (1999). Environmental chemistry. Lewis Publishers.
- Manahan, S. E. (2010). Environmental chemistry (9th ed.). CRC Press.
- Moriarty, F. (2006). Ecotoxicology: The study of pollutants in ecosystems (3rd ed.). Academic Press.
- Newman, M. C. (2020). Fundamentals of ecotoxicology: The science of pollution. CRC Press.
- Seinfeld, J. H., & Pandis, S. N. (2016). Atmospheric chemistry and physics: From air pollution to climate change (3rd ed.). Wiley.
- Sparks, D. L. (2003). Environmental soil chemistry (2nd ed.). Academic Press.
- United Nations Environment Programme (UNEP). (n.d.). Retrieved from http://www.unep.org/
- World Health Organization (WHO). (n.d.). Retrieved from http://www.who.int/

- Wright, D. A., & Welbourn, P. (2009). Environmental toxicology (Cambridge Environmental Chemistry Series, Vol. 11). Cambridge University Press.

Course Title: Environmental Chemistry and Toxicology **Credit Hour: 1**

Course Code: ESM 518 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Introduction

Laboratory and field practical skills in Environmental Chemistry and Toxicology are essential for identifying toxic substances in the environment, assessing associated risks, and implementing mitigation measures. This practical course emphasizes primary hands-on skills in laboratory and field testing, enabling students to evaluate contaminants, analyze exposure pathways, and assess health impacts.

Objectives

After completing the course, students should be able to:

- Apply knowledge to evaluate distribution and exposure of environmental chemical contaminants.
- Use skills, techniques, and tools necessary for assessment of environmental toxicants.
- Conduct environmental assessments, analyze data, and evaluate health impacts from exposure to contamination.

A. Practical Work **[10 Practicals × 3 hrs = 30 hrs]**

1. Sampling and Preservation Techniques: Air (particulates, gases), Water/Wastewater (Microbial, Physical, Chemical), Soil, Solid Waste, Leachate, and Noise.
2. Laboratory Instruments and Safety: Demonstration of general laboratory instruments (TLC, HPLC, spectrophotometry, AAS) and safety regulations.
3. Volumetric and Spectrophotometric Analysis: Principles, instrumentation, and applications.
4. Quality Assurance and Quality Control (QA/QC): Procedures in chemical analysis.
5. Physicochemical Parameters (Water): pH, Conductivity, Turbidity, Salinity, Alkalinity, Hardness, TDS, Nitrate, Phosphate, Sulphate, Fluoride.
6. Air Quality Monitoring (Particulates): Measurement of TSP, PM_{10}, $PM_{2.5}$.
7. Air Quality Monitoring (Gases): Measurement of NO_x, SO_x, CO_x, O_3, hydrocarbons.

8. Water Quality Monitoring (Wastewater/Leachate): COD, BOD, TKN, Ammonia, Phosphorus, Oil and grease, Heavy metals.
9. Soil Quality Monitoring: Temperature, pH, EC, Texture, Bulk density, Moisture, Organic matter/Carbon, NPK.
10. Heavy Metals and Arsenic: Determination of Pb, Cd, Hg, As in water and soil and pesticide detection.

B. Field Work, Data Analysis and Report Writing [15 hrs]

1. Community Assessment 6 hrs

- Field visit to local community sites.
- Sampling of water, soil, and air for toxicant analysis.
- Use of standard checklist for environmental toxicant assessment.

2. Industrial Assessment 6 hrs

- Visit to selected industry for environmental toxicant assessment.
- Observation of pollutant sources and mitigation practices.
- Collection of samples for laboratory analysis.

3. Data Analysis and Report Writing 3 hrs

Each student will prepare concise field reports for community and industrial assessments in the prescribed format.

Reports must integrate field observations with laboratory data, including tables, graphs, and short interpretations.

Suggested Readings

- Boehnke, D. N., & Delumyea, R. D. (2000). Laboratory experiments in environmental chemistry. Prentice Hall.
- American Public Health Association (APHA), American Water Works Association (AWWA), & Water Pollution Control Federation (WPCF). (2017). Standard methods for the examination of water and wastewater (23rd ed.). American Public Health Association.
- Manahan, S. E. (2017). Environmental chemistry (10th ed.). CRC Press.
- Connell, D. W., & Miller, G. J. (2006). Chemistry and ecotoxicology of pollution. Wiley.

Rand, G. M., Wells, P. G., & McCarty, L. S. (1995). Fundamentals of aquatic toxicology. Taylor & Francis.

Course Title: Meteorology and Hydrology **Credit Hours: 3**

Course Code: ESM 515 **Lecture Hours: 45**

Nature of Course: Theory (Compulsory) **Full Marks: 75**

Introduction

Meteorology and hydrology together form the scientific foundation for understanding atmospheric processes, weather and climate variability, and the movement, storage, and availability of water on and beneath the Earth's surface. This course introduces key concepts of atmospheric structure, circulation, and precipitation processes alongside hydrological pathways of surface water, groundwater, and cryosphere reservoirs. Emphasis is placed on the South Asian monsoon and its role in regional climate and water availability. The course combines physical principles with observational and analytical approaches used in modern hydro-meteorology. Students are introduced to meteorological instruments, remote sensing and reanalysis datasets, synoptic interpretation, and basic hydrological modelling concepts. Case studies and applied exercises connect theory to practice, preparing students to analyze atmospheric processes and hydrological systems. Through applied examples and regional case studies, students develop the capacity to analyse coupled atmosphere–hydrology systems, assess natural and anthropogenic impacts, and support climate adaptation, water resources planning, and disaster risk reduction.

Objectives

After completion of the course, the students will be able to:

- Explain the physical principles governing atmospheric structure, energy balance, circulation, and weather systems.
- Describe the hydrological cycle at basin scales, including surface water, groundwater, snow, and glacier components
- Analyze precipitation (snow and rain) and evapotranspiration, using standard observation techniques and estimation methods
- Interpret runoff generation and hydrographs, and evaluate flood frequency characteristics under natural and urban conditions.
- Evaluate surface water and groundwater systems, including discharge, sediment transport, aquifers properties, recharge, and interactions.

- Assess the role of large-scale climate drivers (monsoon, ENSO) in hydro-meteorological extremes such as droughts and floods.
- Apply observational, remote sensing, and modelling tools to analyse meteorological and hydrological datasets for decision support.

Unit 1: Atmospheric Physics **8 hrs**

1. Role of atmospheric physics in weather and climate systems
2. Structure and composition of the atmosphere
3. Atmospheric thermodynamics, stability, and lapse rates
4. Solar and terrestrial radiation
5. Earth's energy balance and greenhouse effect
6. Atmospheric motion and governing forces
7. Global circulation and monsoon systems
8. Atmospheric moisture, cloud formation, precipitation initiation, and atmospheric pollutants dispersion

Unit 2: Atmospheric Dynamics, Monsoon and Weather Systems **7 hrs**

1. Atmospheric pressure systems, winds, Coriolis force, and planetary circulation
2. South Asian monsoon: mechanisms, seasonal evolution, and variability
3. ENSO teleconnections and their influence on regional climate and hydrology
4. Synoptic weather systems: fronts, cyclones, and large-scale disturbances
5. Extreme weather events: heatwaves, heavy rainfall, and droughts
6. Atmospheric drivers of floods and droughts
7. Fundamentals of weather and seasonal forecasting
8. Meteorological Instruments: Thermometers, barometers, anemometers, hygrometers, radiometers and radiosondes
9. Satellite observations and reanalysis products for weather and climate analysis
10. Principles of numerical weather prediction

Unit 3: Hydrological Cycle and Watershed Water Balance **5 hrs**

1. Hydrological cycle and basin-scale water movement
2. Reservoirs and fluxes: surface water, soil moisture, groundwater, snow, and ice
3. Basin delineation and characteristics: lumped vs. distributed perspectives
4. Water balance equations and conceptual hydrological models
5. Snow and glacier contributions to Himalayan River flows
6. Seasonal water availability and climate sensitivity
7. Applied watershed analysis using regional examples

Unit 4: Precipitation, Snow Processes, and Evapotranspiration **5 hrs**

1. Precipitation mechanisms: convective, frontal, cyclonic, and orographic
2. Measurement techniques: gauges, tipping buckets, radar, and satellite precipitation products
3. Snowpack properties, accumulation, and melt processes
4. Rain-on-snow events and hydrological implications
5. Evapotranspiration and sublimation concepts and controls
6. Canopy interception, sublimation, and wind-driven snow redistribution
7. Energy budget for snow and ice melts
8. Spatial and temporal analysis of hydro-meteorological data

Unit 5: Surface and Groundwater Processes and Flood Hydrology **5 hrs**

1. Infiltration processes and runoff generation mechanisms
2. Hydrograph components and interpretation
3. Flood frequency analysis and return periods
4. Impacts of urbanization and land use change on runoff
5. Flood mitigation and management strategies
6. River network geometry and flow routing concepts
7. Streamflow measurement techniques and rating curves
8. Sediment erosion, transport and deposition
9. Aquifer types and groundwater properties
10. Groundwater recharge, vulnerability, and sustainability

Suggested Readings

- Ahrens, C. D. (2014). Essentials of meteorology: An invitation to the atmosphere. Cengage Learning.
- Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). Crop evapotranspiration (FAO Irrigation and Drainage Paper 56). Food and Agriculture Organization (FAO).
- Barry, R. G., & Chorley, R. J. (2010). Atmosphere, weather and climate (9th ed.). Routledge.
- Beven, K. (2011). Rainfall-runoff modelling: The primer (2nd ed.). Wiley-Blackwell.
- Brutsaert, W. (2005). Hydrology: An introduction. Cambridge University Press.
- Chow, V. T., Maidment, D. R., & Mays, L. W. (2013). Applied hydrology. McGraw-Hill.
- Critchfield, H. J. (1974). General climatology (3rd ed.). Prentice-Hall.
- Dingman, S. L. (2015). Physical hydrology (3rd ed.). Waveland Press.
- Garg, S. K. (2002). Hydrology and water resources engineering. Khanna Publishers.
- Hardy, J. T. (2003). Climate change: Causes, effects, and solutions. John Wiley & Sons.
- Intergovernmental Panel on Climate Change (IPCC). (2023). AR6 synthesis report: Climate change 2023 (selected chapters on water cycle and extremes). https://www.ipcc.ch/report/ar6/syr/
- Jha, P. K., Tiwari, A., Gaire, N. P., & Shrestha, M. L. (2025). Climate change and forests in the Himalayas. In Himalayan forests in a changing world: Volume II: Climate impacts, biodiversity and human interactions (pp. 67–100). Springer Nature Singapore.
- Linsley, R. K., Kohler, M. A., & Paulhus, J. L. H. (1975). Hydrology for engineers. McGraw-Hill.
- Pradhananga, D., & Pomeroy, J. W. (2022). Recent hydrological response of glaciers in the Canadian Rockies to changing climate and glacier configuration. Hydrology and Earth System Sciences, 26, 2605–2625. https://doi.org/10.5194/hess-26-2605-2022
- Reddy, P. J. R. (2023). A textbook of hydrology (3rd ed.). Firewall Media.
- Shrestha, A., Pradhananga, D., & Karmacharya, J. (Eds.). (2019). Report on Bara-Parsa tornado. Department of Hydrology and Meteorology, Ministry of Energy, Water Resources and Irrigation, Government of Nepal. https://archive.smallearth.org.np/wp-content/uploads/2019/04/Report-on-Bara-Parsa-Tornado.pdf

- Ward, R. C., & Trimble, S. W. (2003). Environmental hydrology. CRC Press.
- World Meteorological Organization (WMO). (2018). Guide to hydrological practices (6th ed.). WMO.

Course Title: Meteorology and Hydrology **Credit Hour: 1**

Course Code: ESM 519 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Introduction

The practical component of meteorological and hydrological is designed to strengthen student's ability to apply atmospheric and hydrological concepts through observation, data analysis, and interpretation. The course aims to link between meteorological processes, such as precipitation, temperature, and atmospheric circulation, and hydrological responses including runoff, snowmelt, and floods. Practical exercises use real datasets and case studies relevant to Nepal and the Himalayan region, enabling students to analyse water-related problems in the context of climate variability, extremes, and disaster risk reduction.

Objectives

After completion of the course, the students will be able to:

- Apply meteorological observations to hydrological analysis.
- Process and quality control hydrological and meteorological data.
- Analyse precipitation-runoff, snow and ice melt, and extreme event responses.
- Use GIS and gridded datasets for basin-scale analysis.
- Interpret meteorological drivers and hydrological extremes for adaptation and risk management.

A. Practical Work **[10 Practicals × 3 hrs = 30 hrs]**

1. Interpretation of Meteorological Data: quality checking, consistency testing, and handling missing data.
2. Rainfall Estimation: Isohyetal and Thiessen polygon methods.
3. Water Balance Analysis: Thornthwaite method for a selected station.
4. Climatic Mapping: preparation of climatic maps of Nepal.
5. Morphometric Analysis: calculation of morphometric parameters of a river basin.
6. Rating Curves and Tables: preparation for hydrological stations.
7. Flow Duration Curves: construction and interpretation of hydrological data.
8. Streamflow Measurement – ADCP, current meters, salt dilution, float methods.

9. Stone Spout and Wastewater Flow: measurement techniques and analysis.
10. Data Handling and Software Applications: use of Surfer and CropWat or similar software; crop water requirement analysis, introductory hydrological modelling and GIS applications

B. Field Work, Data Analysis and Report Writing [15 hrs]

1. Meteorological Field Assessment 6 hrs

- Visit to meteorological stations.
- Observation of meteorological instruments and data recording procedures.
- Preparation of field notes and a preliminary meteorological field report.

2. Hydrological Field Assessment 6 hrs

- Streamflow measurement exercises in rivers and stone spouts.
- Observation of rating curves and flow duration characteristics.
- Preparation of a hydrological field report.

3. Data Analysis and Report Writing 3 hrs

Each student will prepare concise field reports for both meteorological and hydrological assessments in the prescribed format.

Reports must integrate field observations with practical data, including tables, maps, graphs, and brief interpretations.

Suggested Readings

- Ahrens, C. D. (2015). Meteorology today: An introduction to weather, climate, and the environment. Cengage Learning Canada Inc.
- Chow, V. T., Maidment, D. R., & Mays, L. W. (1988). Applied hydrology. McGraw-Hill.
- Díez-Herrero, A., Huerta, L. L., & Isidro, M. L. (2009). A handbook on flood hazard mapping methodologies. Geological Survey of Spain.
- Shaw, E. M. (1994). Hydrology in practice (3rd ed.). CRC Press.
- Subramanya, K. (2013). Engineering hydrology (4th ed.). Tata McGraw-Hill.
- World Meteorological Organization (WMO). (2018). Guide to meteorological instruments and methods of observation. WMO.
- Singh, V. P. (1995). Computer models of watershed hydrology. Water Resources Publications.

SEMESTER II

Advanced Theory, Research, and Practice-based Courses

Course Title: Energy, Society and Sustainability **Credit Hour: 2**

Course Code: ESM 521 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

Introduction

Energy underpins human development, livelihoods, and national security while simultaneously shaping environmental outcomes and climate trajectories. This course examines the historical evolution of energy use, the classification of major sources and technologies, and situates energy within both global and Nepal-specific policy frameworks. Students will analyze environmental impacts, economic considerations, and governance structures, while exploring equitable pathways toward low-carbon transitions. Emphasis is placed on integrating technical knowledge with social dimensions, enabling students to critically assess real-world energy systems and design sustainable, just, and context-appropriate solutions.

Objectives

After completion of the course, the students will be able to

- Explain energy classifications, units, and historical evolution while linking energy to development indicators such as SDGs and HDI
- Compare renewable and non-renewable technologies, storage options, and grid architectures including practical solar applications
- Assess emissions, hazards, and life-cycle impacts and evaluate energy's role in climate mitigation using EIA, IEE, and sustainability indicators
- Evaluate costs, subsidies, tariffs, planning, and Nepal's regulatory and NDC commitments through modelling and audit tools
- Design pathways for sustainable energy transitions that incorporate social acceptance, inclusion, justice, and behavioral change in Nepal's context

Unit 1: Introduction to Energy and Society **6 hrs**

1. Historical evolution of energy use and human development
2. Definition of energy, classification of sources, standard energy units
3. National, regional, and global energy scenario

4. Energy in Maslow's hierarchy, SDGs, HDI, and consumption
5. Energy conservation, efficiency, and national energy mix

Unit 2: Energy Resources and Technologies **6 hrs**

1. Renewable vs non-renewable resources
2. Overview of solar, wind, hydro, biomass, biogas, fossil fuels
3. Solar radiation basics (Global, Diffuse, Direct; Insolation; Air mass; Albedo)
4. On-grid vs off-grid systems and solar electricity for drinking water pumping
5. Energy storage systems and Agrivoltaics

Unit 3: Energy, Environment and Climate **6 hrs**

1. Emissions and hazards
2. Life-cycle environmental impacts
3. Energy in climate change mitigation
4. Environmental assessments: BES, IEE, EIA
5. Sustainability indicators, footprints, and clean development mechanism

Unit 4: Energy Economics and Policy **6 hrs**

1. Cost of energy, LCOE, payback concepts
2. Energy subsidies, tariffs, incentives
3. Energy security and national energy planning
4. SDG 7 and Nepal's regulatory frameworks
5. National commitments (SNDC, Zero Emission by 2045), Energy modelling software, and Energy audit

Unit 5: Sustainable Energy Transitions and Social Dimensions **6 hrs**

1. Pathways toward low-carbon energy systems (clean cooking, EVs)
2. Barriers to clean energy adoption
3. Innovations, distributed systems, and integrated planning
4. Regional examples, Nepal's energy transition, and COP resolutions
5. Social acceptance, inclusion, justice, and behavioral change

Suggested Readings

- Da Rosa, A. V. (n.d.). Fundamentals of renewable energy processes (latest ed.). Academic Press (Elsevier).
- Boyle, G. (n.d.). Renewable energy: Power for a sustainable future (latest ed.). Oxford University Press.
- Shrestha, J. N., et al. (2015). Solar PV systems for engineers: Manual. Alternative Energy Promotion Centre (AEPC), Ministry of Energy and Planning (MoEP), Government of Nepal.
- Shrestha, J. N., et al. (2015). Solar water pumping: Manual. Alternative Energy Promotion Centre (AEPC), Ministry of Energy and Planning (MoEP), Government of Nepal.

Course Title: Energy, Society and Sustainability **Credit Hour: 1**

Course Code: ESM 527 **Lecture Hours: 45**

Nature of Course: Term Paper and Seminar (Compulsory) **Full Marks: 25**

Introduction

This practical course provides applied exposure to energy demand estimation, renewable energy system design, equipment demonstration, socio-economic analysis, and community-based energy projects. Students will connect theoretical knowledge with real-world applications, strengthening their ability to evaluate energy systems and propose sustainable solutions for Nepal's energy transition.

Objectives

After completion of the course, the students will be able to

- Estimate energy demand and design simple renewable energy systems such as solar home and biogas units
- Analyze socio-economic impacts and sustainability of local and community-based renewable energy projects through field visits and practical demonstrations

Unit 1: Energy Demand and System Design **15 hrs**

1. Simple energy demand estimation of a residential/office building
2. Design of solar home system and biogas unit
3. Demonstration of solar PV equipment (Modules, Inverters, Charge controllers, Batteries)

Unit 2: Socio-Economic Analysis of Renewable Energy Projects **15 hrs**

1. Case studies of local renewable energy projects
2. Economic viability, Social acceptance, Gender and inclusion aspects
3. Community participation and ownership models

Unit 3: Field Work and Community-Based Energy Systems **15 hrs**

1. Visits to solar PV systems (On-grid, Off-grid, Rooftop)
2. Visits to biogas and hydro/micro-hydro plants
3. Documentation of technical and social dimensions of community-based energy projects

4. Seminar and presentation

Suggested Readings

- Da Rosa, A. V. (n.d.). Fundamentals of renewable energy processes (latest ed.). Academic Press (Elsevier).
- Boyle, G. (n.d.). Renewable energy: Power for a sustainable future (latest ed.). Oxford University Press.
- Recent articles published in IEEE professional journals. (n.d.). [Details to be specified: author(s), year, title, journal name, volume/issue, pages, DOI].
- Shrestha, J. N., et al. (2015). Solar PV systems for engineers: Manual. Alternative Energy Promotion Centre (AEPC), Ministry of Energy and Planning (MoEP), Government of Nepal.
- Shrestha, J. N., et al. (2015). Solar water pumping: Manual. Alternative Energy Promotion Centre (AEPC), Ministry of Energy and Planning (MoEP), Government of Nepal.

Course Title: Environmental Economics **Credit Hour: 2**

Course Code: ESM 528 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

Introduction

Resource economics applies economic principles to the sustainable management of natural resources and the resolution of environmental challenges. The course explores the interconnections between economy, environment, and society, introducing fundamental concepts such as demand, supply, equilibrium, elasticity, and market interventions in the context of environmental and resource economics. Emphasis is placed on sustainability, market failures, and externalities, alongside innovative approaches including Payment for Ecosystem Services (PES), green finance, and carbon offset markets. Students will also engage with benefit–cost analysis (BCA) and valuation methods for environmental goods and services, equipping them with analytical tools to evaluate policies, projects, and strategies for ecosystem conservation and sustainable development.

Objectives

After completing this course, the students will be able to:

- Analyze the linkages between economic systems, environmental resources, and societal welfare
- Evaluate market failures, externalities, and public goods using economic theory
- Assess costs and benefits of environmental policies and projects through benefit–cost analysis
- Examine sustainability concepts and ecosystem services in resource management
- Develop strategies for sustainable resource use by valuing ecosystem services and disservices

Unit 1: Introduction to Resource Economics **5 hrs**

1. Basic concepts: Demand, Supply, Equilibrium, Elasticity, Costs, Revenue, Government Interventions
2. Environmental, ecological, and resource economics
3. Interrelationship between economy, environment, and society

4. Open access and public goods problem
5. Ethics in economics and social welfare

Unit 2: Environmental Sustainability **5 hrs**

1. Pollution externalities and market failure
2. Consumption externalities and efficiency
3. Measuring sustainability: Weak vs. strong sustainability
4. Alternatives to GDP as measures of progress
5. Sustainable development indicators and global frameworks

Unit 3: Ecosystem Services and Markets **5 hrs**

1. Ecosystem services and their economic significance
2. Nature's contribution to people
3. Global trends and case studies of PES in Nepal
4. Green finance and carbon offset markets
5. Institutional frameworks and governance of ecosystem service markets

Unit 4: Benefit–Cost Analysis (BCA) **5 hrs**

1. Concept of benefits vs. costs
2. Welfare foundation of BCA: Consumer and producer surplus
3. Steps in BCA and applications in decision-making
4. Limitations and ethical considerations in BCA
5. Case studies of BCA in environmental and resource management

Unit 5: Economic Valuation of Environmental Goods and Services **10 hrs**

1. Total economic value (use, non-use, option, existence)
2. Productivity change method
3. Human capital/foregone earnings
4. Opportunity cost method
5. Replacement and restoration cost
6. Damage cost and defensive expenditure

7. Cost-of-illness method
8. Contingent valuation (CVM)
9. Choice experiments and contingent ranking
10. Travel cost and hedonic pricing

Suggested Readings

- Barry, C. F., & Martha, K. F. (2015). Environmental economics: An introduction (7th ed.). McGraw-Hill.
- International Union for Conservation of Nature (IUCN) Nepal. (2013). Payment for ecosystem services in Nepal: Prospect, practices, and process. IUCN Nepal.
- Jonathan, M. H., & Brian, R. (2022). Environmental and natural resource economics: A contemporary approach. Routledge.
- Karpagam, M. (1991). Environmental economics: A textbook. Sterling Publishers Pvt. Ltd.
- Markandya, A. (2019). Valuation of ecosystem services. United Nations Forum on Natural Capital Accounting.
- Mohammadyari, F., Tavakoli, M., Zarandian, A., & Lajayer, B. A. (2023). Economic valuation of ecosystem services. Springer Nature.
- Tom, T., & Lynne, L. (2024). Environmental and natural resource economics (12th ed.). Routledge.

Course Title: Environmental Economics **Credit Hour: 1**

Course Code: ESM 528 **Lecture Hours: 45**

Nature of Course: Term Paper and Seminar (Compulsory) **Full Marks: 25**

Introduction

Environmental economics applies economic principles to environmental and resource management, addressing market failures, sustainability, and valuation of ecosystem services. This course emphasizes practical application through term papers and seminars, enabling students to analyze policy instruments, conduct benefit–cost analysis, and evaluate environmental goods and services with a focus on freshwater ecosystems.

Objectives

After completion of the course, students will be able to:

- Understand the foundations of resource and environmental economics.
- Analyze sustainability indicators and externalities in environmental systems.
- Evaluate ecosystem services, markets, and policy instruments.
- Apply benefit–cost analysis to environmental projects.
- Conduct valuation of environmental goods and services, including freshwater ecosystems.
- Prepare a structured term paper and seminar presentation.

Unit 1: Resource Economics and Sustainability **15 hrs**

1. Demand–supply dynamics of irrigation water pricing.
2. Government interventions in hydropower tariffs and river ecology.
3. Weak vs. strong sustainability in freshwater fisheries.
4. Pollution externalities in polluted river.

Unit 2: Ecosystem Services and Markets **10 hrs**

1. Economic significance of ecosystem services (forests, freshwater, wetlands).
2. PES in watershed management for drinking water supply.
3. Governance challenges in freshwater ecosystem service markets.

Unit 3: Benefit–Cost Analysis and Valuation **10 hrs**

1. Applied BCA of drinking water or irrigation projects.
2. Case review: Waste recycling, Waste/Wastewater treatment
3. Valuation methods: Contingent valuation, Travel cost, Replacement/restoration cost.
4. Recreational value of Rara Lake; Willingness-to-pay for improved water quality.

Unit 4: Field Work and Seminar Presentations **10 hrs**

1. Field visits to freshwater ecosystems, hydropower sites, or community-based water projects.
2. Documentation of technical, social, and economic dimensions.
3. Preparation of term papers based on field observations.
4. Seminar presentations and peer discussions.

Suggested Readings

- **Boardman, A. E., Greenberg, D. H., Vining, A. R., & Weimer, D. L.** (2018). *Cost–benefit analysis: Concepts and practice* (5th ed.). Cambridge University Press.
- **National Research Council.** (2005). *Valuing ecosystem services: Toward better environmental decision-making*. The National Academies Press. https://doi.org/10.17226/11139
- **Stavins, R. N.** (Ed.). (2019). *Economics of the environment: Selected readings* (7th ed.). W. W. Norton & Company.

Course Title: Geospatial Analysis **Credit Hour: 2**

Course Code: ESM 523 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

Introduction

Geospatial Analysis is an interdisciplinary field focusing on geospatial data creation, collection, analysis, and interpretation to solve environmental science and management problems. The course covers GIS, remote sensing, GPS, spatial statistics, and modelling, enabling students to analyze patterns, relationships, and trends in geo-environmental data. Students will gain theoretical knowledge and practical skills to work with geospatial software and datasets, preparing them for real-world applications in environmental management.

Objectives

After completion of the course, students will be able to:

- Understand concepts, techniques, and applications of geospatial science and technology for data handling and analysis.
- Acquire practical knowledge of geospatial tools and technologies through hands on exercises.
- Apply geospatial knowledge and skills to real world environmental issues via project work and report submission

Unit 1: Introduction to Geospatial Science and Technology **8 hrs**

1. Remote Sensing: concepts, EMR interaction, sensors, platforms, resolution, applications
2. Digital Image Processing: georectification, corrections, enhancement, interpretation, classification
3. GIS: concepts, functions, components, applications
4. GPS: introduction and applications

Unit 2: Geographical Data Source, Creation and Model **8 hrs**

1. Geographic data types: point, line, polygon
2. Data sources: satellite, aerial photo, GPS, maps, databases
3. Data models: raster and vector, advantages/disadvantages

4. Map projection and transformation

Unit 3: Geospatial Analysis Techniques and Interpolation **7 hrs**

1. Vector-based: geo-processing, proximity, overlay analysis
2. Raster-based: cell-based and surface analysis
3. Geospatial statistics, modelling, interpolation

Unit 4: Geospatial Data Visualization and Map Output **7 hrs**

1. Cartographic principles
2. Map elements and concepts: scale, variables, techniques
3. Map design, visualization, output

Suggested Readings

- Campbell, J. B. (2011). Introduction to remote sensing (5th ed.). Guilford Press.
- Chang, K. T. (2022). Introduction to geographic information systems (10th ed.). McGraw-Hill.
- Li, Z. (2006). Global positioning system: Signals, measurements, and performance. Springer.
- Lillesand, T. M., & Kiefer, R. W. (2015). Remote sensing and image interpretation (7th ed.). Wiley.
- Bolstad, P. (2019). GIS fundamentals: A first text on geographic information systems (6th ed.). XanEdu Publishing.
- Burrough, P. A. (1987). Principles of geographical information systems for land resource assessment. Clarendon Press.
- Chakraborty, D., & Sahoo, R. N. (2007). Fundamentals of GIS. Viva Books.
- Chang, K. T. (2014). Introduction to geographic information systems (8th ed.). McGraw-Hill.
- De Smith, M. J., Goodchild, M. F., & Longley, P. A. (2007). Geospatial analysis: A comprehensive guide to principles, techniques and software tools. Troubador Publishing Ltd.

- Fang, Y., Shandas, V., & Arriaga Cordero, E. (2014). Spatial thinking in planning practice: An introduction to GIS. Portland State University Library.
- Heywood, I., Cornelius, S., & Carver, S. (2011). An introduction to geographic information systems (4th ed.). Pearson Education Limited.
- Kimerling, A. J., Buckley, A. R., Muehrcke, P. C., & Muehrcke, J. O. (2016). Map use: Reading, analysis, interpretation (8th ed.). Esri Press.
- Kraak, M. J., & Ormeling, F. (2021). Cartography: Visualization of geospatial data (4th ed.). CRC Press.
- Lo, C. P., & Yeung, K. W. A. (2017). Concepts and techniques of geographical information systems (2nd ed.). Pearson India.
- Longley, P. A., & Batty, M. (Eds.). (1997). Spatial analysis: Modelling in a GIS environment. John Wiley & Sons.
- Olaya, V. (2018). Introduction to GIS. CreateSpace Independent Publishing Platform.
- Rigaux, P., Scholl, M., & Voisard, A. (2001). Spatial databases: With application to GIS. Elsevier.
- Rocha, J., Gomes, E., Boavida-Portugal, I., Viana, C. M., Truong-Hong, L., & Phan, A. T. (Eds.). (2023). GIS and spatial analysis. IntechOpen. https://doi.org/10.5772/intechopen.100705

Course Title: Geospatial Analysis **Credit Hour: 1**

Course Code: ESM 529 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Introduction

Remote Sensing (RS), Geographic Information Systems (GIS), and Global Positioning System (GPS) are essential tools for geospatial data handling and environmental analysis. This practical course provides hands-on training in satellite image processing, GIS data creation and analysis, and GPS data integration. Students will learn to apply geospatial techniques for land use/land cover change detection, suitability analysis, hot-spot identification, surface temperature analysis, and terrain modeling. The course emphasizes the integration of RS, GIS, and GPS for solving real-world environmental problems through laboratory exercises and a final project.

Objectives

After completion of this practical course, students will be able to:

- Perform satellite image download, correction, enhancement, classification, and accuracy assessment.
- Create, manage, and analyze spatial data using GIS tools (vector and raster analysis).
- Integrate GPS data with GIS for environmental applications.
- Apply RS/GIS techniques to analyze land use change, suitability, hot-spots, surface temperature, and terrain.
- Design and present a comprehensive project that demonstrates integration of RS, GIS, and GPS for environmental problem-solving.

Unit 1: Digital Image Processing and Interpretation **15 hrs**

1. Satellite image download, band display, mosaic, subset, geo-rectification
2. Geometric and radiometric corrections
3. Single/multi-band operations: radiance, reflectance, temperature
4. Spectral indices (soil, vegetation, water), Classification, Accuracy assessment

Unit 2: GIS Data Creation, Management and Analysis **15 hrs**

1. Spatial data capture: point, line, polygon
2. Georeferencing and projection transformation
3. Vector analysis: clip, union, intersection
4. Raster analysis: surface creation
5. Non-spatial data linking and GPS integration

Unit 3: Applications of RS, GIS and GPS in Environmental Issues **15 hrs**

1. Land use/land cover change
2. Land evaluation and suitability analysis
3. Hot-spot analysis
4. Surface temperature analysis
5. Terrain analysis

Final Project: Integration of RS, GIS, and GPS to solve a real-world spatial problem, with report and presentation.

Suggested Readings

- **Aral, M. A.** (2010). *Environmental modeling and health risk analysis (ACTS/RISK)*. Springer.
- **Campbell, J. B.** (1998). *Introduction to remote sensing* (5th ed.). Taylor & Francis.
- **Chang, K. T.** (2018). *Introduction to geographic information systems* (9th ed.). McGraw-Hill.
- **Jensen, J. R.** (2005). *Introductory digital image processing*. Prentice Hall.
- **Lillesand, T. M., Kiefer, R. W., & Chipman, J. W.** (2004). *Remote sensing and image interpretation* (5th ed.). Wiley.
- **Lo, C. P., & Yeung, A. K. W.** (2006). *Concepts and techniques of geographical information systems*. Prentice Hall.
- **Mooney, D. D., & Swift, R. J.** (2021). *A course in mathematical modeling*. American Mathematical Society (AMS).
- NASA. (n.d.). *Remote sensing tutorial*. Retrieved from http://rst.gsfc.nasa.gov/

- ESRI. (n.d.). *ArcUser magazine*. Retrieved from http://www.esri.com/esri-news/arcuser
- Natural Resources Canada. (n.d.). *Satellite imagery products: Educational resources*. Retrieved from http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9309
- GRASS Development Team. (n.d.). *GRASS GIS*. Retrieved from https://grass.osgeo.org/
- QGIS Development Team. (n.d.). *QGIS: A free and open source geographic information system*. Retrieved from http://www.qgis.org/

Course Title: Environmental Assessment and Mitigation **Credit Hour: 2**

Course Code: ESM 524 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

Introduction

Environmental Assessment (EA) is a systematic process for identifying, predicting, and evaluating the potential impacts of development projects on the environment. It ensures that the projects are designed and implemented in ways that minimize negative effects while promoting sustainability and harmony with local communities. This course introduces the principles, procedures, and legislative frameworks of environmental assessment, with emphasis on Nepal's policies and practices. Students will learn methodologies for impact assessment, preparation of reports, and development of the environmental management plans. The course also covers monitoring, auditing, grievance redress mechanisms, and mitigation strategies such as pollution control, habitat restoration, and sustainable resource management. Case studies and applied exercises connect theory to practice, preparing students to make informed decisions that balance development needs with environmental management.

Objectives

After completion of the course, the students will be able to:

- Understand the principles, procedures, and applications of environmental assessment.
- Apply national policies, laws, and regulations related to EA in Nepal.
- Use methodologies for baseline data collection, impact prediction, and report preparation.
- Develop environmental management and mitigation plans for developmental projects.

- Evaluate monitoring, auditing, and grievance redress mechanisms for sustainable project implementation.

Unit 1: Fundamentals of Environmental Assessment **5 hrs**

1. Concepts, history and applications of EA
2. National policies, laws, and regulations related to EA
3. Provisions of EA in Nepal (BES, IEE, EIA, SEA)
4. Scope of EA at local, provincial, and federal levels
5. International frameworks and comparative practices

Unit 2: Methodologies for Baseline Data Collection and Impact Assessment **8 hrs**

1. Preparation of Scoping Document (SD) and Terms of Reference (ToR)
2. Methods of baseline environmental data collection
3. Impact assessment, prediction, and analysis techniques
4. Standards and guidelines related to baseline data
5. Public consultation and stakeholder engagement in various stages of EAs

Unit 3: Environmental Management and Mitigation **7 hrs**

1. Environmental management plans (EMP)
2. Pollution control measures
3. Habitat restoration and biodiversity conservation
4. Sustainable resource management strategies
5. Case studies of mitigation in development projects

Unit 4: Monitoring and Auditing **5 hrs**

1. Types and methods of environmental monitoring
2. Monitoring responsibilities and evaluation criteria
3. Parameters and processes for monitoring
4. Environmental auditing systems and parameters
5. Auditing plans and compliance mechanisms

Unit 5: Governance, Grievance, and Redress Mechanisms **5 hrs**

1. Environmental governance systems and procedures
2. Grievance and redress mechanisms: Principles and steps
3. Transparency and accountability in EA processes
4. Conflict of interest and disclosure guidelines
5. Role of institutions and international agencies

Suggested Readings

- Asian Development Bank, & International Centre for Integrated Mountain Development (ICIMOD). (2006). Environmental assessment of Nepal: Emerging issues and challenges. ICIMOD.
- Nepal Law Commission. (n.d.). Legal provisions of Nepal. Retrieved December 23, 2025, from https://lawcommission.gov.np/
- International Union for Conservation of Nature (IUCN). (1996). EIA training manual for professionals and engineers. Asian Regional Environmental Assessment Program, IUCN Nepal.
- Khadka, R. B., Gorzula, S., Joshi, A. R., Guragain, S., & Mathema, A. B. (2013). Environment impact assessment: Process, methods and practices in South Asia (Bangladesh, Bhutan, India, and Nepal). SchEMS and IED/RCBI.
- National Trust for Nature Conservation (NTNC). (2015). Information disclosure, grievance redressal and conflict of interest guidelines for transparency and accountability. NTNC.
- World Bank. (2014). The World Bank's approach to grievance redress in projects. World Bank.
- **World Bank.** (2025). *International Bank for Reconstruction and Development / The World Bank*. World Bank. https://www.worldbank.org

Course Title: Environmental Assessment and Mitigation **Credit Hour: 1**

Course Code: ESM 530 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Introduction

Environmental assessment and mitigation are critical components of sustainable development planning. This course equips students with practical skills to identify environmental issues, collect and analyze baseline data, predict and evaluate impacts, and prepare comprehensive environmental management plans. Through hands-on exercises, stakeholder engagement, and report preparation, students will develop the capacity to integrate scientific methods with participatory approaches for effective environmental decision-making.

Objectives

After completion of the course, students will be able to:

- Identify and analyze key environmental issues in proposed projects through screening, scoping, and stakeholder consultation.
- Design and conduct baseline studies using field sampling and laboratory analysis of air, water, soil, noise, and biodiversity.
- Apply predictive models and evaluation matrices to assess the magnitude, significance, and cumulative impacts of development activities.
- Prepare and appraise environmental assessment reports including management, monitoring, and auditing plans with budgetary considerations.

Unit 1: EIA Preliminary exercises **10 hrs**

1. Identify key environmental issues for a proposed project, Screening exercise
2. Develop ToR and SD for the EA study
3. Consult stakeholders and plan for public participation

Unit 2: Baseline Information Collection **15 hrs**

1. Field sampling (Air, Water, Soil, Noise and Biodiversity)
2. Baseline data collection

3. Air sampling and measurement
4. Water sampling and quality analysis
5. Soil quality test
6. Noise level determination
7. Assessment of floral and faunal abundance and diversity
8. Other site-specific baseline data

Unit 3: Impact Prediction and Evaluation **10 hrs**

1. Assessment and predicting impacts using mathematical models
2. Assessing significance using magnitude matrices
3. Cumulative impact assessment

Unit 4: Environmental Reports and Plans **10 hrs**

1. Preparation of EA report
2. Environmental management plan (including budget)
3. Environmental monitoring and auditing plan (including budget)

Suggested Readings

- Anjaneyulu, Y., & Manickam, V. (2011). Environmental impact assessment methodologies. CRC Press.
- Glasson, J., Therivel, R., & Chadwick, A. (2012). Introduction to environmental impact assessment. Routledge.
- International Union for Conservation of Nature (IUCN). (1996). EIA training manual for professionals and engineers. Asian Regional Environmental Assessment Program, IUCN Nepal.
- Khadka, R. B., Gorzula, S., Joshi, A. R., Guragain, S., & Mathema, A. B. (2013). Environment impact assessment: Process, methods and practices in South Asia (Bangladesh, Bhutan, India, and Nepal). SchEMS & IED/RCBI.

Course Title: Environmental Policy and Governance **Credit Hour: 2**

Course Code: ESM 525 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

Introduction

Environmental Policy and Governance examine the principles and processes of public policy formulation, implementation, and evaluation in relation to environmental issues. The course highlights the interplay between development and environment, emphasizing the need for harmonization through sustainable approaches. Students will study the roles and responsibilities of federal, provincial, and local governments in Nepal, alongside the involvement of civil society, private sector, and global institutions. The course also explores global environmental challenges such as climate change, biodiversity loss, and pollution, and introduces multilateral agreements and international governance frameworks. Case studies from Nepal and abroad provide practical insights into environmental justice, diplomacy, and policy effectiveness, preparing students to critically analyze governance systems and propose strategies for sustainable development.

Objectives

After completion of the course, students will be able to:

- Understand the fundamentals of public policy and governance in environmental contexts
- Acquire knowledge on formulation, execution, monitoring, and evaluation of environmental policies
- Critically analyze the balance between environmental justice and development actions
- Assess the roles of governments, institutions, and stakeholders in environmental governance
- Formulate strategies and agendas to address emerging environmental challenges at national and global levels

Unit 1: Fundamentals of Public Policy **6 hrs**

1. Concept and principles of public policy
2. Policy cycle: Formulation, Implementation, Monitoring, and Evaluation
3. Theories of public policy: Elite, Group, Incremental, Political system, Public process
4. Emerging trends in public policy

5. Roles of governmental and non-governmental sectors

Unit 2: Environmental Policy and Governance in Nepal **6 hrs**

1. Constitutional provisions on environmental rights and duties
2. Policies, Acts, Rules, Directives, and Guidelines of Nepal
3. Pollution control principles, safeguards, and standards compared to global norms
4. Functions of three levels of government in environmental governance
5. Roles of private sector, NGOs, CBOs, CFUGs, eco-clubs, and media

Unit 3: Global Perspectives on Environmental Governance **6 hrs**

1. Global environmental challenges: Climate change, Biodiversity loss, Land use change, Urbanization
2. Multilateral Environmental Agreements (MEAs): UNFCCC, CBD, Paris Agreement, Kyoto Protocol, Montreal Protocol, etc.
3. Roles of intergovernmental and global institutions: UNEP, UNDP, IPCC, GEF, GCF, World Bank, ICIMOD, WWF, ADB
4. International cooperation and global governance frameworks
5. Emerging global environmental justice issues

Unit 4: Environmental Diplomacy and Justice **6 hrs**

1. Nepal's strategies and actions to address environmental challenges
2. Negotiation processes and global power dynamics in climate diplomacy
3. Environmental justice and equity for marginalized communities
4. Capacity building and technology transfer: Green technologies, Digital diplomacy, Emerging technologies
5. Diplomacy on loss and damage, Climate action, and global carbon markets

Unit 5: Harmonization and Case Studies **6 hrs**

1. Development concepts, dimensions, and circular economy
2. Ecological economics and sustainable development (SDGs, MDGs)
3. Balancing environment and development agendas

4. Domestic case studies: Hydropower, Electric vehicles, Pollution standards, Community forestry, Biological corridors
5. International case studies: Best practices in balancing development and environmental protection

Suggested Readings

- Government of Nepal. (n.d.). Acts, rules, and regulations related to environment, governance, and policy of Nepal. Government of Nepal.
- Daly, H. E., & Farley, J. (2011). Ecological economics: Principles and applications. Island Press.
- Dixit, K. (2023). Dateline Earth: Journalism as if the planet mattered. Jagadamba Prakashan.
- Food and Agriculture Organization of the United Nations (FAO). (2015). Environmental and social management: Guidelines. FAO.
- Hill, M., & Hupe, P. (2006). Implementing public policy: Governance in theory and practice. Sage Publications.
- Palekar, S. A. (2012). Development administration. PHI Learning Pvt. Ltd.
- Pandey, J. N. (2002). Environmental management and sustainable development. Vikas Publishing.
- Peters, B. G., & Zittoun, P. (2016). Contemporary approaches to public policy: Theories, controversies and perspectives (International Series on Public Policy). Palgrave Macmillan.
- Pieterse, J. N. (2010). Development theory. Sage Publications.
- Sandler, R. L. (2014). Environmental justice and environmentalism: The social justice challenge to the environmental movement. MIT Press.
- Sapru, R. K. (2014). Public policy: Formulation, implementation and evaluation. Sterling Publishers Pvt. Ltd.
- Susskind, L., & Ali, S. H. (2015). Environmental diplomacy: Negotiating more effective global agreements. Oxford University Press.

Course Title: Environmental Policy and Governance **Credit Hour: 1**

Course Code: ESM 531 **Lecture Hours: 45**

Nature of Course: Term Paper and Seminar **Full Marks: 25**

Introduction

This practical-oriented course builds on theoretical foundations of environmental policy and governance by integrating applied exercises, field-based case studies, and seminar-style discussions. Students will engage in policy analysis, stakeholder mapping, and simulation of governance processes. Practical components emphasize Nepal's environmental governance structures, comparative global frameworks, and experiential learning through field visits, mock negotiations, and policy evaluation exercises.

Objectives

After completion, students will be able to:

- Apply policy cycle frameworks to real-world environmental issues.
- Conduct stakeholder analysis and evaluate governance roles at federal, provincial, and local levels.
- Simulate negotiation and diplomacy processes in climate and environmental governance.
- Prepare policy briefs and case study reports linking theory to practice.
- Critically assess governance effectiveness through field-based observations and seminar presentations.

Unit 1: Applied Public Policy Analysis **15 hrs**

1. Policy cycle workshop: Analyze a current environmental policy.
2. Stakeholder mapping exercise: Identify roles of government, NGOs, private sector, and communities.
3. Case-based discussion: Incremental vs. Elite theories applied to Bagmati River governance.
4. Short policy for evaluating one environmental policy instrument.

Unit 2: Governance in Practice **15 hrs**

1. Field visit: Observe governance mechanisms in action (community forestry group, hydropower project, Eco-club).
2. Comparative analysis: Nepal's pollution control standards vs. WHO guidelines.
3. Role-play exercise: Simulate provincial vs. federal government decision-making on environmental issues.
4. Practical output: Group report documenting governance challenges and opportunities in Nepal.

Unit 3: Global Governance and Diplomacy Simulation **15 hrs**

1. Simulation exercise: Mock UNFCCC negotiation (Students represent different countries/stakeholders).
2. Case study analysis: Hydro-diplomacy, Loss and damage diplomacy in COP negotiations.
3. Workshop: Drafting a position paper for Nepal on climate justice.
4. Practical output: Seminar presentation

Suggested Readings

- Anjaneyulu, Y., & Manickam, V. (2011). Environmental impact assessment methodologies. CRC Press.
- Asian Development Bank, & International Centre for Integrated Mountain Development (ICIMOD). (2006). Environmental assessment of Nepal: Emerging issues and challenges. ICIMOD.
- Burrough, P. A. (1987). Principles of geographical information systems for land resource assessment. Clarendon Press.
- Campbell, J. B. (2011). Introduction to remote sensing (5th ed.). Guilford Press.
- Chakraborty, D., & Sahoo, R. N. (2007). Fundamentals of GIS. Viva Books.
- Chang, K. T. (2022). Introduction to geographic information systems (10th ed.). McGraw-Hill.
- Daly, H. E., & Farley, J. (2011). Ecological economics: Principles and applications. Island Press.

- De Smith, M. J., Goodchild, M. F., & Longley, P. A. (2007). Geospatial analysis: A comprehensive guide to principles, techniques and software tools. Troubador Publishing Ltd.
- Dixit, K. (2023). Dateline Earth: Journalism as if the planet mattered. Jagadamba Prakashan.
- Dryzek, J. S. (2013). The politics of the earth: Environmental discourses (3rd ed.). Oxford University Press.
- Food and Agriculture Organization of the United Nations (FAO). (2015). Environmental and social management: Guidelines. FAO.
- Glasson, J., Therivel, R., & Chadwick, A. (2012). Introduction to environmental impact assessment. Routledge.
- Government of Nepal. (n.d.). Constitution, periodic plans, acts, rules, and regulations related to environment, governance, and policy of Nepal. Government of Nepal.
- Hill, M., & Hupe, P. (2006). Implementing public policy: Governance in theory and practice. Sage Publications.
- International Union for Conservation of Nature (IUCN). (1996). EIA training manual for professionals and engineers. Asian Regional Environmental Assessment Program, IUCN Nepal.
- Khadka, R. B., Gorzula, S., Joshi, A. R., Guragain, S., & Mathema, A. B. (2013). Environment impact assessment: Process, methods and practices in South Asia (Bangladesh, Bhutan, India, and Nepal). SchEMS & IED/RCBI.
- National Trust for Nature Conservation (NTNC). (2015). Information disclosure, grievance redressal and conflict of interest guidelines for transparency and accountability. NTNC.
- OECD. (2021). Environmental performance reviews: Policy and governance. OECD Publishing.
- Palekar, S. A. (2012). Development administration. PHI Learning Pvt. Ltd.
- Pandey, J. N. (2002). Environmental management and sustainable development. Vikas Publishing.
- Peters, B. G., & Zittoun, P. (2016). Contemporary approaches to public policy: Theories, controversies and perspectives (International Series on Public Policy). Palgrave Macmillan.

- Pieterse, J. N. (2010). Development theory. Sage Publications.
- Sandler, R. L. (2014). Environmental justice and environmentalism: The social justice challenge to the environmental movement. MIT Press.
- Sapru, R. K. (2014). Public policy: Formulation, implementation and evaluation. Sterling Publishers Pvt. Ltd.
- Susskind, L., & Ali, S. H. (2015). Environmental diplomacy: Negotiating more effective global agreements. Oxford University Press.
- United Nations Environment Programme (UNEP). (2019). Global environment outlook – GEO-6: Healthy planet, healthy people. Cambridge University Press.
- Vatn, A. (2015). Environmental governance: Institutions, policies and actions. Edward Elgar Publishing.
- World Bank. (2014). The World Bank's approach to grievance redress in projects. World Bank.
- World Bank. (2022). Integrating environmental governance into development planning. World Bank Publications.

Course Title: Research Methodology **Credit Hour: 2**

Course Code: ESM 526 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

Introduction

Research methodology is a systematic plan that researchers use to conduct a study, guiding how a problem is identified, how data is gathered, and how findings are analyzed and interpreted. It includes choosing an appropriate research design (whether qualitative, quantitative, or mixed methods), selecting suitable sampling techniques, and applying effective data collection tools such as interviews, surveys, or field and laboratory observations. A clear methodology ensures that a study is credible, ethical, and replicable by outlining every step, from reviewing related literature to analyzing results and drawing conclusions. This course therefore equips students with the skills to develop appropriate research methods for their research work. It covers techniques for identifying smart research questions, developing effective research design and producing a method which effectively helps to collect field-level data.

Objectives

After completion of the course, the students should be able to:

- Develop understanding on procedures and practices in research methods.
- Acquaint the students with skills in designing experiments.
- Apply the knowledge to develop effective research questions and designs.
- Comprehend the concept of research methods and procedures in completing dissertation work.

Unit 1: Scientific Reasoning **8 hrs**

1. Concept of scientific reasoning
2. Inductive and deductive reasonings: Concept, theory and examples
3. Population, samples; Grain and extent of research
4. Manipulative and natural experiments; Variables
5. Research ethics
6. Research metrics

Unit 2: Research Problem Identification **7 hrs**

1. Formulation of research problem (Research questions and objectives)
2. Criteria for a good research problem
3. Literature review: Purpose, identifying credible sources, using databases, summarizing, synthesizing and critiquing literature
4. Gap analysis and justification of research problems
5. Aligning research problems with policy relevance and practical applications

Unit 3: Sampling Design **10 hrs**

1. Overview of research process
2. Replication, randomization and control
3. Sample and Sampling methods
4. Research design (qualitative and quantitative)
5. Random sampling and non-random sampling methods
6. Data collection methods, management, data wrangling;
7. Sample size and effect size
8. Approaches to laboratory and field data analysis

Unit 4: Writing Research Report **5 hrs**

1. Structure of a research report
2. Research components (Proposals, Thesis, Scientific papers): Writing introduction, methods, findings, discussion, implications, conclusion and recommendations
3. Preparing for an academic presentation
4. Writing in-text citations and references
5. Plagiarism, originality, and use of reference management tools (EndNote, Mendeley, Zotero)

Suggested Readings

- Creswell, J. W., & Creswell, J. D. (2022). Research design: Qualitative, quantitative, and mixed methods approaches. Sage Publications.
- Jha, P. K., Shakya, D. D., Joshi, S. D., Chaudhary, R. P., & Shakya, S. R. (2004). Research methods and practice. Buddha Academic Publishers & Distributors Pvt. Ltd.
- Kothari, C. R. (2017). Research methodology: Methods and techniques. New Age International Publishers.
- Marra, M., & Nielsen, B. B. (2025). Research methodology: Best practices for rigorous, credible, and impactful research (Review of Herman Aguinis, Research methodology: Best practices for rigorous, credible, and impactful research, Sage Publications, 2024, ISBN 978-1071871942).
- Medhi, J. (2013). Statistical methods: An introductory text (2nd ed.). New Age International Publishers.
- Sokal, R. R., & Rohlf, F. J. (2009). Introduction to biostatistics (2nd ed.). Dover Publications.
- Zar, J. H. (2010). Biostatistical analysis (5th ed.). Pearson Education.
- Pant, R. R., Acharya, K. P., Bishwakarma, K., & Awasthi, M. P. (2023). Writing and publishing a scientific research paper. Curriculum Development Journal, 31(45), 148–166.

Course Title: Research Methodology **Credit Hour: 1**

Course Code: ESM 532 **Lecture Hours: 45**

Nature of Course: Practical (Compulsory) **Full Marks: 25**

Introduction

Research methodology is the systematic approach used to identify, select, process, and analyze information about a topic. A practical course in research methodology helps students to apply the theoretical knowledge to real research situations. Through hands-on activities such as designing questionnaires, collecting data, analyzing results, and preparing reports, students gain the essential skills required to conduct academic and professional research. This practical course bridges the gap between theory and application, enabling students to develop critical thinking, scientific inquiry, and problem-solving abilities. It prepares students to work independently on research projects, dissertations, internships, and real-world investigations.

Objectives

After completion, students will be able to:

- Support students to identify appropriate research questions, hypothesis and research questions.
- Equip with different research methods to answer the research questions framed.
- Provide hands-on-experience in data collection and analysis.
- Develop skills in academic writing and communicate findings.

Unit 1 : Selection of research topic 5 hrs

Unit 2 : Review of literature (Narrative review, Systematic review and Meta-analysis) 10 hrs

Unit 3 : Tools development: Questionnaire preparation, test for reliability 5 hrs

Unit 4 : Conduct surveys for primary data collection or secondary data collection 15 hrs

Unit 5 : Data analysis and management (Prepare tables, graphs, charts; Apply descriptive and inferential statistics) 5 hrs

Unit 6 : Prepare report and presentation 5 hrs

Suggested Readings

- Creswell, J. W., & Creswell, J. D. (2022). Research design: Qualitative, quantitative, and mixed methods approaches. Sage Publications.
- Jha, P. K., Shakya, D. D., Joshi, S. D., Chaudhary, R. P., & Shakya, S. R. (2004). Research methods and practice. Buddha Academic Publishers & Distributors Pvt. Ltd.
- Kothari, C. R. (2017). Research methodology: Methods and techniques. New Age International Publishers.
- Marra, M., & Nielsen, B. B. (2025). Research methodology: Best practices for rigorous, credible, and impactful research. Sage Publications.
- Zar, J. H. (2010). Biostatistical analysis (5th ed.). Pearson Education.

SEMESTER III

Specialized Theory, Applied Research, and Advanced Case Study/Project-based Practice Courses

Course Title: Environmental Modeling **Credit Hour: 2**

Course Code: ESM 631 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

Introduction

Understanding and predicting environmental change requires strong skills in spatial analysis, data-driven modeling and critical evaluation of model performance. This course provides hands-on training in geospatial and statistical tools used to model ecological and environmental processes with a prerequisite of course on spatial analysis. Through practical exercises using R and MaxEnt, students will learn to develop species distribution models, analyze land-use and climate change interactions and evaluate model performance and uncertainty. The course emphasizes applied learning through real-world environmental datasets and culminates in an independent modeling project, enabling students to apply computational and spatial analysis techniques to address pressing environmental challenges. This course enables students to apply quantitative modeling approaches used to analyze and simulate environmental systems. Through a combination of practical exercises and project-based learning, students will explore how to use leading modeling tools to study ecological and climate-related processes. Emphasis is placed on hands-on learning using real-world datasets, model building, validation and interpretation of results for environmental management and research applications. Software covered includes GIS, R and MaxEnt, along with global open-access data sources such as GBIF, WorldClim and Earthdata.

Objective

After completion of this course, the students are expected to:

- Develop and evaluate species distribution, land-use and climate change models using real-world ecological and geospatial data.
- Analyze model outputs to assess spatial and temporal environmental patterns and trends.
- Examine model performance and quantify uncertainty through appropriate evaluation metrics and validation techniques.
- Integrate modeling approaches and datasets to design and implement a scenario based environmental modeling project addressing a real-world issue.
- Explain the fundamental principles and purpose of environmental modeling.

- Identify and access key environmental datasets for modeling ecological and climate systems.
- Build and validate models using ArcGIS/QGIS,R and MaxEnt.
- Apply model evaluation metrics and sensitivity analysis to assess model performance.
- Interpret and communicate model outputs in scientific and policy-relevant contexts.
- Develop and present a small-scale modeling project addressing environmental problems

Module 1: Hands-on training with GIS and RS **5 hrs**

1. Introduction to Environmental modeling
2. Spatial data sources and coordinate systems
3. Raster analysis and terrain modeling
4. Introduction to R for environmental data analysis
5. Spatial data handling and visualization in R

Module 2: Training in Species Distribution Modeling **5 hrs**

1. Introduction to SDM concepts
2. Data preparation for SDM
3. Running SDM in MaxEnt
4. Model validation
5. Scenario modeling: Future projections

Module 3: Land Use and Climate Change Modeling **5 hrs**

1. Introduction to land-use change modeling
2. Image classification and land-cover mapping
3. Change detection and transition matrices
4. Integrating climate data with land-use models
5. Scenario building and visualization

Module 4: Model Evaluation and Uncertainty Analysis **5 hrs**

1. Model evaluation basics
2. Implementing evaluation metrics in R

3. Sensitivity analysis
4. Uncertainty quantification
5. Reporting and interpretation

Module 5: Project work **10 hrs**

1. Proposal development
2. Data acquisition and preparation
3. Model execution
4. Model evaluation
5. Reporting and presentation

Suggested Readings

- Bonan, G. (2019). Climate change and terrestrial ecosystem modeling (1st ed.). Cambridge University Press.
- Carnegie Mellon University (CMU). (1996). A brief Maxent tutorial. CMU School of Computer Science. Retrieved from https://www.cs.cmu.edu/afs/cs/user/aberger/www/html/tutorial/tutorial.html
- Fisher, R. A., & Koven, C. D. (2020). Perspectives on the future of land surface models and the challenges of representing complex terrestrial systems. Journal of Advances in Modeling Earth Systems, 12(4). https://doi.org/10.1029/2018ms001453
- Fisher, R. A., Koven, C. D., Anderegg, W. R. L., Christoffersen, B. O., Dietze, M. C., Farrior, C. E., Holm, J. A., Hurtt, G. C., Knox, R. G., Lawrence, P. J., Lichstein, J. W., Longo, M., Matheny, A. M., Medvigy, D., Muller-Landau, H. C., Powell, T. L., Serbin, S. P., Sato, H., Shuman, J. K., … Moorcroft, P. R. (2017). Vegetation demographics in Earth System Models: A review of progress and priorities. Global Change Biology, 24(1), 35–54. https://doi.org/10.1111/gcb.13910
- Merow, C., Smith, M. J., & Silander, J. A. (2013). A practical guide to MaxEnt for modeling species' distributions: What it does, and why inputs and settings matter. Ecography, 36(10), 1058–1069. https://doi.org/10.1111/j.1600-0587.2013.07872.x

- Peterson, A. T., Soberón, J., Pearson, R. G., Anderson, R. P., Martínez-Meyer, E., Nakamura, M., & Araújo, M. B. (2011). Ecological niches and geographic distributions (MPB-49). Princeton University Press.
- Phillips, S. J. (2010). A brief tutorial on Maxent. American Museum of Natural History. Retrieved from https://www.amnh.org/content/download/141371/2285439/file/a-brief-tutorial-on-maxent.pdf

Web Resources

- Climate Hazards Group. (n.d.). CHIRPS: Climate hazards group infrared precipitation with stations. Retrieved December 23, 2025, from https://www.chc.ucsb.edu/data/chirps
- CMIP6. (n.d.). Coupled Model Intercomparison Project Phase 6. Retrieved December 23, 2025, from https://esgf-node.llnl.gov/projects/cmip6/
- Copernicus Global Land Service. (n.d.). Global land products. Retrieved December 23, 2025, from https://land.copernicus.eu/global/
- EM-DAT. (n.d.). The international disaster database. Retrieved December 23, 2025, from https://public.emdat.be/
- ESA. (n.d.). Climate change initiative land cover. Retrieved December 23, 2025, from https://www.esa-landcover-cci.org/
- FAO. (n.d.). SoilGrids. Retrieved December 23, 2025, from https://soilgrids.org/
- GBIF. (n.d.). Global biodiversity information facility. Retrieved December 23, 2025, from https://www.gbif.org/
- OpenStreetMap. (n.d.). OpenStreetMap project. Retrieved December 23, 2025, from https://www.openstreetmap.org/
- HydroSHEDS. (n.d.). Hydrological data and maps based on SHuttle Elevation Derivatives at multiple Scales. Retrieved December 23, 2025, from https://www.hydrosheds.org/
- Map of Life. (n.d.). Global biodiversity mapping. Retrieved December 23, 2025, from https://www.mol.org/
- NASA. (n.d.). MODIS vegetation indices. Retrieved December 23, 2025, from https://modis.gsfc.nasa.gov/
- NASA. (n.d.). Earthdata. Retrieved December 23, 2025, from https://earthdata.nasa.gov/
- NASA JPL. (n.d.). SRTM/ASTER DEM. Retrieved December 23, 2025, from https://www2.jpl.nasa.gov/srtm/

- USGS. (n.d.). Earth Explorer. Retrieved December 23, 2025, from https://earthexplorer.usgs.gov/
- UNEP-WCMC. (n.d.). World database on protected areas (WDPA). Retrieved December 23, 2025, from https://www.protectedplanet.net/
- WorldClim. (n.d.). Global climate data. Retrieved December 23, 2025, from https://www.worldclim.org/

Course Title: Applied Statistics **Credit Hours: 2**

Course Code: ESM 632 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 50**

Introduction

Applied Statistics course introduces statistical tools and methods used to analyze and interpret data collected from field and laboratory studies. It emphasized on applications of applied statistical procedures to solve problems, support decision making and research for pertinent environmental issues. The selection of appropriate statistical tools and methods helps in providing valid and reliable research outputs and ensure informed decision making. In this context, this course will familiarize the students with the ability to design and organize research and interpretation of the data appropriately to draw valid inferences. The course provides a basis for carrying standard statistical methods for evaluation of the environmental covariates.

Objectives

After completion of the course, the students will be able to:

- Understand and apply the statistical procedures for the data collected from field and laboratory experiments.
- Perform the hypothesis testing procedures and interpret the results.
- Demonstrate the skills for designing research, including statistical techniques, in solving environmental problems.
- Develop computational and statistical skills for analyzing environmental data.

Unit 1: Data and Distributions **5 hrs**

1. Presentation and classification of data
2. Data collection methods and sampling procedures
3. Replication, randomization and control
4. Normal, binomial and Poisson probability distributions

Unit 2: Sampling and Estimation **5 hrs**

1. Elements of sampling theory
2. Sample size; Effect size

3. Checking data, errors and outliers; Data transformation
5. Measures of location and dispersion

Unit 3: Hypothesis Testing Methods **10 hrs**

1. Point and interval estimation
2. Hypothesis testing procedures; Level of significance and types of errors
3. Independent sample t-test, Paired t-test, Variance ratio test, one-way and two-way ANOVA, Nested ANOVA
4. Chi-square test, Wilcoxon test, Mann-Whitney U-test, Kruskal and Wallis test, Friedman test; Post Hoc tests

Unit 4: Correlation and Regression **10 hrs**

1. Correlation coefficients, test of significance of correlation coefficients
2. Linear regression; Fitting regression line
3. Multiple regressions and coefficients
4. Logistic regression and coefficients
5. Use and classification of multivariate analysis

Suggested Readings

- Cox, D. R., & Donnelly, C. A. (2011). Principles of applied statistics. Cambridge University Press.
- Davis, J. C. (2002). Statistics and data analysis in geology (3rd ed.). John Wiley & Sons.
- Hinton, P. R. (2024). Statistics explained. Routledge.
- Jha, P. K., Shakya, D. D., Joshi, S. D., Chaudhary, R. P., & Shakya, S. R. (2004). Research methods and practice. Buddha Academic Publishers & Distributors Pvt. Ltd.
- Medhi, J. (2013). Statistical methods: An introductory text (2nd ed.). New Age International Publishers.
- Sokal, R. R., & Rohlf, F. J. (2009). Introduction to biostatistics (2nd ed.). Dover Publications.
- Swain, A. K. P. C. (2004). Statistics with applications. V. K. Printers.
- Zar, J. H. (2010). Biostatistical analysis (5th ed.). Pearson Education.

Course Title: Research Proposal and Academic Writing **Credit Hour: 2**

Course Code: ESM 633 **Lecture Hours: 30**

Nature of Course: Theory (Compulsory) **Full Marks: 45**

Introduction

The course intends to provide theoretical and practical knowledge on the research and publication process, starting from how to framing a research idea and structure a proposal. Further, the students will be guided for the process of literature review and using referencing tools, designing research, hypothesis testing and finally they will be able to understand the process of writing a manuscript, peer review, and publication simulation. Overall, the students develop a clear research idea and builds academic skill needed for credible and publishable work to contribute both local and international scholarly discussions.

Objectives

After completion of the course, the students will be able to:

- Understand to frame research ideas, reviewing literatures
- Analyze research problem to frame clear and focused research ideas
- Understand research design, hypothesis testing and how to develop a well-structured research proposal
- Apply appropriate tools and techniques for manuscript writing and publication procedures

Unit 1: Literature review and research idea framing **5 hrs**

Literature review: Introduction to literature review; Searching sources of literature (types of sources, academic database using search engines; Reviewing, synthesizing and writing literature review); Research idea framing: Identifying research gap from literature; Developing research questions and formulating research hypotheses; Setting research objectives; Building theoretical and conceptual research framework; Assessing feasibility

Unit 2: Research Design and Proposal Writing **15 hrs**

Introduction to research design: Conceptualization of research design; Ensuring validity and reliability; Matching research questions and objectives; Types of research design: Qualitative

designs; Quantitative designs; Mixed-method designs; Choosing an appropriate research design based on research goals; Sampling strategy and data collection and analysis methods: Population, sample and sampling frame; Probability and non-probability samplings; Sample size determination; Quantitative and qualitative data collection tools; Environmental data analysis; Proposal structure and writing: Component of research proposal (title, abstract or summary, introduction/background, problem statement, research questions/hypothesis, research objectives, literature review section, methodology section, work plant/Gantt chart, budget, expected results/outcomes/outputs, novelty of research, ethical considerations, references, research tools); Referencing tools and techniques; Plagiarism checking

Unit 3: Manuscript Writing and Publication **5 hrs**

Purpose and importance of publishing research; Research proposal and manuscript (differences); Components of research manuscript; Journal selection and understanding journal guidelines; Submission portals/Online submission; Review procedures, addressing reviewers' comments and proofreading techniques; Ethical issues in publication

Unit 4: Seminars **5 hrs**

Presentation of research papers of interested thematic area published in journals

Suggested Readings

- **Cargill, M., & O'Connor, P. D.** (2013). *Writing scientific research articles: Strategy and steps*. John Wiley & Sons.
- **Creswell, J. W., & Creswell, J. D.** (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage Publications.
- **Friedland, A. J., Folt, C. L., & Mercer, J. L.** (2018). *Writing successful science proposals*. Yale University Press.
- **Mayyas, F., & Alzoubi, K.** (2022). Awareness and knowledge of manuscript writing and research integrity: A cross-sectional survey among graduate students. *Heliyon, 8*(11), e11345. https://doi.org/10.1016/j.heliyon.2022.e11345

- **Moore, S.** (2023). Submitting a manuscript to a scientific journal. *Respiratory Care, 68*(9), 1314–1319. https://doi.org/10.4187/respcare.11234
- **Pickett, S. T., & McDonnell, M. J.** (2017). The art and science of writing a publishable article. *Journal of Urban Ecology, 3*(1), jux018. https://doi.org/10.1093/jue/jux018
- **Sedaghat, A. R., Bernal-Sprekelsen, M., Fokkens, W. J., Smith, T. L., Stewart, M. G., & Johnson, R. F.** (2024). How to be a good reviewer: A step-by-step guide for approaching peer review of a scientific manuscript. *Laryngoscope Investigative Otolaryngology, 9*(3), e1266. https://doi.org/10.1002/lio2.1266
- **Terrell, S. R.** (2015). *Writing a proposal for your dissertation: Guidelines and examples*. Guilford Publications.
- **Pant, R. R., Acharya, K. P., Bishwakarma, K., & Awasthi, M. P.** (2023). Writing and publishing a scientific research paper. *Curriculum Development Journal, 31*(45), 148–166.

Note: The application-oriented courses offered this semester are designed to complement and support the specialized courses. Exercises and internal examinations will emphasize applied aspects directly related to the specialized subjects.

Group A: Disaster Risk Management

Course Title: Disaster Types and Principles of Disaster Risk Management (DRM)

Credit Hours: 2

Course Code: ESM 634 DT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

This course introduces students to the diverse types of disasters affecting Nepal and the world. It explains the disaster management cycle and emphasizes preparedness, response, and resilience. Students will engage with theoretical concepts, case studies, and interactive activities to critically understand vulnerabilities, risks, and strategies for disaster reduction.

Objectives

After completion of the course, students will be able to:

- Understand the differences between hazards, vulnerabilities and exposure.
- Analyze the unknown key concepts, theories, models and principles relevant to disaster management and risk reduction.
- Critically evaluate the severity of different disaster types.

Unit 1: Disaster Classification **6 hrs**

1. Natural disasters: Flood, Landslides, Earthquake, Earthquake and its occurrence, some deadly earthquakes of the past, Earthquakes in Nepal, Seismic measurement, Fire, Thunderstorm, Hailstorm, GLOF, Climate Change, Drought, Famine, Tsunami, Desertification, Epidemics and Avalanche
2. Man-induced disasters: Nuclear, Biological, Chemical, Building Fire, Forest Fire, Coal Fire, Oil Fire, Air Pollution, Avalanche, Deforestation, Road Accidents, Rail Accidents, Sea Accidents and Mountaineering Accidents Water Pollution, Industrial Wastewater Pollution

Unit 2: Disaster Terminology and Principles **6 hrs**

1. Hazards, Disaster, Risk, Vulnerability, Resilience
2. Principles of Disaster Risk Reduction: Prevention, Preparedness, Mitigation, Relief, Rescue and Recovery
3. Historical evolution of disaster risk and reduction policies and practices

Unit 3: Hazard and Vulnerability **6 hrs**

1. Hazard Analysis: Deterministic, Probabilistic, Stochastic and Recursive
2. Study of vulnerability: Impact on city and society, Vulnerability analysis and Risk Assessment, Observation and perception of vulnerability, Vulnerability Identification, Vulnerability: Social Factors, Mapping Social Vulnerability, Vulnerability: Economic Factors, The Experience of Vulnerability, Strategies for Survival, Geographic information system and remote sensing for vulnerability assessment

Unit 4: Earthquake Vulnerability and Risks **7 hrs**

1. Earthquake Vulnerability, Vulnerability Assessment Tools, Rapid Visual Screening, Pattern of failures of buildings, Fragility Curves, Study made on earthquakes, Preparedness in Nepal with emphasis on urban and rural areas, Retrofitting and its progress in Nepal, Earthquake Resistant Technology, Assessment of vulnerability using quantitative and qualitative methods
2. Understanding Risk: Concepts and Elements, Risk Analysis Technique, and Development, Risk Sharing and Financing, Resource Analysis and Mobilization, Strategic Developments for Vulnerability Reduction, Participatory Risk Assessment, Integrating risk assessment in planning process, Risk Management Tools such as HAZUS, RADIUS

Unit 5: Disaster Impact and Resilience **5 hrs**

1. Physical Impact, Buildings and infrastructure, integrating disaster risk management in development planning
2. Disaster risk financing in development planning, Social Impact, Poverty and marginalized population, Disability and Disasters, Cultural Impact, Damage on the monuments, Resilience, Build Back Better

Unit 2: Principles of Disaster Risk Reduction **6 hrs**

1. Disaster management cycle: Preparedness, Response, Recovery, Reconstruction
2. Hazard analysis: Deterministic, Probabilistic, Stochastic approaches
3. International frameworks and Nepal's disaster policies

Unit 3: Vulnerability and Risk Assessment **6 hrs**

1. Social and economic dimensions of vulnerability
2. Tools for vulnerability identification and risk assessment
3. Case studies of urban and rural vulnerability in Nepal

Unit 4: Earthquake Risk and Preparedness **6 hrs**

1. Seismic hazards and earthquake history in Nepal
2. Building failures and retrofitting technology
3. Earthquake-resistant design and community preparedness

Unit 5: Resilience and Sustainable Disaster Management **6 hrs**

1. Concepts of resilience and "Build Back Better"
2. Resource mobilization and participatory risk assessment
3. Physical, social, and cultural impacts of disasters
4. Strategies for long-term vulnerability reduction

Suggested Readings

- Conant, A., & Brewer, G. (2022). Principles and practice: Towards disaster risk reduction in New South Wales, Australia. Urban Governance, 2(2), 285–295. https://doi.org/10.1016/j.ugov.2022.12.005
- Shrivastav, A., Singh, D., Saxena, R., Gautam, S., & Chaudhary, D. S. (n.d.). A textbook of disaster management. [Publisher information needed].
- Seddiky, M. A., Giggins, H., & Gajendran, T. (2020). International principles of disaster risk reduction informing NGOs strategies for community-based DRR mainstreaming: The

Bangladesh context. International Journal of Disaster Risk Reduction, 48, 101580. https://doi.org/10.1016/j.ijdrr.2020.101580

- Government of Nepal, Ministry of Home Affairs. (2023). Nepal disaster report 2023. Government of Nepal.
- Shaw, R. (2014). Community practices for disaster risk reduction in Japan. Springer. https://doi.org/10.1007/978-4-431-54246-0

Course Title: Disaster Types and Principles of Disaster Risk Management (DRM)

Credit Hour: 1

Course Code: ESM 634 DP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Introduction

This case study course emphasizes the practical application of disaster risk management principles in diverse contexts. Students will critically examine natural and man-made disasters, their causes, impacts, and management strategies. Selected case studies from Nepal, including earthquakes, floods, landslides, glacial lake outburst floods (GLOFs), and epidemics, will be used to strengthen analytical skills and contextual understanding. The course integrates scientific, technical, governance, and socio-economic perspectives to highlight challenges and opportunities in disaster preparedness, response, and resilience building.

Objectives

After completion of the course, students will be able to:

- Analyze case studies of natural and man-made disasters across diverse urban and rural contexts.
- Evaluate disaster preparedness, response, and reconstruction strategies applied in Nepal and globally.
- Investigate vulnerability and resilience factors influencing disaster impacts.
- Apply theoretical frameworks to practical case studies linking technical, ecological, and socio-economic dimensions.
- Formulate strategies for sustainable disaster risk reduction based on evidence and lessons learned.

Case Study Themes

1. Disaster Classifications and their occurrence in Nepal
2. Earthquake case studies**:** 2015 Gorkha Earthquake (Nepal), building failures, retrofitting, community preparedness.

3. Flood and GLOF case studies**:** Mahakali flood, Koshi floods, Melamchi flood disaster, Imja Lake GLOF risk management.
4. Landslide case studies**:** Sindhupalchok landslides, Slope stability and Community relocation.
5. Fire and epidemic case studies**:** Urban fire hazards in Kathmandu Valley, COVID-19 pandemic response in Nepal.
6. Man-made disaster case studies**:** Industrial accidents, Air pollution episodes, Transport accidents.
7. Governance and institutions**:** Role of NDRRMA, municipalities, NGOs, and international agencies in disaster response.
8. Community-based approaches**:** Participatory risk assessment, Gender and equity in disaster preparedness.
9. Best practices**:** National and International case studies in resilience building, "Build Back Better" strategies
10. Vulnerability Assessment Tools
11. Social Impact of Disasters in Nepal
12. Cultural Impact of Disasters in Nepal

Suggested Readings

- Conant, A., Brewer, G., & colleagues. (2022). Principles and practice: Towards disaster risk reduction in New South Wales, Australia. Urban Governance, 2(2), 285–295. https://doi.org/10.1016/j.ugov.2022.12.005
- Alexander, D. (2013). Principles of emergency management and planning. Oxford University Press.
- Coppola, D. P. (2015). Introduction to international disaster management. Elsevier.
- Government of Nepal, Ministry of Home Affairs. (2017). Disaster Risk Reduction and Management Act. Government of Nepal.
- International Centre for Integrated Mountain Development (ICIMOD). (2019). Glacial lake outburst floods and disaster preparedness in the Hindu Kush Himalaya. ICIMOD.

- Seddiky, M. A., Giggins, H., & Gajendran, T. (2020). International principles of disaster risk reduction informing NGOs strategies for community-based DRR mainstreaming: The Bangladesh context. International Journal of Disaster Risk Reduction, 48, 101580. https://doi.org/10.1016/j.ijdrr.2020.101580
- National Disaster Risk Reduction and Management Authority (NDRRMA). (2021). Nepal disaster report 2021: Status and trends of disaster risk reduction in Nepal. Government of Nepal.
- National Planning Commission (NPC), & United Nations Development Programme (UNDP). (2015). Post disaster needs assessment (PDNA): Nepal earthquake 2015. Government of Nepal.
- Practical Action Nepal. (2018). Community-based disaster preparedness in Nepal: Case studies and lessons learned. Practical Action Nepal.
- United Nations Office for Disaster Risk Reduction (UNDRR). (2015). Sendai framework for disaster risk reduction 2015–2030. UNDRR.
- Wisner, B., Gaillard, J. C., & Kelman, I. (2012). Handbook of hazards and disaster risk reduction. Routledge.
- Shrivastav, A., Singh, D., Saxena, R., Gautam, S., & Chaudhary, D. S. (2024). A textbook of disaster management. Shaswant Publication.
- Twigg, J. (2004). Good practice review: Disaster risk reduction, mitigation and preparedness in development and emergency programming. Humanitarian Practice Network.
- Shaw, R. (2014). Community practices for disaster risk reduction in Japan. Springer. https://doi.org/10.1007/978-4-431-54246-0
- Government agency or organization. (n.d.). Report by a government agency or other organization. [Publisher details needed].
- Government of Nepal, Ministry of Home Affairs. (2023). Nepal disaster report 2023. Government of Nepal.

Course Title: Disaster Science and Laboratory **Credit Hours: 2**

Course Code: ESM 635 DT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

This course introduces the scientific principles underlying different disaster phenomena and provides opportunities to understand them through laboratory demonstrations. It emphasizes the physics, chemistry, and Earth Science processes that govern disasters such as earthquakes, floods, landslides, fires, and atmospheric hazards. Students will gain practical exposure to hazard simulation, measurement techniques, and experimental analysis, bridging theory with applied disaster science.

Objectives

After completion of the course, students will be able to:

- Understand the differences between hypothesis, theory, science, technology and innovation.
- Analyze the scientific causes of earthquakes, floods, landslides, fires, lightning, and strong wind.
- Demonstrate disaster phenomena through laboratory experiments and simulations.
- Apply scientific instruments and techniques for hazard measurement and monitoring.
- Evaluate laboratory findings to connect disaster science with risk reduction strategies.

Unit 1: Earthquake **8 hrs**

1. Earthquake, History, Causes, Classification and Impact, Tectonics movement, Faults and Margins, Primary, Secondary and Surface waves, Liquefaction
2. Measurement and Scales, Seismographs, Real time warning system, Local seismological network, Building Code and Earthquake Resistant Technology

Unit 2: Flood **8 hrs**

1. Flood, Rainfall run off attributes of Nepal, Cloud burst, Glacial Lake Outburst, and Landslide Burst floods in Nepal

2. Flood Hazard Mapping, Absorption of the rain by the ground, Saturation with water, Contribution to formation of water body and its movement

Unit 3: Landslide **6 hrs**

1. Landslide, Occurrence and Impact, Geological and Geomorphological subdivision of Nepal triggering landslides, Earthquake induced landslides
2. Landslide Hazard Assessment, Rainfall, building up of the pore pressure and the occurrence of the landslide, Cracks Formation and Water Leakage triggering landslides, Early warning system, Bio-Engineering

Unit 4: Fire and Winds **8 hrs**

1. Fire, Types: Structural, Wild and Industrial fires, Fundamental of Fire Behaviour such as Fire triangle, Ignition, Combustion and Heat Transfer, Fire Dynamics: Flame Spread, Smoke movement and Fire Growth, Fire Hazard and Risk Analysis
2. Fire Detection System: Heat Detectors, Flame Detectors and Drying up of the building materials, Reaching of the inflammation point, Creation of convection currents, Fire mitigation and Management
3. Wind, Creation of the low and high-pressure zone and the movement of the air relating to wind

Suggested Readings

- Bell, F. G. (1999). Geological hazards. CRC Press.
- Shrivastav, A., Singh, D., Saxena, R., Gautam, S., & Chaudhary, D. S. (2024). A textbook of disaster management. Shaswant Publication.
- Hyndman, D., & Hyndman, D. (2010). Natural hazards and disasters (3rd ed.). Cengage Learning.
- Government of Nepal, Ministry of Home Affairs. (2023). Nepal disaster report 2023. Government of Nepal.
- Pettijohn, F. J. (1983). Sedimentary rocks (3rd ed.). HarperCollins.
- Plummer, C., Carlson, D., & Hammersley, L. (2014). Physical geology (15th ed.). McGraw Hill

- Shaw, R. (2014). Community practices for disaster risk reduction in Japan. Springer. https://doi.org/10.1007/978-4-431-54246-0
- Parajuli, R. R. (2020). Citizen disaster science education for effective disaster risk reduction in developing countries. Geoenvironmental Disasters, 7(1), 1–12. https://doi.org/10.1186/s40677-020-00155-3
- Aven, T. (2025). On the relationship between disaster science and risk science. Risk Analysis, 45(9), 2494–2503. https://doi.org/10.1111/risa.14567

Course Title: Disaster Science and Laboratory **Credit Hour: 1**

Course Code: ESM 635 DP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Introduction

This case study course focuses on the scientific principles underlying disaster phenomena and their laboratory demonstrations. Students will critically examine earthquakes, floods, landslides, fires, and atmospheric hazards through experimental simulations and case studies. Selected examples from Nepal including seismic events, glacial lake outburst floods (GLOFs), landslides, and urban fire hazards will be used to strengthen analytical skills and contextual understanding. The course integrates Earth Science, physics, hydrology, and atmospheric science perspectives to highlight challenges and opportunities in disaster science and laboratory practice.

Objectives

After completion of the course, students will be able to:

- Analyze case studies of disaster phenomena using scientific and laboratory approaches.
- Evaluate experimental methods for simulating earthquakes, floods, landslides, fires, and wind hazards.
- Investigate the physical processes and environmental conditions that trigger disasters.
- Apply laboratory findings to real-world disaster case studies in Nepal and globally.

- Formulate strategies for linking scientific evidence with disaster preparedness and risk reduction.

Case Study Themes

1. **Earthquake science**: Case studies of the 2015 Gorkha Earthquake; laboratory demonstrations of seismic waves, tectonic stress, and building response.
2. **Flood and hydrological hazards:** Mahakali flood, Koshi floods, Melamchi flood disaster; Laboratory experiments on infiltration, runoff, and hydrograph simulation.
3. **Landslide processes:** Sindhupalchok landslides; Laboratory experiments on slope stability, pore pressure, and soil shear strength.
4. **Fire hazards:** Urban fire incidents; laboratory demonstrations of ignition points, combustion dynamics, and convection currents.
5. **Atmospheric hazards:** Case studies of windstorms and lightning strikes in Nepal; Laboratory simulations of pressure zones, airflow, and electrical discharge.
6. **Integration of science and practice:** Linking laboratory experiments with disaster preparedness, mitigation, and resilience strategies.
7. **Best practices:** National and international case studies in hazard simulation, monitoring, and laboratory-based disaster education.
8. **Laboratory experiment on:**
    1. Hand-specimen study of common Igneous, Metamorphic and Sedimentary rocks
    2. Seismograph Interpretation
    3. Hydraulic Modelling and Simulation
    4. Rainfall induced Landslide Simulation
    5. Atmospheric Fluid Dynamics Simulation
    6. Fire Behavior modelling

Note: As per the availability of resources, both field-based study and laboratory analysis will be conducted. Laboratory experiment (no. 8) is compulsory and must be completed in designated laboratories.

Suggested Readings

- Bolt, B. A. (1999). Earthquakes. W. H. Freeman & Co.
- Coppola, D. P. (2015). Introduction to international disaster management. Elsevier.
- Drysdale, D. (2011). An introduction to fire dynamics. Wiley.
- Government of Nepal, Ministry of Home Affairs. (2017). Disaster Risk Reduction and Management Act. Government of Nepal.
- International Centre for Integrated Mountain Development (ICIMOD). (2019). Glacial lake outburst floods and disaster preparedness in the Hindu Kush Himalaya. ICIMOD.
- National Disaster Risk Reduction and Management Authority (NDRRMA). (2021). Nepal disaster report 2021: Status and trends of disaster risk reduction in Nepal. Government of Nepal.
- National Planning Commission (NPC), & United Nations Development Programme (UNDP). (2015). Post disaster needs assessment (PDNA): Nepal earthquake 2015. Government of Nepal.
- Practical Action Nepal. (2018). Community-based disaster preparedness in Nepal: Case studies and lessons learned. Practical Action Nepal.
- Wallace, J. M., & Hobbs, P. V. (2006). Atmospheric science: An introductory survey. Academic Press.

  Wisner, B., Gaillard, J. C., & Kelman, I. (2012). Handbook of hazards and disaster risk reduction. Routledge.

Course Title: Disaster Preparedness and Response **Credit Hour: 2**

Course Code: ESM 636 DT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

This course emphasizes the practical application of disaster preparedness and response principles in real-world contexts. Students will critically examine preparedness planning, emergency response mechanisms, and community-based approaches through selected case studies. Examples from Nepal including earthquakes, floods, landslides, epidemics, and glacial lake outburst floods (GLOFs) will be used to strengthen analytical skills and contextual understanding. The course integrates scientific, institutional, and socio-economic perspectives to highlight challenges and opportunities in building resilience and effective disaster response.

Objectives

After completion of the course, students will be able to:

- Understand disaster preparedness fundamentals
- Recognize stakeholder roles in preparedness and response
- Identify key response sectors and standards
- Explain coordination, information management, and logistics
- Apply needs assessment methodologies

- Formulate a response framework and case study plan
- Evaluate national and international response systems

Unit 1: Preparedness **5 hrs**

1. Disaster Preparedness, Concept and nature, Indigenous Methods, Disaster Preparedness Plan
2. Disaster Preparedness for people with special needs, Health and Sanitation
3. WASH, Shelter and Nutrition

Unit 2: Housing and Infrastructure **5 hrs**

1. Disaster Preparedness with Relevance to housing, rural and Urban Settlement.
2. Infrastructure and livestock, Industry Transport and Infrastructure, Water Resources and Energy
3. Disaster Needs Assessment and PDNA

Unit 3: Community Based Preparedness **5 hrs**

1. Community based disaster Preparedness Plan and Early Warning System, Hazard Mapping, Mapping Social Vulnerability, Gender sensitivity and Inclusion
2. Agriculture and Food Security, Forest, Bio-diversity and Water Shed Construction
3. Role of information, education
4. Communication and training, Simulation and Modelling
5. Necessary Logistics

Unit 4: Disaster Response and Communication **5 hrs**

1. Disaster Response: Indigenous Methods, Participation, and Activation of Emergency Preparedness Plans
2. Health and Disease Transmission
3. Emergency Communication: Wireless, Radio, and Ham Radio
4. Search and Rescue Operations; The Cluster Approach

Unit 5: Logistics and Emergency Planning **5 hrs**

1. Logistic Management, Needs and Damage Assessment
2. Declaration of Emergency and Calls for Assistance
3. PDNA, Emergency and Temporary Shelters
4. Construction of WASH Facilities in Emergency Planning

Unit 6: Governance, Stakeholders, Institutions and Standards **5 hrs**

1. Central, Provincial, District, and Local Administration; Armed Forces, Police, and Other Organizations
2. Role of NGOs, INGOs, and International Agencies; Gender, Disability, and Social Inclusion
3. Psychological Response: Trauma, Stress, Rumor, and Panic Management
4. Minimum Standards of Relief; SPHERE Standards; Managing and Funding Relief
5. Hyogo Framework of Action, Sendai Framework

Suggested Readings

- Alexander, D. (2013). Principles of emergency management and planning. Oxford University Press.
- Coppola, D. P. (2015). Introduction to international disaster management. Elsevier.
- Government of Nepal, Ministry of Home Affairs. (2017). Disaster Risk Reduction and Management Act. Government of Nepal.
- Government of Nepal, Ministry of Home Affairs. (2019). National disaster risk reduction policy. Government of Nepal.
- International Centre for Integrated Mountain Development (ICIMOD). (2019). Glacial lake outburst floods and disaster preparedness in the Hindu Kush Himalaya. ICIMOD.
- National Disaster Risk Reduction and Management Authority (NDRRMA). (2021). Nepal disaster report 2021: Status and trends of disaster risk reduction in Nepal. Government of Nepal.
- National Planning Commission (NPC), & United Nations Development Programme (UNDP). (2015). Post disaster needs assessment (PDNA): Nepal earthquake 2015. Government of Nepal.

- Practical Action Nepal. (2018). Community-based disaster preparedness in Nepal: Case studies and lessons learned. Practical Action Nepal.
- United Nations Office for Disaster Risk Reduction (UNDRR). (2015). Sendai framework for disaster risk reduction 2015–2030. UNDRR.
- Wisner, B., Gaillard, J. C., & Kelman, I. (2012). Handbook of hazards and disaster risk reduction. Routledge.
- Suparji, S.,…(2024). Disaster preparedness culture in Japan and Indonesia: Cultural perspectives and practical implementation. [Journal name]. [Publisher details/DOI needed].
- Guo, L.,…. (2025). The development of disaster preparedness education for public: A scoping review. International Journal of Health Economics and Management. Springer. https://doi.org/[insert DOI]
- Shrivastav, A., Singh, D., Saxena, R., Gautam, S., & Chaudhary, D. S. (2024). A textbook of disaster management. Shaswant Publication.
- Twigg, J. (2004). Good practice review: Disaster risk reduction, mitigation and preparedness in development and emergency programming. Humanitarian Practice Network.
- Shaw, R. (2014). Community practices for disaster risk reduction in Japan. Springer. https://doi.org/10.1007/978-4-431-54246-0
- Sutton, J., …. (2006). Disaster preparedness: Concepts, guidance, and research. Natural Hazards Center, Institute of Behavioral Science, University of Colorado Boulder. Retrieved from http://www.colorado.edu/hazards

Course Title: Disaster Preparedness and Response **Credit Hour: 1**

Course Code: ESM 636 DP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Case Study Themes

1. **Earthquake preparedness and response**: 2015 Gorkha Earthquake, emergency operations, search and rescue, medical response.
2. **Flood and GLOF preparedness**: Mahakali flood, Koshi floods, Imja Lake GLOF risk management, early warning systems.
3. **Landslide preparedness**: Sindhupalchok landslides, Slope monitoring, Community relocation strategies.
4. **Epidemic and pandemic response**: COVID-19 in Nepal, Coordination of health services, Vaccination campaigns.
5. **Community-based disaster preparedness**: Participatory risk assessment, Gender and equity in preparedness, Role of NGOs and civil society.
6. **Institutional frameworks**: Role of NDRRMA, local governments, and humanitarian agencies in preparedness and response.
7. **Best practices**: National and international case studies in resilience building, "Build Back Better" strategies.
8. Search and Rescue Operations
9. Review of Post Disaster Needs Assessment
10. Disability and Social Inclusion in Disaster Management in Nepal
11. Performance of GOs and NGOs in Disaster Response in Nepal
12. Sphere Standards and their application in Nepal

Suggested Readings:

- Yang, X., Yao, Y., Tian, K., Jiang, W., Xing, Q., Yang, J., & Liu, C. (2023). Disaster response strategies of governments and social organizations: From the perspective of infrastructure damage and asymmetric resource dependence. Heliyon, 9(10), e22222. https://doi.org/10.1016/j.heliyon.2023.e22222
- Ardiansyah, M., …. (2024). Disaster management and emergency response: Improving coordination and preparedness. [Publisher details needed].
- Government agency or organization. (n.d.). Report by a government agency or other organization. [Publisher details needed].
- Government of Nepal, Ministry of Home Affairs. (2023). Nepal disaster report 2023. Government of Nepal.

Course Title: Disaster Reconstruction and Legal Framework **Credit Hour: 2**

Course Code: ESM 637 DT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

This course explores the processes of disaster reconstruction and the legal frameworks that guide them. It emphasizes post-disaster recovery, rehabilitation, and reconstruction strategies, while analyzing national and international laws, policies, and institutional arrangements. Students will learn how reconstruction integrates with sustainable development, resilience building, and community empowerment. Special focus is given to Nepal's disaster-related legal instruments, constitutional provisions, and international conventions.

Objectives

After completion of the course, students will be able to:

- Understand the principles and processes of disaster reconstruction and rehabilitation.
- Analyze national and international legal frameworks governing disaster management.
- Evaluate institutional arrangements and policies for post-disaster recovery in Nepal.
- Apply reconstruction strategies that integrate resilience and sustainability.
- Formulate recommendations for strengthening legal and policy frameworks in disaster governance.

Unit 1: Concepts of Disaster Reconstruction **6 hrs**

1. Recovery, rehabilitation, reconstruction.
2. Principles of reconstruction: Resilience, Sustainability, Inclusivity.
3. Case studies: Nepal earthquake 2015 reconstruction.

Unit 2: Legal Frameworks for Disaster Management **6 hrs**

1. National Disaster Risk Reduction and Management Act (2017).
2. Local Government Disaster and Climate Resilience Planning Guideline (2018).
3. Constitutional provisions of Nepal related to disaster governance.
4. International conventions: Sendai Framework, Hyogo Framework, UNDRR guidelines.

Unit 3: Institutional Arrangements and Policies **6 hrs**

1. National Disaster Risk Reduction and Management Authority (NDRRMA).
2. Role of government ministries, NGOs, INGOs, and civil society.
3. Coordination mechanisms in post-disaster reconstruction.
4. Case studies: Post Disaster Needs Assessment (PDNA) Nepal 2015.

Unit 4: Reconstruction Strategies and Practices **6 hrs**

1. Housing reconstruction: Retrofitting, Earthquake-resistant design.
2. Infrastructure recovery: Schools, hospitals, roads, heritage sites.
3. Livelihood restoration and social protection.
4. Community participation in reconstruction.

Unit 5: Challenges and Future Directions **6 hrs**

1. Legal gaps and enforcement challenges.
2. Financing reconstruction: Relief funds, insurance, donor support.
3. Integrating reconstruction with sustainable development goals (SDGs).
4. Future of disaster governance in Nepal.

Suggested Readings

- Alexander, D. (2013). Principles of emergency management and planning. Oxford University Press.
- Coppola, D. P. (2015). Introduction to international disaster management. Elsevier.
- Government of Nepal, Ministry of Federal Affairs and General Administration. (2018). Local disaster and climate resilience planning guideline. Government of Nepal.
- Government of Nepal, Ministry of Home Affairs. (2017). Disaster Risk Reduction and Management Act. Government of Nepal.
- International Centre for Integrated Mountain Development (ICIMOD). (2019). Heritage reconstruction and resilience in the Hindu Kush Himalaya. ICIMOD.
- National Planning Commission (NPC), & United Nations Development Programme (UNDP). (2015). Post disaster needs assessment (PDNA): Nepal earthquake 2015. Government of Nepal.
- National Reconstruction Authority. (2016–2020). Annual reports on post-earthquake reconstruction. Government of Nepal.
- National Disaster Risk Reduction and Management Authority (NDRRMA). (2021). Nepal disaster report 2021: Status and trends of disaster risk reduction in Nepal. Government of Nepal.
- United Nations Office for Disaster Risk Reduction (UNDRR). (2015). Sendai framework for disaster risk reduction 2015–2030. UNDRR.
- Wisner, B., Gaillard, J. C., & Kelman, I. (2012). Handbook of hazards and disaster risk reduction. Routledge.

Course Title: Disaster Reconstruction and Legal Framework **Credit Hour: 2**

Course Code: ESM 637 DP **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

Disaster Reconstruction and Legal Framework include actions taken during the period after the emergency phase following the rules and regulations. Reconstruction refers to the actions taken in the aftermath of a disaster to enable basic services to resume functioning, assist victims' self-help efforts to repair physical damage and community facilities, revive economic activities and provide support for rehabilitation including the psychological and social well-being of the survivors. It focuses on enabling the affected population to resume more-or-less normal (pre-disaster) patterns of life with the added dimension of reducing risks and vulnerabilities that led to the disaster in the first place and avoid creating new ones.

Objectives

After completion of the course, students will be able to:

- Place reconstruction within the wider development processes.
- Understand the purpose of reconstruction.
- Demonstrate linkages between development and risk reduction in reconstruction processes.
- Describe and operationalize Reconstruction Guiding Principles.
- Outline key factors, benefits, barriers, strategies and activities for integrating disaster risk reduction in reconstruction.
- Identify tools, mechanisms and key relationships in pre-disaster reconstruction planning.
- Know about the legal provisions existent in the area of disaster risk reduction reconstruction

Unit 1: Reconstruction **8 hrs**

1. Disaster Reconstruction, Indigenous Methods
2. Problems on the acquisition of the land
3. Cost effective technology for construction of houses

4. Innovative technologies in disaster risk reduction such as drones, artificial intelligence, augmented and virtual reality
5. Tourism, natural and cultural heritage

Unit 2: Settlement Planning and Technologies **6 hrs**

1. Disaster resilient Planning of settlements
2. Achieving resilient planning through sustainable development, Disaster Reconstruction in Giranchour, Nepal
3. Disaster resistant technologies

Unit 3: Disaster Governance **8 hrs**

1. Definition of Law, Equality to the law, Concept of Law
2. Legislation, Ordinance, Bil, Act, Regulations and Bye Laws, Importance of Law and its relationship to disaster management Disaster Risk Management
3. Nepal Constitution and disaster risk management
4. National Disaster Risk Reduction and Management Act
5. Natural Calamity Act
6. National Strategy on Disaster Risk Management
7. Existing Acts and Policies
8. Mainstreaming disaster risk reduction in sectoral policies and plans

Unit 4: Disaster Management Plans, Bye Laws, and International Experience **8 hrs**

1. National Management Plans and Mainstreaming of Disasters in Periodic Plans of Nepal
2. Disaster Risk Management: District and Community-Level Plans
3. Building Bye Laws and Building Codes
4. International Experience: Review of Studies by the United Nations, International Organizations, and Research Institutes
5. International Framework Laws and Treaties

Suggested Readings

- Alexander, D. (2013). Principles of emergency management and planning. Oxford University Press.
- Coppola, D. P. (2015). Introduction to international disaster management. Elsevier.
- Government of Nepal, Ministry of Federal Affairs and General Administration. (2018). Local disaster and climate resilience planning guideline. Government of Nepal.
- Government of Nepal, Ministry of Home Affairs. (2017). Disaster Risk Reduction and Management Act. Government of Nepal.
- International Centre for Integrated Mountain Development (ICIMOD). (2019). Heritage reconstruction and resilience in the Hindu Kush Himalaya. ICIMOD.
- National Planning Commission (NPC), & United Nations Development Programme (UNDP). (2015). Post disaster needs assessment (PDNA): Nepal earthquake 2015. Government of Nepal.
- National Reconstruction Authority. (2016–2020). Annual reports on post-earthquake reconstruction. Government of Nepal.
- National Disaster Risk Reduction and Management Authority (NDRRMA). (2021). Nepal disaster report 2021: Status and trends of disaster risk reduction in Nepal. Government of Nepal.
- United Nations Office for Disaster Risk Reduction (UNDRR). (2015). Sendai framework for disaster risk reduction 2015–2030. UNDRR.
- Wisner, B., Gaillard, J. C., & Kelman, I. (2012). Handbook of hazards and disaster risk reduction. Routledge.
- Puri, A., [additional authors]. (2024). Identifying major challenges in managing post-disaster reconstruction projects: A critical analysis. International Journal of Disaster Risk Reduction, 107, 104491. https://doi.org/10.1016/j.ijdrr.2024.104491
- Puri, A., [additional authors]. (2025). Contracting challenges in post-disaster reconstruction in developing countries: Evidence from Nepal reconstruction. International Journal of Disaster Risk Reduction, 121. https://doi.org.

- Shrestha, B., [additional authors]. (2025). A longitudinal study of post-disaster resettlement in Nepal: Insights into building back better. ResearchGate. https://www.researchgate.net/.
- Shrestha, B., [additional authors]. (2023). Factors influencing housing satisfaction in post-disaster resettlement. Sustainability, 15(12), 10045. https://doi.org/[insert DOI]
- Shrivastav, A., Singh, D., Saxena, R., Gautam, S., & Chaudhary, D. S. (2024). A textbook of disaster management. Shaswant Publication.
- Twigg, J. (2004). Good practice review: Disaster risk reduction, mitigation and preparedness in development and emergency programming. Humanitarian Practice Network.
- Shaw, R. (2014). Community practices for disaster risk reduction in Japan. Springer. https://doi.org/10.1007/978-4-431-54246-0
- Government agency or organization. (n.d.). Report by a government agency or other organization. [Publisher details needed].
- Government of Nepal, Ministry of Home Affairs. (2023). Nepal disaster report 2023. Government of Nepal.

Course Title: Disaster Reconstruction and Legal Framework **Credit Hour: 1**

Course Code: ESM 637 DP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Introduction

This case study course emphasizes the practical application of disaster reconstruction strategies and the legal frameworks guiding them. Students will critically examine post-disaster recovery, rehabilitation, and reconstruction processes, with a focus on housing, infrastructure, livelihoods, and heritage restoration. Selected case studies from Nepal, including the 2015 Gorkha Earthquake, flood recovery, and landslide rehabilitation, will be used to strengthen analytical skills and contextual understanding. The course integrates legal, institutional, and socio-economic perspectives to highlight challenges and opportunities in achieving resilient reconstruction.

Objectives

After completion of the course, students will be able to:

- Analyze case studies of disaster reconstruction and rehabilitation across diverse contexts.
- Evaluate national and international legal frameworks governing disaster management and reconstruction.
- Investigate institutional arrangements and policies for post-disaster recovery in Nepal.
- Apply reconstruction strategies linking technical, ecological, and socio-economic dimensions.
- Formulate recommendations for strengthening legal and policy frameworks in disaster governance.

Case Study Themes

1. **Earthquake reconstruction**: 2015 Gorkha Earthquake, housing retrofitting, earthquake-resistant design, community participation.
2. **Flood and landslide recovery**: Koshi floods, Sindhupalchok landslides, relocation and livelihood restoration.
3. **Legal frameworks**: Disaster Risk Reduction and Management Act (2017), Local Disaster and Climate Resilience Planning Guideline (2018), constitutional provisions.

4. **Institutional arrangements**: Role of NDRRMA, National Reconstruction Authority (NRA), municipalities, NGOs, INGOs.
5. **Heritage reconstruction**: Case studies of cultural monuments and heritage sites damaged in the 2015 earthquake.
6. **Community-based approaches**: Participatory reconstruction, gender and equity in recovery.
7. **Best practices**: National and international case studies in "Build Back Better" and resilient reconstruction.
8. Cost Effective Technologies for Post Disaster Reconstruction
9. Disaster Legislations in Nepal
10. Disaster Reconstruction Financing
11. Building Bye Laws, Building Code and their implementation in Nepal
12. Support of National and International Institutions for Disaster Reconstruction in Nepal

Note: As per the needs and requirements, the department/campus can conduct case studies in the form of project work. Students must select a topic related to disaster preparedness, response, reconstruction, or disaster science. The project should be a live case undertaken in consultation with the local government so that its outcomes can be applied, partly or fully, after completion.

Suggested Readings

- Alexander, D. (2013). Principles of emergency management and planning. Oxford University Press.
- Coppola, D. P. (2015). Introduction to international disaster management. Elsevier.
- Government of Nepal, Ministry of Federal Affairs and General Administration. (2018). Local disaster and climate resilience planning guideline. Government of Nepal.
- Government of Nepal, Ministry of Home Affairs. (2017). Disaster Risk Reduction and Management Act. Government of Nepal.
- International Centre for Integrated Mountain Development (ICIMOD). (2019). Heritage reconstruction and resilience in the Hindu Kush Himalaya. ICIMOD.

- National Planning Commission (NPC), & United Nations Development Programme (UNDP). (2015). Post disaster needs assessment (PDNA): Nepal earthquake 2015. Government of Nepal.
- National Reconstruction Authority. (2016–2020). Annual reports on post-earthquake reconstruction. Government of Nepal.
- National Disaster Risk Reduction and Management Authority (NDRRMA). (2021). Nepal disaster report 2021: Status and trends of disaster risk reduction in Nepal. Government of Nepal.
- United Nations Office for Disaster Risk Reduction (UNDRR). (2015). Sendai framework for disaster risk reduction 2015–2030. UNDRR.
- Wisner, B., Gaillard, J. C., & Kelman, I. (2012). Handbook of hazards and disaster risk reduction. Routledge.

Group B: Natural Resources Management

Course Title: Natural Resources and Management Systems **Credit Hour: 2**

Course Code: ESM 634 NT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

Natural Resource Management (NRM) is an integrated and multidisciplinary approach combining ecology, life science, social science, and conservation science to manage and restore natural resources and ecosystems. This course emphasizes resource accounting, sustainable use, and restoration of biotic and abiotic resources across land, atmosphere, wetlands, forests, and grasslands, while relating them to human demand and supply. It is designed to balance the needs of people and the economy with special focus on ecosystem protection.

Objectives

After completion of the course, students will be able to:

- Understand conceptual and analytical perspectives to study natural resources and their management.
- Explain governance paradigms and roles of researchers, governance, markets, and civil society.
- Develop critical thinking and interdisciplinary expertise in resource management.
- Evaluate policy and planning tools integrating sustainability and ecosystem services.

Unit 1: Conceptual Approaches and Issues **6 hrs**

1. The Crisis of Planet Earth, Public Concerns
2. Concept of Natural Resources and their interrelationship
3. Carrying capacity, Ecological footprint, Resilience capacity, Sustainability
4. Property Rights, Externalities
5. Perspectives of Deep Ecology, Ecofeminism, Ecological Pragmatism, Political Ecology, Political Economy

Unit 2: Classification and Principles of Conservation **6 hrs**

1. Classification of Natural Resources: Inexhaustible vs. Exhaustible
2. Inventories and projections of resource use
3. Interlocking resource relationships
4. Multiple use of a given resource
5. Role of Government and individual responsibility in conservation

Unit 3: Human Population and Land Resources **6 hrs**

1. Population size, density, dispersion, migration, fluctuation
2. Mortality rate factors, Malthusian theory, Food and energy shortages
3. Soil: History of land use, Soil erosion and management
4. Depletion of soil nutrients and restoration of fertility
5. Soil conservation regulations

Unit 4: Wetlands and Their Management **6 hrs**

1. Wetland types, functions, values, threats
2. Wise use principles, Wetland governance and restoration
3. Major wetlands of the world and Nepal
4. Ramsar sites of Nepal
5. Ramsar Convention and other regulations

Unit 5: Governance and Sustainable Resource Management **6 hrs**

1. Common property resources: Concepts and types
2. Institutional arrangements for management
3. Gender and equity in NRM
4. Role of NGOs and civil societies
5. The limit to growth, Natural resources accounting (NRA)
6. Cost-benefit ratio
7. Sustainable development, Resource conflicts, Poverty implications
8. Future of Planet Earth

Suggested Readings

- Everard, M. (2009). The business of biodiversity. WIT Press.
- Government of Nepal, Ministry of Agriculture and Livestock Development (MoALD). (2024). Statistical information on Nepalese agriculture. Government of Nepal.
- Government of Nepal, Ministry of Forests and Soil Conservation (MoFSC). (2025). Nepal national biodiversity strategy and action plan. Government of Nepal.
- Jha, P. K., Neupane, F. P., Shrestha, M. L., & Khanal, I. P. (Eds.). (2013). Biological diversity and conservation. Nepal Academy of Science and Technology (NAST).
- Jha, P. K., Neupane, F. P., Shrestha, M. L., & Khanal, I. P. (Eds.). (2013). Environment and natural resources. Nepal Academy of Science and Technology (NAST).
- Government of Nepal. (n.d.). National policies, acts, and regulations of Nepal regarding natural resource management, soil, and watershed conservation. Government of Nepal.
- Nishi, M., Subramanian, S. M., & Varghese, P. (2025). Business and biodiversity. Springer Singapore.
- Panicker, L. K., Nelliyat, P., & Oommen, O. V. (2024). Biodiversity and business. Springer Cham.
- Pearce, D., Barbier, E., & Markandya, A. (2000). Sustainable development: Economics and environment in the third world. Routledge.
- Uttarakhand Open University (UOU). (2023). Fundamentals of natural resource management. Uttarakhand Open University.

Course Title: Natural Resources and Management Systems **Credit Hour: 1**

Course Code: ESM 634 NP **Lecture Hours: 45**

Nature of Course: Case Study (Specialization) **Full Marks: 25**

Introduction

This case study course emphasizes practical application of natural resource management concepts through real-world examples. Students will critically examine ecological, socio-economic, and governance dimensions of resource use, focusing on successes, failures, and lessons learned. The course highlights Nepal's diverse ecosystems, with selected examples from the Terai, Hill, and Himalayan regions of Far Western Nepal, to strengthen contextual understanding and analytical skills.

Objectives

After completion of the course, students will be able to:

- Analyze case studies of natural resource management systems in varied ecological and socio-economic contexts.
- Evaluate governance systems, institutional arrangements, and community-based practices.
- Investigate socio-economic and ecological impacts of resource use and conservation.
- Apply theoretical frameworks to practical case studies.
- Formulate strategies for sustainable resource management based on evidence and lessons learned.

Case Study Themes

1. **Land resources**: Land Use Change, Soil Erosion, Watershed Management, Agro-Ecological Zoning.
2. **Wetlands**: Ramsar Sites (e.g., Ghodaghodi Lake, Rara Lake), Wetland Governance, Restoration Practices.
3. **Forests and biodiversity**: Community Forestry, Protected Areas (e.g., Shuklaphanta National Park, Api Nampa Conservation Area), Wildlife Management.
4. **Water resources**: River Basin Management, Irrigation Systems, Transboundary Governance.

5. **Mineral resources**: Mining Practices, Environmental Impacts, Sustainable Mining Approaches.
6. **Human dimensions**: Migration, Urban Expansion (e.g., Dhangadhi), Resource Conflicts, Livelihood Challenges.
7. **Governance and institutions**: Common Property Management, Role of NGO's and Civil Society, Gender and Equity in NRM.
8. **Sustainability frameworks**: Natural resource accounting, cost-benefit analysis, climate resilience, poverty implications.

Suggested Readings

- Adhikari, A. D. (1998). Urban and environmental planning in Nepal. [Publisher details needed].
- Everard, M. (2009). The business of biodiversity. WIT Press.
- Food and Agriculture Organization of the United Nations (FAO). (2007). Land evaluation: Towards a revised framework. FAO.
- Food and Agriculture Organization of the United Nations (FAO). (2011). The state of the world's land and water resources for food and agriculture (SOLAW). FAO.
- Government of Nepal, Ministry of Agriculture and Livestock Development (MoALD). (2024). Statistical information on Nepalese agriculture. Government of Nepal.
- Government of Nepal, Ministry of Forests and Soil Conservation (MoFSC). (2025). Nepal national biodiversity strategy and action plan. Government of Nepal.
- International Centre for Integrated Mountain Development (ICIMOD). (2022). Transboundary landscapes and resource governance in the Himalayas. ICIMOD.
- Jha, P. K., Neupane, F. P., Shrestha, M. L., & Khanal, I. P. (2013). Biological diversity and conservation. Nepal Academy of Science and Technology (NAST).
- Government of Nepal, Ministry of Urban Development (MoUD). (2017). National urban development strategy 2017. Government of Nepal.
- United Nations Environment Programme (UNEP). (2013). Integrating the environment in urban planning and management. UNEP.

Course Title: Biological And Agricultural Resources Management **Credit Hour: 2**

Course Code: ESM 635 NT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

Biological Resource Management (BRM) enriches students with approaches for responsible resource management and decision-making. It integrates agriculture and fisheries, forests and wildlife, grasslands and livestock, medicinal and aromatic plants, horticulture, and other biomaterial resources, emphasizing sustainable use, management, analysis, processing, product development, marketing, and economic development.

Objectives

After completion of the course, students will be able to:

- Critically analyze conceptual and analytical perspectives on biological and agricultural resources and their management.
- Appraise and synthesize governance paradigms, explaining the roles of researchers, governance, civil society, entrepreneurs, products, and markets.
- Foster and apply interdisciplinary expertise and critical thinking skills in biological resource management.
- Formulate and evaluate policy and planning tools that integrate sustainability and ecosystem services.

Unit 1: Biodiversity and Biological Resources **6 hrs**

1. Biodiversity as a source of biological resources
2. Values of biodiversity and biological resources
3. Valuation of different ecosystems
4. Major biological resources, causes of loss, current challenges
5. Principles of sustainable resource management

Unit 2: Agricultural, Fisheries, and Livestock Resources **6 hrs**

1. Agriculture development in Nepal
2. Agricultural plans and policies of Nepal
3. Food sources: Demand and supply
4. Fish farming: production and challenges
5. Agribusiness, Sustainable agriculture, Environmental concerns, and Management approaches
6. Grassland and livestock: Importance, contribution, threats, and management approaches

Unit 3: Forest and Wildlife Resources **6 hrs**

1. Forests and their importance globally and in Nepal
2. Forest production, contribution, demand, and challenges
3. Status of wildlife and their role in ecosystems in Nepal
4. Protected areas of Nepal and their contribution to nature conservation

Unit 4: Medicinal, Aromatic, and Horticultural Resources **6 hrs**

1. Medicinal and aromatic plants (MAPs) in Nepal and global scenario
2. Trade, threats, sustainable wild collection principles for MAPs
3. Policies and regulations regarding MAPs
4. Bioprospecting of MAPs
5. Status of fruits, vegetables, nuts, flowering plants, turf, and indoor plants in Nepal
6. Challenges and solutions in horticulture

Unit 5: Biotechnology, Product Processing, and Marketing Strategies **6 hrs**

1. Development of genetically modified organisms and their impacts
2. Biopesticides, Biofertilizers, Bioremediation, Biological warfare
3. Innovations in product development, grading, and packaging
4. Biomaterials
5. Marketing benefits
6. Green banking and Ecotourism
7. Royalties from resource extractions, successful business models

Suggested Readings

- Acquaah, G. (2009). Horticulture: Principles and practices. PHI Learning Pvt Ltd.
- Everard, M. (2009). The business of biodiversity. WIT Press.
- Farooqi, A. A., & Sreeramu, B. S. (2010). Cultivation of medicinal and aromatic crops. Universities Press Pvt Ltd.
- Government of Nepal, Ministry of Agriculture and Livestock Development (MoALD). (2024). Statistical information on Nepalese agriculture. Government of Nepal.
- Government of Nepal, Ministry of Forests and Soil Conservation (MoFSC). (2015). State of Nepal's forests. Department of Forest Research and Survey, Government of Nepal.
- Government of Nepal, Ministry of Forests and Soil Conservation (MoFSC). (2025). Nepal national biodiversity strategy and action plan. Government of Nepal.
- Food and Agriculture Organization of the United Nations (FAO). (n.d.). State of forest genetic resources conservation and management in Nepal. Retrieved December 23, 2025, from https://www.fao.org
- Jha, P. K., Karmacharya, S. B., Balla, M. K., Chettri, M. K., & Shrestha, B. B. (2010). Sustainable uses of biological resources in Nepal. Ecological Society (ECOS).
- Jha, P. K., Karmacharya, S. B., Chettri, M. K., Thapa, C. B., & Shrestha, B. B. (2008). Medicinal plants in Nepal. Ecological Society (ECOS).
- Jha, P. K., Neupane, F. P., Shrestha, M. L., & Khanal, I. P. (Eds.). (2013). Biological diversity and conservation. Nepal Academy of Science and Technology (NAST).
- Jha, P. K., Neupane, F. P., Shrestha, M. L., & Khanal, I. P. (Eds.). (2013). Environment and natural resources. Nepal Academy of Science and Technology (NAST).
- Government of Nepal. (n.d.). National policies, acts, and regulations of Nepal. Government of Nepal.
- Panicker, L. K., Nelliyat, P., & Oommen, O. V. (2024). Biodiversity and business. Springer Cham.
- Shyaula, S. L., Bajracharya, G. B., K. C., G., Shakya, S. M., & Subba, D. (2021). Comprehensive insights in vegetables of Nepal. Nepal Academy of Science and Technology (NAST).

- Siwakoti, M., Mandal, T. N., Rai, S. K., Rai, S. K., Gautam, T. P., Aryal, H. P., & Limbu, K. P. (2021). Integrating biological resources for prosperity. Botanical Society of Nepal.
- Uttarakhand Open University (UOU). (2023). Fundamentals of natural resource management. Uttarakhand Open University.

Course Title: Biological and Agricultural Resources Management **Credit Hour: 1**
Course Code: ESM 635 NP **Lecture Hours: 45**
Nature of Course: Case Study (Specialization) **Full Marks: 25**

Introduction

This case study course emphasizes the practical application of biological and agricultural resource management concepts through real-world examples. Students will critically examine agriculture, fisheries, forests, livestock, medicinal plants, horticulture, and biotechnology systems, focusing on sustainable use, governance, and socio-economic impacts. Selected case studies from Nepal including Terai farming systems, hill community forestry, and Himalayan livestock practices will strengthen contextual understanding and analytical skills.

Objectives

After completion of the course, students will be able to:

- Analyze case studies of biological and agricultural resource management across diverse ecological contexts.
- Evaluate governance systems, institutional arrangements, and market mechanisms influencing biological resources.
- Investigate socio-economic and ecological impacts of agriculture, forestry, fisheries, and livestock practices.
- Apply theoretical frameworks to practical case studies in biological resource management.
- Formulate strategies for sustainable biological and agricultural resource use, integrating innovation and policy tools.

Case Study Themes

1. **Agriculture and food systems**: Crop Diversification, Irrigation Practices, Food Security Challenges in Terai.
2. **Fisheries and aquaculture**: Fish Farming Models, Production Constraints, Community-Based Management.
3. **Forests and wildlife**: Community Forestry in Hills, Protected Areas, Biodiversity Conservation.

4. **Grasslands and livestock**: Grazing Management, Pastoralism in Himalayan Regions, Livelihood Impacts.
5. **Medicinal and aromatic plants (MAPs)**: Sustainable Collection, Trade, Bioprospecting, Policy Frameworks.
6. **Horticulture**: Fruit And Vegetable Production, Challenges in Commercialization, Case Studies of Success.
7. **Biotechnology and bioresources**: GMOs, Biofertilizers, Biopesticides, Innovations in Product Development.
8. **Markets and sustainability**: Agribusiness Models, Eco-Tourism, Royalties from Biological Resources, Green Banking.

Suggested Readings

- Acquaah, G. (2009). Horticulture: Principles and practices. PHI Learning Pvt Ltd.
- Everard, M. (2009). The business of biodiversity. WIT Press.
- Farooqi, A. A., & Sreeramu, B. S. (2010). Cultivation of medicinal and aromatic crops. Universities Press.
- Government of Nepal, Ministry of Agriculture and Livestock Development (MoALD). (2024). Statistical information on Nepalese agriculture. Government of Nepal.
- Government of Nepal, Ministry of Forests and Soil Conservation (MoFSC). (2025). Nepal national biodiversity strategy and action plan. Government of Nepal.
- Jha, P. K., Karmacharya, S. B., Balla, M. K., Chettri, M. K., & Shrestha, B. B. (2010). Sustainable uses of biological resources in Nepal. Ecological Society (ECOS).
- Jha, P. K., Neupane, F. P., Shrestha, M. L., & Khanal, I. P. (2013). Biological diversity and conservation. Nepal Academy of Science and Technology (NAST).
- Government of Nepal. (n.d.). National policies, acts, and regulations of Nepal related to agriculture, forestry, fisheries, and biodiversity. Government of Nepal.
- Panicker, L. K., Nelliyat, P., & Oommen, O. V. (2024). Biodiversity and business. Springer Cham.
- Siwakoti, M., Mandal, T. N., Rai, S. K., Rai, S. K., Gautam, T. P., Aryal, H. P., & Limbu, K. P. (2021). Integrating biological resources for prosperity. Botanical Society of Nepal.

Course Title: Watershed and Water Resources Management **Credit Hour: 2**

Course Code: ESM 636 NT **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

Water resources lie at the core of environmental systems, sustaining ecosystems, livelihoods, and national prosperity. Watersheds, as fundamental hydrological units, integrate land, water, and ecological processes, making their management central to water security. In the context of climate change, increasing variability, hydro-climatic extremes, and competing demands pose challenges to sustainable water use. This course provides students with concepts, approaches, and tools for water resource management, with a particular emphasis on watershed-based planning, monitoring, governance, and pathways for resilience and water security.

Objectives

After completing this course, students will be able to:

- Explain the central role of water in environmental security, development, and national prosperity.
- Assess the adequacy of hydro-climatic monitoring systems and analyze hydrological data.
- Evaluate approaches to water resource management, including watershed-based and integrated frameworks.
- Identify pathways for water security under climate variability and change.
- Examine governance structures, policies, and transboundary issues in water resource management.

Unit 1. Water Resources as a component of Environment **5 hrs**

1. Water for environment and development: Water as a driver of prosperity; Nexus with energy, food, and ecosystems
2. Water resources availability and use: Sources, global and regional trends, Nepal's water resources context
3. Hydrological systems and watershed boundaries: System thinking, factors affecting water yield

4. Need for water resources management: Development practices and climate change challenges

Unit 2. Monitoring, Data Management, and Analysis **5 hrs**

1. Hydro-climatic monitoring systems: Rainfall, climate, and hydrological stations; Adequacy and gaps
2. Data acquisition and quality assessment
3. Time-series analysis: Spatial and temporal trends, Heterogeneities
4. Snow-fed vs. rained hydrological systems: Data characteristics and implications

Unit 3. Water Resources Management Approaches **7 hrs**

1. Surface water dynamics: River systems in Nepal, Watershed characterization, Challenges of surface water use
2. Groundwater dynamics: Aquifers in Nepal, availability, use, and management challenges
3. Evolution of water resource management: From development-focused to efficiency and sustainability
4. Integrated Water Resources Management (IWRM): Concepts, principles, practices, and watershed-based approaches

Unit 4. Water Security in the Changing Climate **8 hrs**

1. Climate variability and change: Scenarios and impacts across water-related sectors
2. Hydro-climatic extremes: Floods, Droughts, Glacial Lake Outburst Floods (GLOFs)
3. Pathways for water security: Efficiency measures (Rainwater harvesting, Irrigation technologies, Reuse), Watershed conservation, Spring/River rejuvenation
4. Resilience of water resource systems: Frameworks, approaches, and challenges

Unit 5. Water Resources Governance **5 hrs**

1. Fundamentals of natural resource governance: Concepts and approaches
2. Legal and policy landscapes: National Water Laws, Policies, and International conventions
3. Water administration in Nepal: Federal, Provincial, and Local structures

4. Transboundary water issues: Shared basins, Inter-provincial and international cooperation, Hydro-diplomacy

Suggested Readings

- CAP-Net, Global Water Partnership (GWP), & United Nations Development Programme (UNDP). (2005). Integrated water resources management plans: Training manual and operational guide. UNDP.
- International Centre for Integrated Mountain Development (ICIMOD). (2019). Springshed management in the Hindu Kush Himalaya. ICIMOD.
- Loucks, D. P., & Van Beek, E. (2005). Water resources systems planning and management. UNESCO.
- Molden, D. (Ed.). (2007). Water for food, water for life: A comprehensive assessment of water management in agriculture. Earthscan.
- Shrestha, S., Babel, M. S., & Pandey, V. P. (2014). Climate change and water resources. CRC Press.
- Simonovic, S. P. (2008). Managing water resources: Methods and tools for a systems approach. Earthscan.
- Water and Energy Commission Secretariat (WECS). (2011). Water resources of Nepal in the context of climate change. Government of Nepal.
- **Pant, R. R., Gautam, S. K., Basnet, N., Awasthi, M. P., Joshi, K. R., & Bishwakarma, K.** (2026). Water governance and Strategic Development Goal 6: Strategies and insights from Central Himalaya, Nepal. Royal Society of Chemistry.

Course Title: Watershed and Water Resources Management **Credit Hour: 1**

Course Code: ESM 636 NP **Lecture Hours: 45**

Nature of Course: Case Study (Specialization) **Full Marks: 25**

Introduction

This case study course emphasizes practical application of watershed and water resource management concepts through real-world examples. Students will critically examine hydrological systems, watershed-based planning, climate change impacts, and governance structures. The course highlights Nepal's diverse water contexts from snow-fed Himalayan rivers to Terai irrigation systems with selected case studies to strengthen analytical skills and contextual understanding.

Objectives

After completion of the course, students will be able to:

- Analyze case studies of watershed and water resource management across ecological and socio-economic contexts.
- Evaluate hydro-climatic monitoring systems, data adequacy, and implications for management.
- Investigate impacts of climate variability, floods, droughts, and glacial lake outburst floods (GLOFs).
- Apply integrated water resource management (IWRM) frameworks to practical case studies.
- Formulate strategies for water security, resilience, and governance based on evidence and lessons learned.

Case Study Themes

1. **Hydrological systems**: Watershed Boundaries, Water Yield Factors, Snow-Fed Vs. Rainfed Systems.

2. **Monitoring and data**: Rainfall and Hydrological Stations, Time-Series Analysis, Data Gaps.
3. **Surface and groundwater management**: River Basin Characterization, Aquifer Use, Challenges of Over-Extraction.
4. **Climate change impacts**: Floods, Droughts, GLOFs, Pathways for Resilience and Water Security.
5. **Water use efficiency**: Irrigation Technologies, Rainwater Harvesting, Reuse, Spring Rejuvenation.
6. **Governance and institutions**: National Water Policies, Federal/Provincial/Local Structures, Hydro-Diplomacy.
7. **Transboundary issues**: Shared Basins, Inter-Provincial Cooperation, International Conventions.

Suggested Readings

- CAP-Net, Global Water Partnership (GWP), & United Nations Development Programme (UNDP). (2005). Integrated water resources management plans: Training manual and operational guide. UNDP.
- International Centre for Integrated Mountain Development (ICIMOD). (2019). Springshed management in the Hindu Kush Himalaya. ICIMOD.
- International Centre for Integrated Mountain Development (ICIMOD). (2022). Transboundary water governance in the Himalayas. ICIMOD.
- Loucks, D. P., & Van Beek, E. (2005). Water resources systems planning and management. UNESCO.
- Molden, D. (Ed.). (2007). Water for food, water for life: A comprehensive assessment of water management in agriculture. Earthscan.
- Government of Nepal. (n.d.). National policies, acts, and regulations of Nepal related to water resources and watershed management. Government of Nepal.
- Shrestha, S., Babel, M. S., & Pandey, V. P. (2014). Climate change and water resources. CRC Press.
- Simonovic, S. P. (2008). Managing water resources: Methods and tools for a systems approach. Earthscan.

- United Nations Environment Programme (UNEP). (2013). Integrating the environment in urban planning and management. UNEP.
- Water and Energy Commission Secretariat (WECS). (2011). Water resources of Nepal in the context of climate change. Government of Nepal.

Course Title: Land and Mineral Resources Management **Credit Hour: 2**
Course Code: ESM 637 NT **Lecture Hours: 30**
Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

Land and mineral resources are fundamental to human survival and development, providing the basis for agriculture, infrastructure, industry, and energy. Their mismanagement leads to degradation, ecological imbalance, and socio-economic conflict. This course equips students with frameworks and tools to critically evaluate, plan, and manage land and mineral resources. It emphasizes sustainable land use, ecological surveys, agro-ecological zoning, mining practices, and the socio-economic and environmental impacts of resource utilization.

Urbanization and rapid land-use change further complicate resource management, creating challenges such as informal settlements, pollution, waste management, and urban heat islands. The course therefore integrates perspectives from urban environmental planning, sustainability, and governance to provide students with a holistic understanding of land and mineral resource management in both rural and urban contexts. Special focus is given to Nepal's policies, legislation, and institutional arrangements, alongside global frameworks for sustainable development.

Objectives

After completion of the course, students will be able to:

- Critically evaluate the concepts, issues, and types of land and mineral resources in rural and urban contexts.

- Apply and synthesize methods for land and mineral resource evaluation, including ecological and urban planning frameworks.
- Investigate and appraise human impacts on land and mineral resources, including socio economic and environmental dimensions of urbanization.
- Integrate and utilize tools and techniques for sustainable land, mineral, and urban resource management.
- Formulate and analyze strategies, policies, and programs for sustainable land, mineral, and urban development.

Unit 1: Foundations of Land Resource Management **6 hrs**

1. Components, functions, concerns, issues, and types of land resources
2. Landscape approaches and ecological surveys
3. Land resource inventories and agro-ecological surveys
4. Linkages between land resources and urbanization

Unit 2: Human Impacts and Land Degradation **6 hrs**

1. Land use change and land degradation processes
2. Drivers of degradation in Nepal and globally
3. Socio-economic and ecological consequences of unsustainable land use
4. Urban environmental challenges: Informal settlements, Pollution, Waste management, Drainage and sewerage

Unit 3: Land Evaluation and Planning Frameworks **6 hrs**

1. FAO framework and other land evaluation methods
2. Land Capability Classification and site assessment
3. Agro-ecological zoning
4. Frameworks for sustainable land management evaluation
5. Principles, processes, and methods of land use planning
6. Role of land use policy in urban planning

Unit 4: Sustainable Land and Urban Management **6 hrs**

1. Concepts, progress, and barriers of Sustainable Land Management (SLM)
2. Land management practices with focus on Nepal
3. Strategies, policies, legislation, and institutional provisions for SLM
4. Urban sustainability: Theories, Socio-ecological systems, Ecological vs Technical Sustainability
5. Climate change challenges in cities; Mitigation and adaptation measures
6. Urban heat island, Biodiversity, Ecological footprint, and Revitalization

Unit 5: Mineral Resources and Sustainable Mining **6 hrs**

1. Definition, classification, and distribution of mineral resources
2. Mining methods and practices
3. Environmental impacts of mining and monitoring approaches
4. Sustainable mining: Concepts, progress, barriers
5. Policies, legislation, and institutions for mineral resource governance

Suggested Readings

- Adhikari, A. D. (1998). Urban and environmental planning in Nepal. IUCN.
- Food and Agriculture Organization of the United Nations (FAO). (2007). Land evaluation: Towards a revised framework. FAO.
- Food and Agriculture Organization of the United Nations (FAO). (2011). The state of the world's land and water resources for food and agriculture (SOLAW). FAO.
- Government of Nepal, Department of Mines and Geology. (2021). Mineral resources of Nepal. Government of Nepal.
- Government of Nepal, Ministry of Forests and Environment. (2022). National land use policy. Government of Nepal.
- International Council on Mining and Metals (ICMM). (2021). Mining principles: Performance expectations. ICMM.
- Government of Nepal, Ministry of Urban Development (MoUD). (2017). National urban development strategy 2017. Government of Nepal.
- United Nations Environment Programme (UNEP). (2013). Integrating the environment in urban planning and management: Key principles and approaches. UNEP.

- United Nations Environment Programme (UNEP). (2020). Sustainable land management and ecosystem restoration. UNEP.
- World Bank. (2019). Mineral resource governance in the 21st century. World Bank.

Course Title: Land, Soils and Mineral Resources Management **Credit Hour: 1**
Course Code: ESM 637 NP **Lecture Hours: 45**
Nature of Course: Case Study (Specialization) **Full Marks: 25**

Introduction

This case study course emphasizes the application of theoretical knowledge of land, soils, and mineral resource management to real-world contexts. Students will critically examine ecological, socio-economic, and governance dimensions of land use, soil conservation, and mineral extraction. Selected case studies from Nepal including Terai agricultural soils, hill erosion sites, and Himalayan mineral deposits will be used to strengthen analytical skills and contextual understanding.

Objectives

After completion of the course, students will be able to:

- Analyze case studies of land, soil, and mineral resource management across varied ecological and socio-economic contexts.
- Evaluate frameworks for land capability, soil conservation, and sustainable mining.
- Investigate human impacts, degradation processes, and environmental consequences of resource use.
- Apply theoretical frameworks to practical case studies linking ecological, economic, and social dimensions.
- Formulate strategies for sustainable land, soil, and mineral resource management based on evidence and lessons learned.

Case Study Themes

1. **Land resources**: Land Use Change, Agro-Ecological Zoning, Land Capability Classification, Urban Expansion Impacts.
2. **Soil resources:** Erosion and Fertility Decline, Watershed Management, Soil Conservation Practices, Restoration Strategies.
3. **Mineral Resources:** Distribution And Extraction, Environmental Impacts of Mining, Sustainable Mining Approaches.
4. **Human dimensions:** Migration, Informal Settlements, Resource Conflicts, Socio-Economic Pressures.
5. **Governance and Institutions:** Policies, Legislation, Institutional Arrangements, Role of NGOs And Civil Society.
6. **Sustainability Frameworks:** Natural Resource Accounting, Cost-Benefit Analysis, Climate Resilience, Poverty Implications.

Suggested Readings

- Adhikari, A. D. (1998). Urban and environmental planning in Nepal.
- Food and Agriculture Organization of the United Nations (FAO). (2007). Land evaluation: Towards a revised framework. FAO.
- Food and Agriculture Organization of the United Nations (FAO). (2011). The state of the world's land and water resources for food and agriculture (SOLAW). FAO.
- Government of Nepal, Department of Mines and Geology. (2021). Mineral resources of Nepal. Government of Nepal.
- Government of Nepal, Ministry of Forests and Environment. (2022). National land use policy. Government of Nepal.
- International Council on Mining and Metals (ICMM). (2021). Mining principles: Performance expectations. ICMM.
- Government of Nepal, Ministry of Urban Development (MoUD). (2017). National urban development strategy 2017. Government of Nepal.
- United Nations Environment Programme (UNEP). (2020). Sustainable land management and ecosystem restoration. UNEP.
- World Bank. (2019). Mineral resource governance in the 21st century. World Bank.

Group C: Environmental Resilience and Management

Course Title: Environmental Pollution and Control **Credit Hour: 2**

Course Code: ESM 634 ET **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

Environmental pollution is one of the most pressing challenges to ecological integrity and human well-being, influencing the abundance, distribution, and interactions of organisms across ecosystems. This course provides a scientific and analytical foundation for understanding the sources, types, and impacts of pollutants including air, water, soil, solid waste, and noise—on abiotic and biotic components at the levels of organism, population, community, and ecosystem. Students will explore the pathways, fate, and ecological consequences of contaminants, while gaining exposure to monitoring techniques, experimental design, data analysis, and interpretation. The course also emphasizes strategies for pollution control and mitigation, equipping students with the knowledge and skills necessary to address environmental resilience and sustainable management.

Objectives

After completion of the course, students will be able to:

- Analyze the fundamental science behind the release, transport, transformation, and fate of environmental contaminants.
- Evaluate and apply monitoring techniques, experimental designs, and analytical tools for assessing pollution.
- Synthesize knowledge of pollutant impacts on abiotic and biotic systems, from individual organisms to ecosystems.
- Formulate evidence-based strategies for pollution control, mitigation, and sustainable environmental management.
- Critically appraise national and global frameworks addressing pollution and resilience in environmental systems.

Unit 1: Air Pollution **7 hrs**

1. Spatial and temporal scales of atmospheric processes; Potential temperature, Lapse rate, Atmospheric stability
2. Boundary layer dynamics and air quality; Transport and dispersion of air pollutants (Gaussian dispersion, Plume rise, Plume behaviors)
3. Long-range atmospheric transport and transboundary air pollution
4. Characteristics of criteria and hazardous air pollutants; Combustion stoichiometry and generation of PM, CO, SO_2, NO_x, hydrocarbons
5. Hazardous emissions from solid waste burning
6. Aerosols: size, distribution, chemical composition, spatiotemporal variation, organic aerosols, molecular markers, source apportionment
7. Atmospheric brown cloud, Aerosol radiative forcing, Haze episodes
8. Impacts of air pollutants on plants, animals, and structures

Unit 2: Water Pollution **8 hrs**

1. Physical, chemical, and microbial contaminants; Criteria for drinking water and surface water quality
2. Characteristics of municipal and industrial wastewater; BOD-COD ratio and its significance
3. Eutrophication, stratification, acidification of lentic environments; Bicarbonate buffering
4. Water quality assessment methods; Sanitary inspection risk score, Microbial risk score, Microbial quality
5. Water safety plans: Hazard prioritization and Risk matrix
6. Impacts of water pollutants on plants, animals, and structures

Unit 3: Soil Pollution **5 hrs**

1. Sources and categorization of soil pollutants; Pathways of soil-subsurface contamination
2. Behavior and interactions of pesticides in the environment
3. Land disposal of waste and soil pollution; Transport pathways of pesticides
4. Major soil pollutants and their ecological interactions
5. Impacts of soil pollutants on plants, animals, and agro-ecosystems

Unit 4: Solid Waste Pollution **5 hrs**

1. Classification and characterization of solid waste; composition of municipal, e-waste, and healthcare wastes
2. Principles of solid waste management
3. Environmental-economic accounting framework for waste
4. Municipal solid waste generation and composition assessment tools
5. Household and institutional waste streams
6. Solid waste management practices in Nepal
7. Impacts of solid waste on plants, animals, and the environment

Unit 5: Noise Pollution **5 hrs**

1. Concept of sound and noise; wave characteristics and propagation
2. Noise monitoring techniques and descriptors; noise rating curves
3. Impacts of noise on humans: Hearing loss, Impairment, Sensory effects, Speech interference, Sleep disturbance, Psychophysical and Mental health effects, Performance impacts, Residential behavior, Annoyance
4. Audiometric testing and assessment methods
5. Noise control and management strategies

Suggested Readings

- American Public Health Association (APHA). (2022). Standard methods for the examination of water and wastewater (24th ed.). American Public Health Association.
- Berglund, B., & Lindvall, T. (1995). Community noise. Center for Sensory Research.
- Brady, N. C., & Well, R. R. (2002). The nature and properties of soils (13th ed.). Pearson Education.
- Centers for Disease Control and Prevention. (1998). Criteria for a recommended standard: Occupational noise exposure—Revised criteria 1998. U.S. Department of Health and Human Services.
- Eugenio, N. R., McLaughlin, M., & Pennock, D. (2018). Soil pollution: A hidden reality. Food and Agriculture Organization of the United Nations.

- Masters, G. M., & Ela, W. P. (2013). Introduction to environmental engineering and science (3rd ed.). Pearson Education.
- Nazaroff, W. W., & Alvarez-Cohen, L. (2001). Environmental engineering science. John Wiley & Sons.
- Pierce, A. D. (2019). Acoustics: An introduction to its physical principles and applications. Springer International Publishing.
- Sapkota, B. (2004). Fundamentals of noise pollution. Department of Physics, Pulchowk Campus.
- Tchobanoglous, G., Burton, F. L., & Stensel, H. D. (2003). Wastewater engineering: Treatment and reuse (4th ed.). McGraw-Hill Education.
- Trivedy, R. K., & Kumar, A. (1998). Ecotechnology for pollution control and environmental management. Enviro Media.
- Vallero, D. (2014). Fundamentals of air pollution (5th ed.). Academic Press.
- World Health Organization (WHO). (2016). Health risk assessment of air pollution: General principles. World Health Organization.
- World Health Organization (WHO). (2022). Guidelines for drinking-water quality (4th ed.). World Health Organization.

Course Title: Environmental Pollution and Control **Credit Hour: 1**

Course Code: ESM 634 EP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Introduction

This case study course emphasizes the practical application of environmental pollution control principles in real-world contexts. Students will critically examine sources, monitoring methods, and mitigation strategies for air, water, soil, solid waste, and noise pollution. Selected case studies from Nepal including industrial sites, rivers and lakes, agricultural lands, landfill facilities, and urban environments will be used to strengthen analytical skills and contextual understanding. The course integrates scientific, technical, and socio-economic perspectives to highlight challenges and opportunities in achieving sustainable pollution management.

Objectives

After completion of the course, students will be able to:

- Analyze case studies of environmental pollution across diverse ecological and socio-economic contexts.
- Evaluate monitoring techniques, sampling frameworks, and treatment technologies for air, water, soil, solid waste, and noise.
- Investigate environmental and health impacts of pollution mismanagement, including hazardous emissions and contaminated resources.
- Apply theoretical frameworks to practical case studies linking technical, ecological, and social dimensions.
- Formulate strategies for sustainable pollution control and management based on evidence and lessons learned.

Case Study Themes

1. **Air pollution:** Ambient Monitoring, Particulate and Gaseous Pollutants, Emission Inventories, Industrial Control Technologies.
2. **Water Pollution:** Drinking Water, Surface Water, Groundwater, Irrigation Water, Wastewater, And Leachate Analysis.

3. **Soil Pollution:** Nutrient and Contaminant Analysis, Pesticide Behavior, Agricultural and Contaminated Site Assessments.
4. **Solid Waste:** Characterization, Healthcare Waste Inventories, Landfill Site Visits, Recycling and Composting Practices.
5. **Noise Pollution:** Monitoring Strategies, Exposure Assessment, Impacts on Human Health and Behavior, Mitigation Approaches.
6. **Governance and Institutions:** National Standards, Policies, Legislation, and Institutional Arrangements for Pollution Control.
7. **Best practices:** National and International Case Studies in Pollution Monitoring, Control, and Sustainable Management.

Suggested Readings

- **American Public Health Association (APHA).** (2022). *Standard methods for the examination of water and wastewater* (24th ed.). American Public Health Association.
- **Berglund, B., & Lindvall, T.** (1995). *Community noise*. Center for Sensory Research.
- **Brady, N. C., & Well, R. R.** (2002). *The nature and properties of soils* (13th ed.). Pearson Education.
- **Centers for Disease Control and Prevention.** (1998). *Criteria for a recommended standard: Occupational noise exposure—Revised criteria 1998*. U.S. Department of Health and Human Services.

Course Title: Climate Change and Resilience **Credit Hour: 2**

Course Code: ESM 635 ET **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

This course provides students with interdisciplinary perspectives on the climate system, future climate change, resilience, mitigation, adaptation, and disaster risk management. It integrates the scientific foundations of atmospheric, oceanic, cryospheric, and terrestrial processes with the socio-economic and governance dimensions of climate change. Emphasis is placed on Nepal's agro-climatic zones, hydro-climatic disasters, and national climate policies, alongside global frameworks such as the UNFCCC and the Paris Agreement. Through case studies and analytical frameworks, students will critically examine the impacts of climate variability on ecosystems, agriculture, and human societies, while exploring strategies for resilience, adaptation, and sustainable development.

Objectives

After completion of the course, students will be able to:

- Critically analyze the functioning of the climate system and its role in driving global and regional change.
- Evaluate emission scenarios, climate projections, and their implications for ecosystems, agriculture, and human well-being.
- Investigate socio-economic vulnerabilities and resilience strategies in the context of hydro-climatic disasters.
- Synthesize mitigation and adaptation frameworks across sectors, integrating community-based and national approaches.
- Appraise international and national climate policies, conventions, and governance mechanisms, including indigenous knowledge systems.
- Formulate evidence-based strategies for climate resilience, disaster risk reduction, and sustainable resource management.

Unit 1: Climate System and Modeling **5 hrs**

1. Description of the climate system and its components: Atmosphere, Ocean, Cryosphere, Land Surface, Terrestrial Biosphere
2. Components of climate models: Atmosphere, Ocean, Sea ice, Land surface, Ice sheets
3. Model uncertainties and sensitivity

Unit 2: Future Climate Change Scenarios and Projections **5 hrs**

1. Emission scenarios: purpose and development
2. Special Report on Emission Scenarios (SRES)
3. Representative Concentration Pathways (RCPs) vs. Shared Socio-economic Pathways (SSPs)
4. Climate projections for the 21st century
5. Changes in global mean surface temperature and precipitation distribution
6. Ocean and sea ice changes

Unit 3: Climate Resilience and Adaptation Frameworks **5 hrs**

1. Introduction to climate resilience
2. Climate Resilience Framework and technology
3. National, provincial, and local resilience solutions
4. Socio-economic implications and challenges
5. Community-based adaptation and national adaptation planning

Unit 4: Mitigation Strategies and Human Dimensions **5 hrs**

1. Causes and physical processes of climate change
2. Consequences for land, water, energy, and food security
3. Climate change mitigation measures
4. Adaptation strategies in different sectors
5. Linkages between climate change and disasters
6. Global environmental problems: Biodiversity loss, Desertification, Water crisis

Unit 5: Climate Agriculture Interactions and Hydroclimatic Disasters **5 hrs**

1. Principles of crop production and responses to weather elements
2. Impacts of climate variability on crop production, insects, and plant diseases
3. Agro-climatic zones and agro-ecological regions of Nepal
4. Hydro-climatic disasters: Floods, Droughts, Landslides, GLOFs/LDOFs, Cyclones, Heatwaves, Extreme temperatures
5. Causes, triggers, impacts, and vulnerability analysis
6. Case studies of hydro-climatic disasters and lessons learned

Unit 6: Climate Change Governance and Policy Frameworks **5 hrs**

1. International climate policy: UNFCCC, Paris Agreement
2. National Climate Policy of Nepal
3. Indigenous knowledge of climate change
4. Historical background of COPs: achievements and implications
5. Nationally Determined Contributions (NDCs)
6. Policy and governance for adaptation and resilience

Suggested Readings

- Coiffier, J. (2012). Fundamentals of numerical weather prediction. Cambridge University Press.
- Goyal, M. N., Gupta, A. K., & Gupta, A. (Eds.). (2006). Disaster resilience and green growth: Hydro-meteorological extremes and disaster. Springer Nature.
- World Meteorological Organization (WMO). (1981). Guide to agricultural meteorological practices (WMO No. 134). WMO.
- Hardy, J. T. (2004). Climate change: Causes, effects and solutions. John Wiley & Sons.
- Harvey, L. D. D. (2010). Global warming: The hard science. Pearson Education.
- Houghton, J. (2004). Global warming: The complete briefing. Cambridge University Press.
- United Nations International Strategy for Disaster Reduction (UNISDR). (2005). Hyogo framework for action: Building the resilience of nations and communities, 18–22 January 2005. UNISDR.
- Intergovernmental Panel on Climate Change (IPCC). (2006). Guidelines for national greenhouse gas inventories. IPCC.

- Manton, M. J., & Stevenson, L. A. (2014). Climate in Asia and Pacific. Advances in Global Change Research (Vol. 56). Springer.
- Government of Nepal, Ministry of Environment (MoE). (2010). National adaptation program of action (NAPA) to climate change. Government of Nepal.
- Government of Nepal, Ministry of Environment (MoE). (2011). Status of climate change of Nepal. Government of Nepal.
- Government of Nepal, Ministry of Population and Environment (MoPE). (2016). Intended nationally determined contributions (INDC) communicated to the UNFCCC Secretariat in February 2016. Government of Nepal.
- Salinger, J., Shivakumar, M. K. V., & Motha, R. P. (2005). Increasing climate variability and change. Springer.
- Subba, D., Jha, P. K., Dhakal, R. P., Devkota, B. D., & Neupane, P. K. (2025). Climate change in Nepal: Impacts, adaptation and mitigation. National Academy of Science and Technology.
- United Nations Framework Convention on Climate Change (UNFCCC). (2011). Clean development mechanism methodology booklet (including EB 6). UNFCCC.
- World Meteorological Organization (WMO). (2001). Lecture notes for training agricultural meteorological personnel (WMO No. 551). WMO.

Course Title: Climate Change and Resilience **Credit Hour: 1**

Course Code: ESM 635 EP **Lecture Hours: 45**

Nature of Course: Case study **Full Marks: 25**

Introduction

This case study course emphasizes the practical application of climate science, resilience frameworks, and adaptation strategies in real-world contexts. Students will critically examine the functioning of the climate system, future climate projections, hydro-climatic disasters, and socio-economic vulnerabilities. Selected case studies from Nepal—including agro-climatic zones, flood-prone river basins, drought-affected regions, and community-based adaptation initiatives, will be used to strengthen analytical skills and contextual understanding. The course integrates scientific, technical, and governance perspectives to highlight challenges and opportunities in achieving climate resilience and sustainable development.

Objectives

After completion of the course, students will be able to:

- Analyze case studies of climate system functioning and variability across ecological and socio-economic contexts.
- Evaluate emission scenarios, climate projections, and their implications for agriculture, ecosystems, and human well-being.
- Investigate socio-economic vulnerabilities and resilience strategies in the context of hydro-climatic disasters.
- Apply theoretical frameworks to practical case studies linking scientific, technical, and governance dimensions.
- Formulate strategies for climate resilience, disaster risk reduction, and sustainable resource management based on evidence and lessons learned.
- Appraise global and national climate policies, conventions, and indigenous knowledge systems for adaptation and resilience.

Case Study Themes

1. **Climate System and Modeling:** Atmospheric Stability, Cryosphere Dynamics, Regional Climate Modelling, Uncertainty Analysis.
2. **Future Climate Scenarios and Projections:** RCPS, SSPS, Nepal-Specific Climate Trends, Temperature and Precipitation Changes.
3. **Resilience and Adaptation Frameworks:** Community-Based Adaptation in Drought-Prone Terai, Provincial and Local Resilience Solutions, Socio-Economic Challenges.
4. **Mitigation Strategies and Human Dimensions:** Renewable Energy Adoption, Food-Water-Energy Security, Biodiversity Loss, Desertification, Water Crisis.
5. **Climate–Agriculture Interactions and Hydro-Climatic Disasters:** Crop Yield Variability, Agro-Climatic Zones of Nepal, Floods, Droughts, Landslides, GLOFS, Cyclones, Heatwaves, Vulnerability Analysis.
6. **Governance And Policy Frameworks:** UNFCCC, Paris Agreement, Nepal's National Climate Policy, NDCS, Indigenous knowledge, COP achievements.
7. **Best Practices:** National and International Case Studies in Resilience, Adaptation, and Disaster Risk Reduction.

Suggested Readings

- Food and Agriculture Organization of the United Nations (FAO). (2017). Climate change and food security: Risks and responses. FAO.
- Government of Nepal, Ministry of Forests and Environment. (2019). National climate change policy. Government of Nepal.
- International Centre for Integrated Mountain Development (ICIMOD). (2020). Climate change and mountain systems in the Hindu Kush Himalaya. ICIMOD.
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). (2018). Assessment report on land degradation and restoration. IPBES.
- Intergovernmental Panel on Climate Change (IPCC). (2021). Climate change 2021: The physical science basis. IPCC.
- United Nations Environment Programme (UNEP). (2020). Global climate change adaptation outlook. UNEP.

- United Nations Framework Convention on Climate Change (UNFCCC). (2015). Paris agreement. UNFCCC.
- World Bank. (2021). Climate risk country profile: Nepal. World Bank.

Course Title: Solid and Hazardous Waste Management **Credit Hours: 2**
Course Code: ESM 636 ET **Lecture Hours: 30**
Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

Waste Management provides an overview of solid waste management, including the generation, collection, storage, transfer, treatment, and disposal of solid and hazardous wastes. This course offers a thorough understanding of waste processing, basic disposal facilities, disposal options, and the economic and environmental aspects of solid waste management. In addition, it provides students with relevant knowledge on municipal solid waste reduction and resource recovery, including reuse, recycling, composting, methane generation, and waste-to-energy incineration, as well as landfill design, sizing, equipment specifications, and associated costs. Hazardous wastes, their types, and management strategies are also discussed.

Objectives

After completion of the course, students will be able to:

- Demonstrate in-depth knowledge of solid and hazardous waste management, with a focus on management systems and treatment methods.
- Analyze various waste management options, including sanitary landfills, material recovery, energy recovery, waste minimization, thermal treatment, chemical, physical, and biological treatment methods, and site remediation.
- Understand and evaluate waste management–related principles, policies, plans, and ongoing programs, with particular emphasis on Nepal.

Unit 1: Fundamentals of Waste **5 hrs**

1. Waste sources and classifications
2. Global and local perspectives on waste generation

3. Factors influencing waste generation
4. Wastes and environmental health impacts
5. Key principles of waste management

Unit 2: Municipal Solid Waste **5 hrs**

1. Sources and effects of solid waste
2. Solid waste characterization and constituents
3. Household and institutional wastes
4. Impacts on plants, animals, and environment
5. Concepts of solid waste management
6. Onsite handling and processing
7. Disposal techniques: open dumping, landfilling, incineration, composting
8. Utilization, recovery, and recycling methods

Unit 3: Hazardous and Specialized Wastes **5 hrs**

1. Hazardous waste sources, effects, classification, collection, segregation, treatment, and disposal
2. Radioactive wastes: definition, sources, treatment, and processing methods
3. E-waste: definition, sources, classification, collection, segregation, treatment, and disposal
4. Biomedical wastes: definition, sources, classification, collection, segregation, treatment, and disposal
5. Industrial wastes: characterization, production quantities, source reduction, treatment, reuse, recycling, disposal

Unit 4: Waste Management Practices and Technologies **5 hrs**

1. Collection practices and segregation methods
2. Transfer operations and efficient disposal site management
3. Techniques: incineration, combustion, stabilization, solidification, chemical fixation
4. Composting and vermicomposting
5. Recovery and reuse: bio-gasification, anaerobic digestion, pyrolysis

6. Landfill bioreactors and sanitary landfill design, construction, operation, and closure
7. Leachate and gas management
8. Land reclamation and medical waste management
9. Integrated solid waste management and zero waste principles
10. Solid waste management practices in Nepal

Unit 5: Waste Valorization and Sustainable Materials Management 5 hrs

1. Waste disposal and valorization approaches
2. Energy recovery from solid waste
3. Sustainable materials management frameworks
4. Industrial and hazardous waste management of specific types (e.g., e-waste, radioactive waste)
5. Circular economy and zero waste practices
6. Case studies of valorization and resource recovery

Unit 6: Waste Handling Rules and Regulations 5 hrs

1. National waste management policy, legal provisions, and strategies
2. Legal framework for waste handling in Nepal
3. International environmental treaties, agreements, and guidelines
4. Environment Protection Act
5. Solid Waste Management Act and Rules
6. Basel Convention on transboundary movement of hazardous waste and disposal

Suggested Readings

- Asian Development Bank (ADB). (2011). Solid waste management in Nepal: Current status and policy recommendations. Asian Development Bank.
- American Public Health Association (APHA), American Water Works Association (AWWA), & Water Environment Federation (WEF). (2017). Standard methods for the examination of water and wastewater (23rd ed.). APHA, AWWA, & WEF.

- Christensen, T. H. (Ed.). (2010). Solid waste technology and management (Vol. 1). John Wiley & Sons.
- Government of Nepal, Ministry of Health and Population, Department of Health Services (MoHP/DoH). (2020). National health care waste management standards and operating procedures – 2020. Government of Nepal.
- Government of Nepal, Ministry of Health and Population, Department of Health Services. (2014). Health care waste management guideline. Government of Nepal.
- Government of Nepal. (2011). Solid Waste Management Act, 2068 (2011). Government of Nepal.
- Government of Nepal. (2013). Solid Waste Management Rules, 2070 (2013). Government of Nepal.
- Solid Waste Management and Resource Mobilization Center (SWMRMC), Government of Nepal, & UN-Habitat. (2008). Solid waste management technical guideline for municipalities of Nepal. SWMRMC & UN-Habitat.
- Tchobanoglous, G., & Kreith, F. (2002). Handbook of solid waste management (2nd ed.). McGraw-Hill Education.
- United Nations Environment Programme (UNEP). (n.d.). Solid waste management. UNEP.
- Worrell, W. A. (2016). Solid waste engineering: A global perspective (3rd ed.). Cengage Learning.

Course Title: Solid and Hazardous Waste Management **Credit Hour: 1**

Course Code: ESM 636 EP **Lecture Hours: 45**

Nature of Course: Case study (Specialization) **Full Marks: 25**

Introduction

This case study course emphasizes the practical application of solid and hazardous waste management principles in real-world contexts. Students will critically examine waste generation, characterization, monitoring, and treatment practices, focusing on household, commercial, municipal, and healthcare waste streams. Selected case studies from Nepal, including landfill sites, composting plants, healthcare facilities, and recycling systems, will be used to strengthen analytical skills and contextual understanding. The course integrates scientific, technical, and socio-economic perspectives to highlight challenges and opportunities in achieving sustainable waste management.

Objectives

After completion of the course, students will be able to:

- Analyze case studies of solid and hazardous waste management across diverse urban and rural contexts.
- Evaluate monitoring techniques, auditing frameworks, and treatment technologies for solid waste and leachate.
- Investigate environmental and health impacts of waste mismanagement, including hazardous and infectious waste streams.
- Apply theoretical frameworks to practical case studies linking technical, ecological, and socio-economic dimensions.
- Formulate strategies for sustainable solid and hazardous waste management based on evidence and lessons learned.

Case Study Themes

1. **Waste Characterization:** Household, Commercial, Municipal, And Healthcare Waste Streams; Physical and Chemical Analysis.
2. **Monitoring And Auditing:** Sampling Techniques, Per Capita Generation, Calorific Value, Moisture Content, Density.
3. **Leachate Analysis:** Temperature, pH, Conductivity, Ammonia, BOD, COD, Heavy Metals.
4. **Recycling Systems:** Identification Of Local Recyclers, Informal Sector Practices, Circular Economy Approaches.
5. **Composting And Treatment Plants:** Operational Challenges, Efficiency, and Sustainability of Composting Facilities.
6. **Landfill Management:** Technologies, Environmental Impacts, And Mitigation Strategies.
7. **Governance And Institutions:** Policies, Legislation, Institutional Arrangements, Role of Municipalities and Private Sector.
8. **Best Practices:** National And International Case Studies in Waste Reduction, Recycling, And Hazardous Waste Management.

Suggested Readings

- American Public Health Association (APHA), American Water Works Association (AWWA), & Water Environment Federation (WEF). (2017). Standard methods for the examination of water and wastewater (23rd ed.). APHA, AWWA, & WEF.
- Christensen, T. H. (Ed.). (2010). Solid waste technology and management (Vol. 1). John Wiley & Sons.
- Tchobanoglous, G., & Kreith, F. (2002). Handbook of solid waste management (2nd ed.). McGraw-Hill Education.
- Worrell, W. A. (2016). Solid waste engineering: A global perspective (3rd ed.). Cengage Learning.

Course Title: Ecosystem Restoration and Resilience **Credit Hour: 2**

Course Code: ESM 637 ET **Lecture Hours: 30**

Nature of Course: Theory (Specialization) **Full Marks: 50**

Introduction

Ecosystem restoration and resilience have become critical priorities in the face of escalating human impacts on the environment. While early human societies exerted minimal pressure on ecosystems, modern development has caused widespread degradation, biodiversity loss, and destabilization of planetary processes, including climate regulation and ecological integrity. The restoration of degraded ecosystems, coupled with strategies to enhance resilience, is now recognized as essential for sustaining life-support systems and ensuring human well-being. The United Nations Decade on Ecological Restoration (2021–2030) underscores the global urgency of this task, setting ambitious goals and targets for ecological recovery and sustainable stewardship. This course equips students with advanced knowledge, analytical frameworks, and innovative tools to address ecosystem degradation, design restoration strategies, and strengthen resilience at local, national, and global scales.

Objectives

After completion of the course, students will be able to:

- Identify drivers of ecosystem degradation and articulate the rationale for restoration.
- Predict desirable ecological attributes and outcomes of restored ecosystems.
- Implement appropriate tools, techniques, and methodologies for restoring diverse ecosystems and habitats.
- Critically examine global and national initiatives, policies, and programs for ecosystem restoration and resilience.
- Formulate evidence-based strategies that integrate ecological, social, and governance dimensions of restoration.

Unit 1: Fundamentals of Ecosystem Restoration **6 hrs**

1. Concept and definition: restoration ecology and ecosystem restoration
2. Ecosystem resilience: concept, factors, and applications in restoration
3. Drivers of ecosystem degradation: land use change, pollution (microplastics, artificial night light), overexploitation, invasions, mining, infrastructure development
4. Rationale for restoration: ethical responsibility, global and national goals (SDGs, CBD targets, IPLC rights)

Unit 2: Ecological Attributes **6 hrs**

1. Direct attributes: species composition, community structure, abiotic environment, landscape context
2. Indirect attributes: ecosystem functionality, historical continuity, ecological complexity, self-organization, resilience, self-sustainability, biosphere support
3. Limitations of ecosystem restoration

Unit 3: Restoration Approaches and Techniques **6 hrs**

1. Ecological references: types of reference sites, models, trajectories
2. Restoration approaches: natural regeneration, assisted regeneration, partial and complete reconstruction
3. Sources of knowledge: traditional ecological knowledge, science-based knowledge
4. Bio-remediation: microorganisms and plants for pollutant removal
5. Case examples: forests, grasslands, wetlands, rivers

Unit 4: Infrastructure Development and Ecosystem Restoration **6 hrs**

1. Environmental impacts of linear infrastructures and hydropower projects
2. Needs of restoration at project sites
3. Integration of restoration in Biodiversity Management Plans
4. Case examples of infrastructure-linked restoration practices

Unit 5: Global and National Initiatives **6 hrs**

1. Multilateral environmental agreements: UNCCD, Stockholm Convention, Ramsar Convention, Kunming-Montreal Global Biodiversity Framework
2. UN Decade on Ecosystem Restoration: strategy, principles, success stories
3. IPBES Assessment Report on Land Degradation and Restoration
4. National policies and practices: Nepal's policy instruments, Environmental Impact Assessments, case examples of successful restoration in Nepal

Suggested Readings

- Van Andel, J., & Aronson, J. (Eds.). (2012). Restoration ecology: The new frontier. Blackwell Publishing.
- Arthur, E. L., Rice, P. J., Anderson, T. A., Baladi, S. M., Henderson, K. L., & Coats, J. R. (2005). Phytoremediation—An overview. Critical Reviews in Plant Sciences, 24(2), 109–122. https://doi.org/10.1080/07352680590952496
- Clewell, A. F., & Aronson, J. (2013). Ecological restoration: Principles, values, and structure of an emerging profession. Island Press.
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). (2018). Summary for policymakers of the assessment report on land degradation and restoration (R. Scholes, L. Montanarella, A. Brainich, N. Barger, B. ten Brink, M. Cantele, B. Erasmus, J. Fisher, T. Gardner, T. G. Holland, F. Kohler, J. S. Kotiaho, G. Von Maltitz, G. Nangendo, R. Pandit, J. Parrotta, M. D. Potts, S. Prince, M. Sankaran, & L. Willemen, Eds.). IPBES Secretariat.
- Madhav, S., Gupta, G. P., Yadav, R. K., Mishra, R., & Hullebusch, E. (Eds.). (2024). Phytoremediation: Biological treatment of environmental pollution. Springer.
- Perrow, M. R., & Davy, A. J. (Eds.). (2008). Handbook of ecological restoration: Volume 1, Principles of restoration. Cambridge University Press.
- Suyal, D. C., & Soni, R. (Eds.). (2022). Bioremediation of environmental pollutants: Emerging trends and strategies. Springer.

Course Title: Ecosystem Restoration and Resilience **Credit Hour:1**

Course Code: ESM 637 EP **Lecture Hours: 45**

Nature of Course: Case Study **Full Marks: 50**

Introduction

This case study course focuses on practical approaches to restoring degraded ecosystems and strengthening resilience. Students will examine drivers of degradation, ecological attributes to be restored, and techniques applied in forests, wetlands, rivers, and grasslands. Case studies from Nepal and global initiatives highlight ecological, technical, and governance perspectives for sustainable restoration.

Objectives

After completion of the course, students will be able to:

- Identify drivers of ecosystem degradation and rationale for restoration.
- Predict ecological attributes and outcomes of restored ecosystems.
- Apply restoration tools, techniques, and bio-remediation methods.
- Examine global and national restoration initiatives and policies.
- Formulate strategies integrating ecological, social, and governance dimensions.

Case Study Themes

1. **Fundamentals:** Concepts of Restoration Ecology, Resilience, Drivers of Degradation, Rationale for Restoration.
2. **Ecological Attributes:** Species Composition, Ecosystem Functionality, Resilience, Limitations of Restoration.
3. **Approaches and Techniques:** Natural/Assisted Regeneration, Reconstruction, Ecological References, Bio-Remediation, Case Examples.
4. **Infrastructure Impacts:** Restoration in Hydropower and Linear Projects, Biodiversity Management Plans.
5. **Global And National Initiatives:** UN Decade on Restoration, IPBES, CBD Targets, Nepal's Policies and Successful Case Examples.
6. **Best Practices:** National and International Case Studies in Ecosystem Restoration and Resilience.

Suggested Readings

- Convention on Biological Diversity (CBD). (2022). Kunming-Montreal global biodiversity framework. CBD Secretariat.
- Food and Agriculture Organization of the United Nations (FAO). (2017). Forest and landscape restoration mechanisms. FAO.
- Government of Nepal, Ministry of Forests and Environment. (2019). National biodiversity strategy and action plan. Government of Nepal.
- International Centre for Integrated Mountain Development (ICIMOD). (2020). Ecosystem restoration in the Hindu Kush Himalaya. ICIMOD.
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). (2018). Assessment report on land degradation and restoration. IPBES Secretariat.
- United Nations (UN). (2020). UN decade on ecosystem restoration strategy. United Nations.Note : Specialized course-related case studies may be conducted in the form of project work or on contemporary environmental issues, as decided by the department or campus.

Note : At least 10 days of field work is to be conducted during the third semester to complete the case studies/project work. This will be carried out under faculty guidance to provide students with practical exposure and insights into real-world scenarios.

SEMESTER IV

Professional Internship and Dissertation Research

Course Title: Internship

Course Code: ESM 641 **Credit Hours: 2**

Year/Semester: II/IV **Lecture Hours: 90**

Nature of Course: Research (Compulsory) **Full Marks: 50**

Introduction

The internship provides students with structured exposure to professional environmental practice. It bridges academic learning with organizational realities, enabling students to critically analyze institutional processes, synthesize practical experiences, and formulate context-specific solutions for environmental challenges.

Objectives

The internship aims to:

- Critically appraise organizational structures, functions, and decision-making processes in environmental institutions.
- Analyze real-world environmental problems and propose evidence-based interventions.
- Synthesize academic knowledge with professional practice to design contextually relevant solutions.
- Formulate recommendations for sustainable environmental management through collaborative engagement with stakeholders.

Requirements

Internship Requirements

Students are required to complete a 15-30-days (total 90 hours) internship in an organization working in the field of environment. During this period, students will actively engage in the organization's regular activities, critically observe institutional practices, and identify pressing environmental problems. They must analyze these issues in consultation with organizational executives and collaboratively design a plan for managing and promoting a healthy environment. Each student will work under the guidance of an assigned supervisor, who will provide continuous support and feedback throughout the internship. At the end of the placement, students must prepare an individual internship report that documents their experiences and analytical reflections. The

report should include a recommendation letter from the host organization, daily records of activities, photographs, and other relevant materials as evidence of participation. Finally, students are required to present their findings through an oral presentation, demonstrating their ability to synthesize practical experiences with academic knowledge and propose actionable solutions for environmental management.

Course Title: Dissertation

Course Code: ESM 642 **Credit Hours: 8**

Year/Semester: II/IV **Lecture Hours: 360**

Nature of Course: Research (Compulsory) **Full Marks: 200**

Introduction

The dissertation is the capstone of the MSc Environmental Science program, designed to cultivate independent research capacity. It requires students to conceptualize original research problems, apply advanced methodologies, and contribute to scholarly and policy-relevant knowledge in environmental science.

Objectives

This research activity has been designed to:

- Formulate significant and original research problems grounded in environmental science.
- Design and implement rigorous methodologies for field, laboratory, or mixed-method research.
- Critically evaluate data and synthesize findings into coherent arguments.
- Produce scholarly outputs (dissertation and manuscript) that meet academic and professional standards.
- Communicate research effectively through seminars, conferences, and peer-reviewed publications.

Requirements

Students are required to submit a comprehensive research proposal based on primary data, which must be approved by the departmental research committee prior to the commencement of dissertation work. Throughout the research period, students are expected to actively participate in departmental research updates, seminars, guest lectures, and national or international conferences and workshops to broaden their academic exposure and strengthen scholarly engagement. In addition to completing the dissertation, each student must prepare at least one manuscript suitable for submission to a peer-reviewed journal, thereby contributing to the advancement of environmental science. The final stage of the dissertation involves a formal defense before the

Dissertation Evaluation Committee (DEC), where students present and critically discuss their research findings for comprehensive evaluation and approval.

Credit Division

The detailed credit allocation framework of the dissertation is outlined below:

SN	Evaluation Scheme	Credit	Marks
1.	Dissertation Proposal seminar	1	25
2.	Mid-term Progress Presentation	1	25
3.	Pre-defense Presentation	1	25
4.	Manuscript	1	25
5.	Final Report and Presentation	4	100
Total		**8**	**200**

Dissertation Proposal Seminar

After registering the dissertation proposal at the department/campus, the student must formally defend the proposal in a seminar organized by the department/campus. During this seminar, the proposal will be critically reviewed by a panel of experts and subsequently approved by the departmental/campus research committee. The committee reserves the authority to reject or require resubmission of the proposal under the following conditions:

a. The topic is inappropriate and does not substantially address issues relevant to MSc Environmental Science.
b. The work is wholly or largely a duplication of previously undertaken research.
c. The topic is unfocused, ill-defined, overly broad, or lacking in specificity.
d. The proposed research cannot be supported due to the unavailability of subject experts, laboratory facilities, or other essential resources.

Mid-term Progress Presentation

The student is required to prepare and submit a detailed progress report, followed by an open presentation that critically explains the activities undertaken, methodological approaches applied, and achievements accomplished to date. This presentation serves as an opportunity to evaluate the student's research trajectory, identify challenges, and receive constructive feedback for refinement. The department/campus will notify the date and time for submission and presentation, which is typically scheduled after three months of the fourth semester.

Pre-defense Presentation

The student is required to submit a comprehensive draft report and present it in an open seminar, providing a critical explanation of the research activities undertaken, methodologies applied, and achievements accomplished to date. This presentation serves as a preparatory stage for the final defense, allowing for constructive feedback and refinement of the dissertation. The department/campus will announce the date and time for submission and presentation, which is typically scheduled after five months of the fourth semester.

Manuscript

The department is committed to fostering scholarly contributions through the publication of peer-reviewed research papers derived from students' dissertations. Accordingly, each student is required to prepare at least one manuscript based on their dissertation work and submit it along with the final dissertation for evaluation. The manuscript should adhere to recognized academic writing standards and may follow any established guidelines for scientific publication. Students are strongly encouraged to publish their work in national or international journals, thereby advancing both their academic profile and the visibility of the department's research outputs.

Final Dissertation and Presentation

The student must prepare the final dissertation in the prescribed format of the department/campus for comprehensive evaluation and formal presentation. The dissertation must be duly signed by both the candidate and the respective supervisor(s), and subsequently approved by the Head of Department upon the supervisor's recommendation. The department/campus will notify the student of the scheduled date for the defense, viva, or examination, during which the dissertation

will be evaluated by members of the Dissertation Evaluation Committee (DEC). The defense program will be facilitated by the dissertation coordinator (faculty member) or the designated internal examiner. During the final evaluation, all components of the dissertation will be critically reviewed and discussed. Independent and confidential scores provided by the expert members will be compiled, and based on this collective assessment, the DEC will issue its recommendation on whether the dissertation has been formally accepted.