GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

M I N U T E S

of the 8th Meeting of the

X ACADEMIC COUNCIL

Day & Date

13th May, 2022

Time

10.00 a.m.

Council Hall
Goa University

Minutes of the Eight Meeting of the X Academic Council

Date: 13-05-2022

Time: 10.00 a.m.

Venue: Council Hall, Goa University

A list of members who attended the meeting of the Academic Council and those who sought leave of absence is appended.

The Chairperson (Vice-Chancellor) welcomed the members to the Eight meeting of the X Academic Council.

The Chairperson informed that the process of amalgamating its existing Department/Centres into respective Schools of Studies has been completed with the notification of the Statute. Ten Schools of Studies have been established on the University Campus headed by a Dean, two Vice-Deans and Programme Directors for the respective Programmes for each School. Henceforth the concept of teaching Departments on the Campus will not exist and every academic Programme which was assigned to a Department on the campus shall be under a particular School.

Thereafter, the agenda was taken up for discussion.

<table>
<tr><td>D</td><td>DISCUSSION ITEMS</td></tr>
<tr><td>D 1</td><td>CONFIRMATION</td></tr>
<tr><td>D 1.1</td><td>To confirm the minutes of the Seventh Meeting of the X Academic Council held on 25.02.2022.
The Member Secretary brought to the notice of the House the following changes suggested by the Dean, Faculty of Medicine with regard to item No. D 3.7 Minutes of the meeting of Board of Studies in Allied Health Science Courses held on 21.01.2022, that needed to be incorporated into the minutes:

Proposed changes:
The Academic Council partly approved the amendment to Clause 5 of the Ordinance OC-76.11 regarding Dissertation.

1. The proposed amendment to clause 5 OC-76.11.5 shall be read as:

<table>
<tr><th>Existing Clause</th><th>Proposed Clause</th></tr>
<tr><td>OC-76.11 Dissertation
5. A Guide shall be appointed by the RC, for a Candidate, based on the Clinical Speciality of the Dissertation. There shall be not more than four Candidates assigned to a Guide.</td><td>OC-76.11 Dissertation
5. A Guide shall be appointed by the RC, for a Candidate, based on the Clinical Speciality of the Dissertation. There shall be not more than four Candidates assigned to a Guide in one academic year.</td></tr>
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	The minutes of the meeting of the Seventh meeting of the X Academic Council held on 25.02.2022 were confirmed with the above correction. **(Action: Assistant Registrar Academic – General/PG)**
D 2	**FOLLOW UP ACTION**
D 2.1	**Follow up action on the minutes of the Seventh Meeting of the X Academic Council held on 25.02.2022.** The Academic Council noted the action taken/initiated on the various decisions taken in its meeting held on 25.02.2022. **(Action: Concerned Assistant Registrars)**
D 3	**BOARDS OF STUDIES**
D 3.1	**Minutes of the meeting of the Board of Studies in Environmental Science held on 08.03.2022.** The Academic Council approved the minutes of the meeting of the Board of Studies in Environmental Science held on 08.03.2022 including the Semester III and IV syllabus of the M.Sc./M.A. in Environmental Science Programme. **(Action: Assistant Registrar Academic – PG)**
D 3.2	**Minutes of the meeting of the Board of Studies in Fine Art held on 04.04.2022.** The Academic Council approved the minutes of the meeting of the Board of Studies in Fine Art held on 04.04.2022 with the following suggestions: 1. The Dissertation to be forwarded to the Guide in advance. 2. The Chairperson, BoS was requested to correct the title of the Ordinance. 3. The proposed recommendation for review of remuneration to Examiners, Technical and Supervisory staff at the B.F.A. Graduate and Post Graduate level was withdrawn by the Chairperson, Board of Studies. **(Action: Assistant Registrar Academic – PG)**
D 3.3	**Minutes of the meeting of the Board of Studies in Marine Microbiology held on 19.04.2022.** The Academic Council approved the minutes of the meeting of the Board of Studies in Marine Microbiology held on 19.04.2022 with the following suggestion: 1. The Syllabus for the Ph. D. Entrance test was approved. 2. The Syllabus pertaining to 80 Credits was deferred. 3. Numbering to be corrected under References/Readings of the syllabus for the Ph. D. Entrance Test for Marine Microbiology. **(Action: Assistant Registrar Academic – PG)**
D 3.4	**Minutes of the meeting of the Board of Studies in Dentistry held on 11.04.2022.** The Academic Council approved the minutes of the meeting of the Board of Studies in Dentistry held on 11.04.2022 recommending the panel of examiners for different examinations at the under-graduate level and the post-graduate level. **(Action: Assistant Registrar Academic – PG)**

X AC- 8
13.05.2022

GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

F I N A L A G E N D A

For the 8th Meeting of the

X ACADEMIC COUNCIL

Day & Date

13th May, 2022

Time

10.00 a.m.

Venue
Conference Hall
Administrative Block

	D 10.3 Suspension of clauses of Special Ordinance OS-1.	Notified to all the Principals of the College and Department of Goa University vide circular No. GU/Exam Div/2022/164 dated 03.03.2022 and No.GU/Exam/2022/165 dated 03.03.2022. (Back to Index)
D 3	**BOARDS OF STUDIES**	
D 3.1	**Minutes of the meeting of the Board of Studies in Environmental Science held on 08.03.2022.** **Part A**. i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: ii. Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: **a. Approval of syllabus and structure of M.Sc./M.A. in Environmental Science (Semester III and IV).** The syllabus and structure of M.Sc./M.A. in Environmental Science (Semester III and IV) was approved after incorporating the suggestions made by the BOS members **Annexure I** **(Refer page no. 12)** **b. Approval of syllabus of EIA III, EIA IV and Ecotourism.** The syllabus of EIA III (ESC 301), EIA IV (ESC 401) and Ecotourism (ESO 411) was deliberated and after incorporating the suggestions from the BOS members, the same was approved. **c. Approval of revised syllabus structure of M.Sc./M.A. in Environmental Science (Semester I, II, III, and IV).** The revised syllabus structure of M.Sc./M.A. in Environmental Science (Semester I, II, III, and IV) was approved. **d. Any other business with the permission of the chair.** **Part B** i. Scheme of Examinations at undergraduate level: Nil ii. Panel of examiners for different examinations at the undergraduate level: Nil iii. Scheme of Examinations at postgraduate level: Nil iv. Panel of examiners for different examinations at post-graduate level: Nil **Part C.** 1. Recommendations regarding preparation and publication of selection of reading material in the subject or group of subjects and the names of the persons recommended for appointment to make the selection: Nil **Part D**	

i. Recommendations regarding general academic requirements in the Departments of University or affiliated colleges: Nil
ii. Recommendations of the Academic Audit Committee and status thereof: Nil

Part E.

i. Recommendations of the text books for the course of study at undergraduate level: Nil
ii. Recommendations of the text books for the course of study at post graduate level:Nil

Part F.

Important points for consideration/approval of Academic Council

i. The important points/recommendations of BOS that require consideration/approval of Academic Council (points to be highlighted) as mentioned below.

a. Approval of syllabus and structure of M.Sc./M.A. in Environmental Science (Semester III and IV).

The syllabus and structure of M.Sc./M.A. in Environmental Science (Semester III and IV) was approved after incorporating the suggestions made by the BOS members.

b. Approval of syllabus of EIA III, EIA IV and Ecotourism.

The syllabus of EIA III (ESC 301), EIA IV (ESC 401) and Ecotourism (ESO 411) was placed in BOS and approved.

c. Approval of revised syllabus structure of M.Sc./M.A. in Environmental Science (Semester I, II, III, and IV).

The revised syllabus structure of M.Sc./M.A. in Environmental Science (Semester I, II, III, and IV) was approved.

ii. The declaration by the Chairperson that the minutes were readout by the Chairperson at the meeting itself.

Date: 08.03.2022 Sd/-
Place: Goa University Campus Signature of the Chairperson

Part G.

The Remarks of the Dean of the Faculty

i. The minutes are in order
ii. The minutes may be placed before the Academic Council with remarks if any.
iii. May be recommended for approval of Academic Council.
iv. Special remarks if any.

Date: 08.03.2022 Sd/-
Place: Goa University Campus Signature of the Dean

(Back to Index)

D 3.1 Minutes of the meeting of the Board of Studies in Environmental Science held on 08.03.2022.

Annexure I

M. Sc. / M.A. in Environmental Science
School of Earth, Ocean and Atmospheric Sciences, Goa University,
Taleigao Plateau, Goa, India-403206.

Why a programme in Environmental Science?

Environmental science has conventionally studied physical, chemical and biological processes in the Earth system (Lithosphere, hydrosphere, atmosphere and cryosphere). Increasingly, it now incorporates nature-human interactions and the social, political and cultural processes which impact the planet. The anthropogenic pressures on the ecological processes have forced disciplinary boundaries to merge and a student of environmental science must understand the complex relationships that drive nature-human interactions. Sustainability is one of the grand challenges that human survival faces on planet Earth.

Why at Goa University?

Goa is a biodiversity-rich state with Western Ghats on one side and the Arabian sea on the other. It has both terrestrial as well as marine biodiversity that sustains human livelihoods and provides numerous ecosystem services.

Goa University is uniquely positioned to offer students a stimulating programme to study the human-environment interaction. The university has all conventional programmes along with frontier areas like biotechnology, data science, hospitality, marine science, microbiology, women's studies among others.

What the course offers?

Goa University has designed an unique two-year postgraduate programme in environmental science keeping the above grand challenge in mind. The programme is hosted by the School of Earth Ocean and Atmospheric Sciences (SEOAS) in collaboration with Departments of Botany, Biotechnology, Zoology, Microbiology, Philosophy, Sociology, History, Faculty of Life Sciences, Goa Business School, ManoharParrikar School of Law, Governance and Public Policy, and School of Chemical Sciences. It is conceived as a multidisciplinary programme which will teach students how to combine skills and knowledge from a variety of domains. It will allow students to explore courses from a large number of disciplines and skill themselves in a manner that they feel best suits them for their knowledge pursuits. The programme will provide a holistic approach to understand environmental issues and undertake environmental impact assessments with diverse perspectives, frameworks and using multiple data sources. All students will undertake fieldwork and laboratory work, to experience different habitats, climates, land formations and social structures.

Eligibility for admission to M.A.Environmental Science

Graduate in any discipline including Medicine and B.Tech.

Eligibility for admission to M. Sc. Environmental Science

Graduate in any science subject including Medicine and B. Tech.

Course structure and assessment methods

M.A/MSc in Environmental Science is a two years programme. The initial stages (first two semesters) of a student's study include compulsory core courses, which aim to impart a general understanding of environmental science and introduce the student to some of the main principles. The following two semesters will typically allow students to choose options from a selection of possible course modules, allowing for growing specialization. Towards the end of the program, one is likely to have the opportunity to carry out own research on a topic of one's choice. Assessment methods include essays, written discussions, exams, problem sheets, laboratory reports, field exercises, field notebooks and seminar presentations.

Key skills

Common skills gained from an Environmental Science degree include:

- Environmental Impact Assessment
- Numeracy and data analysis
- IT skills
- Research skills
- Laboratory and fieldwork
- Team work
- Self-management, including planning and meeting deadlines
- Critical evaluation
- Effective and professional communication, both spoken and written

Course structure for Semester I & II of M. Sc. / M. A. in Environmental Science with effect from July, 2021.

Sr.No	Course code	Course name	No. of credits
		Common core courses for M.Sc. / M.A.	
Semester I			
1	ESC-101	Environmental Issues and Perspectives	3
2	ESC-102	Fundamentals of Economics	3
3	ESC-103	Environmental Ethics	3
4	ESC-104	Ecosystems and Biodiversity	3
5	ESC-105	Land, Ocean and Atmospheric Interactions	3
6	ESC-106	Environmental Impact Assessment I	1
Semester II			
7	ESC-201	Ecology and Society	3
8	ESC-202	Climate Change and Sustainability	3
9	ESC-203	Environmental Geoinformatics	3
10	ESC-204	Basic Statistics	3
11	ESC-205	Environmental Management	3
12	ESC-206	Environmental Impact Assessment II	1

Course structure for Semester III & IV of M. Sc. / M. A. in Environmental Science

Sr. no.	Course code	Course name	No. of credits
Semester III - M. Sc. in Environmental Science			
13	ESC-301	Environmental Impact Assessment III	3
14	ESO-302	Lab Course in Environmental Science	3
15	ESO-303	Marine Pollution	3
16	ESO-304	Environmental Microbiology	3
17	ESO-305	Environmental Biotechnology	3
18	ESO-306	Conservation Biology	3
19	ESO-307	Water Resource Management	3
20	ESO-308	Disaster Management	3
21	ESO-309	Marine Plankton Ecology	3
22	ESO-310	Water and Wastewater: Monitoring and Treatment Technologies	3
23	ESO-311	Industrial Water and Wastewater Treatment Technologies	3
24	ESO-312	Water and Wastewater Analysis	4
25	ESO-313	Occupational Work Environment and Health Hazards	2
26	ESO-314	Mangrove Ecosystem and Biodiversity	1
27	ESO-315	Mangrove Ecology	1
28	ESO-316	Mangrove Restoration and Conservation	1
Semester III - M. A. in Environmental Science			
29	ESC-301	Environmental Impact Assessment III	3
30	ESO-317	Environmental History of India	3
31	ESO-318	Environmental Politics	3
32	ESO-319	Global Environmental Governance	3
33	ESO-320	Women and Environment	3
34	ESO-321	Environmental Externalities and Policy	1
35	ESO-322	Introduction to Sustainable Development	1
36	ESO-323	Introduction to Environmental Valuation	1
Semester IV - M. Sc. in Environmental Science			
37	ESC-401	Environmental Impact Assessment IV	3
38	ESC-402	Dissertation	8

39	ESO-403	Environmental Chemistry	3
40	ESO-404	Green Chemistry	3
41	ESO-405	Ecotoxicology	3
42	ESO-406	Microplastics in Environment	3
43	ESO-407	Renewable Energy System	3
44	ESO-408	Coral Ecology	3
45	ESO-409	Polar Sciences	3
46	ESO-410	Marine Biodiversity & Conservation Practices	3
47	ESO-411	Ecotourism	3
48	ESO-412	Mineral Resources, Environmental Problems and Management	1
49	ESO-413	Pollution and Environment	1
50	ESO-414	Natural and Manmade Hazards	1
Semester IV - M. A. in Environmental Science			
51	ESC-401	Environmental Impact Assessment IV	3
52	ESC-402	Dissertation	8
53	ESO-415	Environmental Security: Dimensions and Perspectives	3
54	ESO-416	Global Environmental History	3
55	ESO-417	Environmental and Literature	2
56	ESO-418	Gender Sensitivity and Equity	2

(Back to Index) **(Back to Agenda)**

Syllabus of M. Sc. / M.A. (Environmental Science) Programme
(Approved in BOS held on 08.03.2022)

The Academic council in its meeting held on 1/3/2021, approved the minutes of the meeting of Board of studies in Environmental Science Programme held on 25/2/2021 (for Semester I and II).

The Academic council in its meeting held on 13/8/2021, approved the minutes of the meeting of Board of studies in Environmental Science Programme held on 10/8/2021 (for Semester III &IV).

Title of the Course:Environmental Issues and Perspectives
Course Code: ESC-101 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2021-22

Prerequisites for the course:	There is no prerequisite for this course apart from the program requirements	
Objective:	This course is an invitation to the study of environment in its multiple nuances. While familiarising environmental issues all the course also intends to introduce students to perspectives on environment.	
Content:	**Module 1: Introduction to Environment** Concept of environment and types of environment Environmental heritage and human dimension of environmental science Interdisciplinary and multidisciplinary approaches to environment and major themes – biological, ecological and social ecological orientations **Module 2: Human population and environment** Basic concepts of population dynamics, population growth, demographic transition, human population effects on earth Environmental systems and ecosystems: Concepts and fundamentals. **Module 3: Environmental issues and concerns** Environmental conservation, Food and agriculture Environmental health, pollution and toxicology Climate and global warming Solid and hazardous waste **Module 4: Social issues and environment** Urban growth and industrial planning Development, displacement and rehabilitation Ideologies of environmentalism Towards articulating sustainable environmental future	10 hours 08 hours 08 hours 10 hours
Pedagogy:	Lectures/assignments/workshops/campus walks/documentaries and discussion/ presentations	
References/Readi	1. Basu, M., & Xavier, S. (2016). *Fundamentals of environmental*	

ngs	*studies.* Cambridge University Press. 2. Carolyn, M. (Ed.). (1996). *Ecology*. Rawat Publications. 3. Gadgil, M., &Guha, R. (2000). *Use and abuse of nature.* Oxford University Press. 4. Gadgil, M., &Guha, R. (1995). *Ecology and equity.* Oxford University Press. 5. Guha, R. (2000). *Environmentalism: A global history.* Oxford University Press. 6. Joseph, B. (2009). *Environmental studies* (2nd ed.).Tata McGraw Hill. 7. Krishna, S. (1996). *Environmental politics.* Sage Publications. 8. Rangarajan, M. (Ed.). (2007). *Environmental issues in India: A reader.* Dorling Kindersley.	
Learning Outcomes	1. Students are introduced to the multi-dimensional feature of environmental reality. 2. They are familiarized with the plural perspectives on environment both as an academic focus and lived-in reality.	

Title of the Course: Fundamentals of Economics
Course Code: ESC-102 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2021-22

Prerequisites for the Course:	There is no prerequisite for this course apart from the program requirements	
Objective:	The aim of the course is to introduce students to the basic concepts, theories and principles that will provide the foundation for a proper understanding of how an economy works. The syllabus seeks to equip students with the basic tools necessary for an understanding and interpretation of economic issues affecting the economy.	
Content:	**Module 1: Introduction** Scope and method of economics; Building blocks of modern economy – agents, resources and classification of goods. **Module 2:Microeconomic analysis** Consumer equilibrium, producer equilibrium, market equilibrium, general equilibrium and possible disequilibrium situations. **Module 3: Macroeconomic analysis** Circular flow and national income, issues related to growth, unemployment and inflation. **Module 4:Public economics and international trade** Market failure, Taxation and Quotas, Efficiency versus Equity. Balanced budgets and Debt financing. International Trade: Comparative advantage theory, gains from trade; tariffs and protection, exchange rates.	04 hours 10 hours 10 hours 12 hours
Pedagogy:	Lectures/assignments/workshops/campus walks/documentaries and discussion/ presentations	

References/Readings	1. Banerjee, A., &Duflo, E. (2019). *Good economics for hard times: Better answers to our biggest problems*. Penguin Books. 2. Dasgupta, P. (2010). *Economics: A very short introduction*. Sterling Pub. 3. Mankiw, G. (2020). *Principles of economics* (9th ed.). Cengage Learning Asia Pte Ltd. 4. Samuelson, P., Nordhaus, W, Chaudhuri S., &Sen A. (2010). *Economics* (19th ed.). McGraw-Hill.	
Learning Outcomes	1. The students will be able to understand the basic concepts-principles and theories of Economics. 2. This course will enable the students to understand and analyse different types of equilibrium, circular flow of the economy and factors affecting growth and employment in an economy. 3. The students will learn the basics of international trade and fundamental concepts in public economics.	

Title of the Course:Environmental Ethics

Course Code: ESC-103 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2021-22

Prerequisites for the course:	There is no prerequisite for this course apart from the programme requirements	
Objectives:	1. To analyse different approaches and broad theories of environmental philosophy. 2. Understand the philosophical basis of various conservative theories.	
Contents:	**Module 1: Introduction** Introduction to environmental ethics **Module 2:Value and Nature** Value and Nature: Moral theories (Consequentialism, Virtue Ethics and Kantianism), Intrinsic value and Instrumental values, anthropocentrism. **Module 3: Ecology** Land ethics & deep ecology, Bio centrism, Eco-centrism, Speciesism, Culture and ecology.	06 hours 15 hours 15 hours
Pedagogy:	Lectures/assignments/workshops/campus walks/documentaries and discussion/ presentations	
References/Readings	1. Jaquet, F. (2019). Is Speciesism Wrong by Definition? *Journal of Agricultural and Environmental Ethics, 32 (3)*. 2. Kopnina, H., Washington, H., Taylor, B., &Piccolo, J.J.(2018). Anthropocentrism: More than Just a Misunderstood Problem. *Journal of Agricultural and Environmental Ethics, 31.* 3. Sandler, R. (2017). *Environmental Ethics: Theory in Practice*. Oxford University Press.	

	4. Attfield, R. (2014). *Environmental Philosophy*. Polity Press. 5. Jamieson, D. (2008). *Ethics and Environment- An Introduction*. Cambridge University Press. 6. Grim, J.A .(Ed.). (2001.). *Indigenous Traditions and Ecology- The Inter-being of Cosmology and Community.* Harvard University Press. 7.Taylor, P. W. (1986). *Respect for Nature: A Theory of Environmental Ethics.* Princeton University Press. 8. Passmore, J. (1974). *Man's Responsibility forNature*. Charles Scribner's son.	
Learning Outcomes	1. Students will be able to learn and evaluate different theories of environmental ethics. 2. Realize the significant role and responsibility towards the protection of the environment.	

Title of the Course:Ecosystems and Biodiversity
Course Code: ESC-104 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2021-22

Prerequisite for the course:	There is no prerequisite for this course apart from the program requirements	
Objective:	The course provides the fundamentals about ecosystems, their types, distribution, components, functioning, services and their role in biodiversity. Biotic components of ecosystems, fundamentally understood as Biodiversity, their measure, and factors that lead to enormous biodiversity, and essential components that maintain biodiversity. More importantly, knowledge on their resilience and thresholds, which are required for management and conservation of both biodiversity and ecosystems will be imparted.	
Content:	**Module 1: Introduction** Ecosystems - Development of concept and the current understanding; Ecosystem as a system. Structural and Functional components of Ecosystems. Ecological complexity. Energy flow in ecosystems; adaptive cycle view of ecosystem development and change; Ecosystem attributes and functioning. Thermodynamics and Information theory in ecosystems. Types of ecosystems, their distribution and composition. Case study - Tropical rain forests ecosystem. **Module 2: Ecosystems processes and applications** Role of species in ecosystem functioning. Applications of ecosystems knowledge. Ecosystem services. Measuring Ecosystem	09 hours 09 hours

	Health. Ecosystem Processes; Controls over Ecosystem Processes. Human-Induced Ecosystem Change: Human Impacts on Ecosystems, Resilience and Threshold Changes, Degradation in Ecosystem Services. **Module 3: Biodiversity** Definition; the past (diversity and extinction) and present; major groups of biological organisms; evolution of biodiversity and drivers of biodiversity. The role of geology and climate in their distribution. Patterns in biodiversity: Spatial and temporal patterns at genetic, species and taxonomic diversity, Approaches to biodiversity studies. Loss of biodiversity and biodiversity targets 2020. **Module 4: Measuring Biodiversity** Species richness and Biodiversity Indices (diversity and evenness indices); Methods of Measuring Biodiversity; Alpha, Beta and Gamma-diversity; Genetic, Species and Ecosystem Diversity; Centres of plant diversity, Hotspots of Biodiversity and their distribution; Drivers of biodiversity change. **Module 5: Biodiversity of India** Bio-geographical regions of India; Forest types and major ecosystems of India. Major groups of organisms and their diversity. Endemism. Concepts of keystone, umbrella and flagship species.	06 hours 06 hours 06 hours
Pedagogy:	Lectures/assignments/workshops/campus walks/documentaries and discussion/ presentations.	
References/Readings	1. Chapman, J. L., &Reiss, M. J.(1999). *Ecology: Principles and applications*(2nded). Cambridge University Press. ISBN: 0521588022, 9780521588027. 2. Kormondy, E. J.(2017).*Concepts of ecology*(4thed) p. 978-9332586093. PubMed: 9332586098; ISBN-13. Pearson. 3. Singh, J.S., Singh, S.P., &Gupta, S.R.(2014). *Ecology*.Environmental Science& Conservation. Chand, S.*Publishing*. ISBN: 9383746009, 9789383746002. 4. Begon, M., Howarth, R.W., &Townsend, C.R.(2014). *Essentials of ecology*(4thed). ISBN: 1118802373, 9781118802373. 5. Bowman, W. D., Hacker, S. D., &Cain, M. L.(2020). *Ecology*(5thed). Oxford University Press, Incorporated. ISBN: 160535922X, 9781605359229. 6. ChapinIII, S.F.,Matson, P. A., &Vitousek, P.(2011). *Principles of terrestrialecosystemecology*(2nded). Springer. ISBN: 1441995048, 9781441995049. 7. Gaston, K. J., &Spicer, J. I.(2004).*Biodiversity:*	

	Anintroduction(2nded). Blackwell Science. ISBN: 978-1-405-11857-6. 8. Gaston, K. J.(Ed.).(1996). *Biodiversity: A biology of numbers and difference*. PubMed: 0865428042. Blackwell Science. ISBN: 978-0865428041 9. Groombridge, B., &Jenkins, M. D.(2002). *World Atlas of biodiversity: Earth's Living Resources in the 21st Century*.University of California Press. ISBN: 0520236688, 9780520236684. 10. Henderson, P. A., &Southwood, T. R. E.(2016). *Ecological methods*(4thed). John Wiley & Sons. ISBN:1118895282, 9781118895283. 11. Jørgensen, S., Xu, L., &Costanza, R.(2016). *Handbook of ecologicalindicators for assessment of ecosystemhealth*(2nded). CRC Press. ISBN: 1439809372, 9781439809372. 12. Jorgensen, S. E.(Ed.).(2009). *Ecosystem ecology*. Elsevier. ISBN: 0444534660, 9780444534668. 13. Krebs, C. J.(2013). *Ecology: Theexperimentalanalysis of distribution and abundance*(6thed). Pearson. ISBN: 1292026278, 9781292026275. 14. Raffaelli, D. G., &Frid, C. L. J.(Eds.).(2010). *Ecosystem ecology: Anewsynthesis*. Cambridge University Press. ISBN: 1139486144, 9781139486149. 15. Smith, T.M., &Smith, R.L.(1988). BiodiversityE.O. Wilson(Ed.). *Elements of ecology*(9thed). Person. ISBN: 1292077409. National Academy Press, 9781292077406. ISBN: 030956736X, 9780309567367.	
Learning Outcomes	After successful completion of the course, students will be able to: 1. Understand and interpret the structure, variables, processes and functions operating in ecosystems. 2. Foresee how the alteration of the components would affect the ecosystem and its functions. 3. Able to see the connectivity among all the components of ecosystems and their services. 4. Understand the importance of biodiversity and methods to measure it. 5. Understand the threshold of resilience and predict the impact of removal of a species in an ecosystem.	

Title of the Course:Land, Ocean and Atmospheric interactions

Course Code: ESC-105 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2021-22

Prerequisites for the course:	There is no prerequisite for this course apart from the program requirements

Objective:	The course will impart an insight to the students about the need for an integral approach to study an ecosystem.	
Content:	**Module 1: Introduction** Earth system science; Evolution of geosphere, biosphere, atmosphere, hydrosphere and cryosphere; Properties of sea and fresh water - distribution of temperature, salinity, density and oxygen in space and time. **Module 2:** Optical characteristics of sea water; Water type and masses: formation and classification, identification of water masses. General circulation of the world ocean; Wind driven and thermohaline circulation; Indian monsoon circulation. Tides- generation and propagation, characteristics of tides, spring and neap tides. **Module 3:** Atmospheric instability and convection-stability criteria; Mixing and convective condensation levels; Potential instability and latent instability; Cloud formation and types; Laws of black body radiation; Solar radiation transfer; Latitudinal and seasonal variation, absorption, scattering and reflection; Photosynthetically available radiation; Terrestrial radiation; Low and high pressure. **Module 4:** Upwelling and downwelling; Major and minor nutrients; Residence time; Dissolved gases; Marine habitats; Marine photosynthesis; Photosynthetic pigments; Biological productivity; Gross and net productivity; Redfield ratio; New and regenerated productivity; Food chain and food web; Exclusive economic zone.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	Use of conventional, online and ICT Methods. Lecture/Tutorials/Assignments	
References/ Readings	1. Wallace, J. M., &Hobbs, P. V. (2006). *Atmospheric science: Anintroductorysurvey*(2nded).Elsevier Academic Press. 2. Marshall, J., &Plumb, R. A. (2008).Atmosphere ocean and climatedynamics: Anintroductory.*Textile*.Elsevier Academic Press. 3. Hess, L. S.*Introduction to theoreticalmeteorology*.Wiley Online Library. 4. Houghton, J. T. (2002).*Physics of the atmosphere*.Cambridge University Press. 5. Stewart, R. L.(2008).*Introduction to physicaloceanography*. Department of Oceanography, Texas A&M University. 6. Open University Course Team.(1999).*Waves, tides and shallowwaterprocesses*. Butterworth-Heinemann Publications. 7. Williams, F. J., &Elder, S.*Fluid Physics for Oceanographers and Physics: An introduction to incompressible, US Naval AcademyPress, Paragon*. 8. Sverdrup, H.U., Johnson, M.W., &Flemming, R.H. (1962–). *The*	

	ocean: Theirphysics, chemistry and biology.Asia Publishing House. 9. Meller, C. B., &Wheeler, P. A.*Biological oceanography*.Wiley-Blackwell Publishers. 10. Grant Gross, M. (1990). *Oceanography* (5th ed).Prentice Hall. 11. Thurman, H.V., &Mercill, C. (1988). *Introductory oceanography* (5th ed) Publ. CO, OH. 12. Talley, L. D., Pickard, G. L., Emery, W. J., &Swift, J. H. (2011). *Descriptive physicaloceanography*(6th ed).Elsevier. 13. Lenton, T. (2016). *Earth systemscience: Averyshortintroduction*(1st ed).Oxford University Press. 14. Ehlers, E., &Kraft, T.*Earth systemscience in the Anthropocene: Emergingissues and problems.* Springer.	
Learning Outcomes	Understanding the interrelation between each component of Earth system to decipher meaningful information of an ecosystem.	

(Back to Index) (Back to Agenda)

Title of the Course:Environmental Impact Assessment - I
Course Code: ESC-106 **Number of Credits:** 01
Total Contact Hours: 12 **Effective from AY:** 2021-22

Prerequisites for the course:	There is no prerequisite for this course apart from the programme requirements	
Objective:	In order to overcome the problems of environmental degradation, it is very necessary to plan the development process in a sustainable manner so that control and mitigation measures can be undertaken prior to occurrence of degradation. One important tool to do this is carrying out Environmental Impact Assessment. Hence, knowledge of this subject is very important for an environmental engineer.	
Content:	**Module 1: Introduction to the Environmental Impact Assessment process** • **Introduction and principals:** Introduction; nature and purpose of EIA; Project, Environment and nature of Impacts; Changing perspective and current issues in EIA; EIA regulations. • **Starting up early stages:** Managing the EIA process; project screening, scoping; understanding the project/development action; establishing the environmental baseline; impact identification. • **Participation, presentation and review:** Impact prediction; Evaluation; mitigation and enhancement; public consultation and participation; the importance of monitoring and auditing in the EIA process; Monitoring and auditing practice; EIA presentation and review. • **Practice and prospects:** Legal Challenges, cost and benefits of EIA; Case studies of EIA in practice; strategic environmental assessment; extending EIA to project implementation.	12 hours
Pedagogy:	Lectures/assignments/workshops/ street play/brain storming sessions/outreach programmes/campus walks/documentaries and discussion/ presentations	
References/Readings	1. Glasson, J., Therivl, R., &Chadwick, A.(2005). *Introduction to environmentalimpactassessment*. Routledge, Taylor &Francis Group. 2. Arts, J., &Morrison-Saunders, A.(Eds.). (2012). *Assessing impact: Handbook of EIA and SEA follow-up*. Routledge, Taylor &Francis Group. 3. Abaza, H., Bisset, R., &Sadler, B.(2004). *Environmental Impact Assessment and Strategic Environmental Assessment: Towards an Integrated approach*. UN Environmental Program. 4. Therivel, R., &Wood, G.(Eds.). (2017). *Methods of environmental and social impact assessment*. Routledge, Taylor &Francis Group. 5. Morris, P., &Therivel, R.(Eds.). (2001). *Methods of environmental impact assessment, 2*. Taylor & Francis.	
Learning Outcomes	After learning the course the students should be able to: 1. Explain the need for EIA 2. Define EIA 3. Demonstrate the understanding of concept of Sustainable	

	Development and justify the methods of achieving SD. 4. Appreciate the importance of EIA as an integral part of planning process. 5. Apply the different methodologies to predict and assess the impacts of minor/major projects on various aspects of environment. 6. Enumerate the role of public participation in environmental decision making process. 7. Characterize the environmental attributes.	

Title of the Course: Ecology and Society

Course Code: ESC-201 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2021-22

Prerequisites for the course:	There is no prerequisite for this course apart from the programme requirements	
Objective:	The module on Goan Society, Gender and Ecology which is taught by faculty from the Women's Studies Programme of ManoharParrikar School of Law, Governance and Public Policy will introduce students to the politics behind the popular connect between women and nature, and will deliberate on the concerns regarding land, water and livelihoods, menstruation and environment with a focus on issues in Goa. The larger objective of ecology is to understand the nature of environmental influences on individual organisms, their populations, and communities, on eco-scapes and ultimately at the level of the biosphere. One core goal of ecology is to understand the distribution and abundance of living things in the physical environment and its importance to humans.	
Content:	**Module 1: Introduction** Introduction to Ecology & Environment: Physical environment; biotic environment; biotic and abiotic interactions.Habitat and Niche: Concept of habitat and niche, niche, width and overlap, resource partitioning. Environmental concepts: laws and limiting factors, ecological models. Ecological structure, Ethno-zoology: The study of the past and present interrelationships between human cultures and the animals in their environment. **Module 2: Ecology and society** Culture and cultural ecology, Environmental ethics, Community based conservation (Sacred Grooves etc.),Society and Laws (Environment Protection Act, Biodiversity Act etc.) **Module 3: Disciplinary traditions** An overview of disciplinary traditions and the study of Environmental issues.Society, culture and environment; Ecological consciousness and ecological conflicts.Environment, development and sustainable development.Environmental movements in India: Issues, ideologies and methods. **Module 4: Gender and Ecology in Goan Society**	06 hours 06 hours 12 hours 12 hours

	"Is Female to Male as Nature is to Culture" Sherry Ortner. Menstruation: Hygiene, Management, Eco-cultural practices and social exclusion. Forest Law, Tribes and Livelihood: Women's experiences in Goa - Kumeri cultivation, Social Ecology, Traditional knowledge, Power and Agency. Ecology, Livelihood and Gender: Water, Land ownership, Work, Participation and impacts (tourism, mining, agriculture, fishing, craft and small scale industry).	
Pedagogy:	Lectures/assignments/workshops/ street play/brain storming sessions/outreach programmes/campus walks/documentaries and discussion/ presentations	
References/Readings	Module 1 and Module 2: 1. Chapman, J. L., &Reiss, M. J.(1999).*Ecology: Principles and applications*.Cambridge University Press. 2. Conklin, A. R.(2004).*Field sampling: Principles and practices in environmentalanalysis*.CRC Press. 3. Fahey, T. J., &Knapp, A. K.(2007).*Principles and standards for measuringprimaryproduction*.Oxford University Press. 4. Grant, W. E., &Swannack, T. M.(2008).*Ecological Modelling, Blackwell*. 5. Odum, E. P., &Barrett, G. W.(2004). *Basic ecology: Fundamentals of ecology*(5th ed).Oxford and IBH Publishing Co, Pvt. 6. Sutherland, W. J.(2006).*Ecological Census techniques a handbook*.Cambridge University Press. 7. Wilkinson, D. M.(2007).*Fundamental Processes in Ecology: An Earth system Approach*.Oxford University Press. 8. Garcia, S. L.(2019). Gender and water. *Gender CC—Women for climatejustice*. UN. 9. Lynn, H.(2018). Seeing red: Menstruation and the environment, #PLASTICFREEPERIODS. *Women's environmentnetwork: London*. 10. Kaur, R., Kaur, K., &Kaur, R.(2018). Menstrual hygienemanagement, and wastedisposal: Practice and challengesfaced by girls/women of developingcountries. In*Journal of Environmental and Public Health*, 2018, (article ID1730964). https://doi.org/10.1155/2018/1730964 11. Manisha, P.et al.(2009). *Human rights, gender and the environment*. Dorling Kinderseley.	
Learning Outcomes	1. Essential in depth understanding of the concepts and components of ecology. 2. Learners will learn ecosystem structure and function along with the interactions involved at various levels. 3. It would provide a vision to understand the ecosystem ecology along with sufficient knowledge of energy flow and exchange. 4. Sensitization of students towards the environment with respect to the global scenario and the related problems, impact, along with methods to tackle the problems.	

Title of the Course:Climate Change and Sustainability

Course Code: ESC-202 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2021-22

Prerequisites for the course:	Basic understanding of the marine environment and microorganisms.	
Objective:	To introduce the students to climate change and also examine the methods and policies for the mitigation of climate change	
Content:	**Module 1: Introduction** Earth system, greenhouse gases: carbon dioxide, methane, nitrous oxide, warming potential, radiation and energy balance, solar variability, ozone and chlorofluorocarbon, aerosols, paleoclimate, ice-ages, carbon budget and global carbon cycle. **Module 2: Impact of climate change and future projections** Land and water resources, global warming, weather and heatwave, drought, biodiversity, extinction, migration, vegetation, agriculture and food security, human livelihood and health, ozone layer depletion, melting ice sheets, sea-level rise, precipitation. **Module 3: Ecological response** Floods, cyclone, changes in physical and biogeochemical properties of ocean: ocean acidification, deoxygenation, oxygen minimum zones, ocean circulation, effect on marine organisms, effect on polar regions, future projections and predictions: decadal, centennial, economic consequences. **Module 4: Mitigation and sustainability** Future Earth, adaptation, alternate energy sources: solar, wind energy, geothermal, biomass, biogas, hydrogen, lithium-ion battery, ocean thermal energy conversion, integrated assessment, emission budgets, future technologies: biofuels, hydrogen, geoengineering, carbon sequestration, contribution of oceans in mitigation, ethics and environmental policy, International agreements: United Nations Framework Convention on Climate Change, Kyoto Protocol, Paris Agreement, role of India, youth and mass media in climate change mitigation.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	Lectures/tutorials/assignments/self-study	
References/ Readings	1. Reichle, D. E.(2020). *The globalcarbon cycle and climateChange: Scalingecologicalenergetics from organism to biosphere*.Elsevier Science. 2. Johansen, B.E.(2017). *Climate Change: Anencyclopedia of science, society, and solutions*.ABC-CLIO. 3. Mélières, M. A., &Maréchal, C.(2015). *Climate Change: Past, present and future*.Wiley-Blackwell. 4. Hodgson, P. E.(2010). *Energy, the environment and climateChange*.Imperial College Press. 5. Laczko, F., &Aghazarm, C.(2009). *Migration, Environment and Climate Change: Assessing the evidence*.International	

	Organization for Migration. 6. National Research Council.(2008). *Ecological impacts of climateChange*.National Academies Press. 7. Dessler, A.(2016). *Introduction to modernclimateChange*(3rded).Cambridge University Press. 8. Srivastav, A.(2019). *The science and impact of climateChange*.Springer. 9. Chen, W. Y., Suzuki, T., &Lackner, M.(2012). *Handbook of climatechangemitigation and adaptation* (2nded).Springer.	
Learning Outcomes	1. Provides brief knowledge about climate change, its impact on all life forms and what measure can be taken to mitigate it. 2. It also highlights the role of youth in adopting a sustainable lifestyle to tackle this global issue.	

Title of the Course: Environmental Geo-informatics

Course Code: ESC-203 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2021-22

Prerequisites for the course:	A compulsory course for students admitted to Environmental Sc. course. Students for this course are expected to have experience of basic use of computers and concepts of Geography & Environment.	
Objective:	Students to gain important skills in spatial data acquisition, analysis and interpretation, lab and field methods of GIS and remote sensing.	
Content:	**Module 1: Introduction** Introduction, Geoinformatics for Environmental Monitoring and management; Introduction to Photogrammetry; Geodata and Geoinformatics (Geodata, Concept of Digital Earth, Geoinformatics Fundamentals). Geoinformatics-Applications to Environmental Monitoring and Management. Geoinformatics for environmental Decision Making.	06 hours
	Module 2: Image visualization Image visualization, analyses and Interpretation. Introduction to Aerial Photos, Satellite Imageries, Concept of Image, Resolution and Scale. Image Visualization and Digital Image Processing, Transformation and Classification; Hands on Tutorials and related image processing Exercises.	10 hours
	Module 3: Fundamentals of Remote Sensing Fundamentals of Remote Sensing (Basic Concept, Principles of EM Radiation, EMR and EMR interaction with Atmosphere, Passive versus Active Remote Sensing); Optical Remote Sensing – Data Acquisition: Sensors and Systems; Microwave Remote Sensing – Principles, Microwave Systems, Radar Imaging, geometry of SAR.	10 hours
	Module 4: Fundamentals of GIS Fundamentals of GIS (Basic Components, functions and applications);	10 hours

	Data Models and Structures (Vector and Raster Data Models, GIS Topology); GIS Data Input (Data Sources, Data Capture and Editing-Vector & Raster Data Input); GIS Database (Geodatabase-Design and Database management); Spatial Analyses (Exploration, measurements, Buffering, Overlay and Reclassification). GIS Terrain Analysis.	
Pedagogy:	Online / Classroom lectures, Tutorials, Assignments, Team activities	
References/Readings	1. Konecny G. (2003) Geoinformation*: remote sensing, photogrammetry, geographic information systems. Taylor and Francis, London.* 2. Campbell JB. (2007) *Introduction to remote sensing, 4th edn. Guilford Press, New York.* 3. Burroughs WJ. (2007) Climate change*: a multidisciplinary approach, 2nd edn. Cambridge University Press, Cambridge,* 4. Jensen JR (2005) Introductory digital image processing*: a remote sensing perspective, 3rd edn. Prentice-Hall, NJ* 5. Longley PA, Goodchild MF, Maguire DJ, Rhind DW. (2005*) Geographic information systems and science. Wiley, West Sussex, England,* 6. Anjireddy, M. (2008) *Textbook of Remote Sensing and GIS. BS Publications, 453p,.* 7. Gabor Farkas. (2017) *Practical GIS. Packts Publishing, 402p..* 8. Joel Lawhead. (2019) *Learning Geospatial Analysis with Python. Packts Publishing, BIRMINGHAM – MUMBAI. 433p. Third Edition.* 9. Reza, H P and Candan G. (2019) *Spatial Modeling in GIS and R for Earth and Environmental Sciences, 770p. Elsevier.*	
Learning Outcomes	Upon successful completion of the course, the students will be prepared to demonstrate: 1. Self-knowledge of their individual strengths and weaknesses in understanding the geospatial applications for environmental management. 2. Lifelong learning skills in Geospatial Technologies.	

(Back to Index) **(Back to Agenda)**

Title of the Course: Basic Statistics
Course Code: ESC-204 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2021-22

Prerequisites for the course:	Completion of first semester of the programme	
Objective:	The aim of the course is to introduce students to the study of basic statistics so that they can independently explore data, analyse it and present it to academics, policy-makers and civil society.	
Content:	**Module 1: Introduction** Exploring Data: Basic concepts of descriptive statistics -- measures central tendency (mode, median and mean) and dispersion (range, interquartile range, variance and standard deviation). Displaying data. **Module 2:Correlation and regression** Bivariate analyses: Correlation, Measures of correlation: (Pearson's r). Scatter plots and Linear regression analysis. Goodness of fit (R-squared). **Module 3:Probability and distribution** Introduction to probability, random variables, concepts of events, sample space and random trials. Conditional probabilities, independence. Probability Distributions:Discrete probability distribution: Binomial and Poisson. Continuous probability distribution: Student-t, Normal, Standard Normal, Chi-square and F-distributions **Module 4:Sampling distributions and inferential statistics** Sampling methods: Random, stratified random, non-random sampling methods. Determining sample size. Inferential statistics:Confidence interval; Testing of hypotheses: the null hypothesis and the alternative hypothesis.	04 hours 06 hours 16 hours 10 hours
Pedagogy:	Lectures/assignments/workshops/ street play/brain storming sessions/outreach programmes/campus walks/documentaries and discussion/ presentations.	
References/Readings	1. Heumann, C., Schomaker, M., &Shalabh. (2016). *Introduction to statistics and dataanalysis: Withexercises, solutions and applications in R*. Springer. 2. Levine, S. D., Krehbiel, &Berenson. (2008). *Statistics for managers: UsingMicrosoft Excel* (5thed). Pearson Education, Inc. 3. McClave, J.T., Benson, P. G., &Sincich, T.(2018). *Statistics for business and economics*. Pearson. 4. Witte, R. S., Witte, J. S., &Wiley. (2017). *Statistics* (11thed).	
Learning Outcomes	1. The students will be able to understand the basic concepts in statistics. 2. They will learn how to collect, arrange, present and analyze data.	

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Title of the Course: Environmental Management
Course Code: ESC-205 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2021-22

Prerequisites for the course:	Completion of first semester of the programme	
Objective:	The objective of the course is to enable participants to have a holistic understanding of the environment and know the methods of managing environmental issues.	
Content:	**Module 1: Introduction environmental management** Introduction to environmental management: Pollution and its various forms, Sustainability and sustainable development. **Module 2: Biodiversity and resources** Biodiversity and Resources: Societal ownership, Biodiversity, Benefits of natural resource protection, Traditional biodiversity knowledge, Bio-piracy. **Module 3: Environmental policies and management** Environmental policies and legislations and life cycle assessment: Environmental sustainability index, National and international environmental legislation, Life cycle assessment, LCA framework, Stages in LCA Energy Management and ISO Certification: Energy audits and methods, Energy conservation, Energy demand and balances, ISO 9000 and ISO 14000 series, Environment management certification **Module 4: Pollution management** Water, air and noise pollution: Water pollution and management of water, Waste water and industrial waste water, Air pollution control measures. Noise pollution law and control measures. Solid waste and hazardous waste: Solid and hazardous waste sources and composition, Effect on health, storage, treatment and disposal of hazardous waste, Landfill designs, methods of disposal of solid waste. Monitoring environment using analytical methods: Statistical and instrumental methods, Analyses of all types of environmental pollution.	06 hours 06 hours 12 hours 12 hours
Pedagogy:	Lectures/tutorials/ laboratory work /field work/outreach activities/ project work/ vocational training/ viva /seminars / term papers/ assignments / presentations / self-study/case studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. Murali Krishna, V., &Manickam, V. (2017).*Environmental Management*.Butterworth-Heinemann. 2. Kulkarni, V., &Ramchandra, T. V. (2009).*Environmental management, commonwealth of learning*.Indian Institute of Science.	
Learning Outcomes	At the end of the course the participant should be able to identify: 1. Environmental impact 2. Methods of control of such impacts 3. Analyse the impact using statistical and other analytical tools	

	4. Suggest specific interventions to alleviate environmental issues.	

Title of the Course: Environmental Impact Assessment II
Course Code: ESC-206 **Number of Credits:** 01
Total Contact Hours: 12 **Effective from AY:** 2021-22

Prerequisites for the course:	Completion of first semester of the programme	
Objective:	To understand the Environmental Impact Assessment processes through the study of EIA reports available for various kinds of projects.	
Content:	**Module 1:** Study of EIA reports for major projects of the country available online and understand the methods used, interpretations made, conclusions drawn, objections raised and decisions taken and their implementation.	12 hours
Pedagogy:	Lectures/tutorials/ laboratory work /field work/outreach activities/ project work/ vocational training/ viva /seminars / term papers/ assignments / presentations / self-study/case studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. Yerramilli, A., &Manickam, V. (2020). *Environmental impactassessmentmethodologies* (3rded). BS Publications/British Society of Periodontology Books. 2. Glasson, J., &Therivel, R. (2019). *Introduction to environmentalimpactassessment* (5thed). Routledge. 3. Khandeshwar, S.R., N.S. Raman and A.R. Gajbhiye. Environmental Impact Assessment. 2019. Dreamtech Press. EIA manuals available at: 1. http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/ommodel3.html 2. Sectoral Manuals under EIA Notification, 2006: 3. http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/ommodel2.html 4. Anonymous. Environmental Impact Assessment Training Manual. 2016. International Institute for Sustainable Development. 5. http://www.iisd.org/learning/eia/wp-content/uploads/2016/06/EIA-Manual.pdf EIA Online Learning Platform www.iisd.org/learning/eia	
Learning Outcomes	After the discussion of case studies, the students will be able to understand how to work and write EIA reports for each of the	

	major sectors.	

Title of the Course: Environment Impact Assessment III
Course Code: ESC-301 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	The student should have completed ESC-106 (EIA I) and ESC-206 (EIA II)	
Objective:	Environmental degradation is occurring at an alarming rate. Hence, it is required to plan the developmental processes in a sustainable manner. An important tool to attain this is through the conduct of Environmental Impact Assessment.	
Content:	**Module 1:Introduction** EIA sectors – River valley, Mining, Manufacturing industries, Infrastructure, Power, Building and large construction, township and area development.	06 hours
	Module 2: EIA guidelines Cost-benefit analysis, Detailed project report, Feasibility report. Terms of Reference (TOR), Generic structure of EIA document and description of the project. Public consultation, Environmental Clearance (EC) processes, validity, extension, monitoring, transfer compliance report, Role of statutory agencies in environmental clearance. EIA consultant accreditation process in India. Components of EIA-Physical, Biological and Socio-cultural environment. EIA methods – Checklist & matrices.	10 hours
	Module 3:Comparative Evaluation of Alternatives Selecting a Preferred Alternative. Conceptual Basis for Trade-Off Analysis. Importance Weighting of Decision Factors. Plans and Monitoring**.** Elements of Mitigation. Environmental Management Plan (EMP), elements, structure and examples of various projects. Objectives of EIA implementation and follow up. Tools of EM &performance review. Environmental auditing. Evaluation of EIA effectiveness and performance.	10 hours
	Module 4: EIA of Mining Potential sites, brief description of the project, identification, nature of mineral, Quality and quantity, resource available, geology, types of mining, carrying capacity, Blasting - Rules and Guidelines, Dust and noise pollution, transportation, Biodiversity assessment, Impact on human settlement, Restoration, reclamation and mitigation measures, hydrology, safety and prevention measures.	10 hours
Pedagogy:	Lectures/assignments/workshops and discussion/presentations.	

References/ Readings	1. Glasson, J., Therivl. R & Chadwick, A. (2005). Introduction to Environmental Impact Assessment. Published by Routledge. Taylor and Francis Group. New York 2. Arts, J., & Morrison-Saunders, A. (Eds.). (2012). *Assessing impact: handbook of EIA and SEA follow-up*. Routledge.Taylor and Francis Group. New York 3. Abaza, H., Bisset, R., Sadler, B., (2004). Environmental Impact Assessment and Strategic Environmental Assessment: towards an Integrated approach. UNEP. 4. Therivel, R., & Wood, G. (Eds.). (2017). *Methods of environmental and social impact assessment*. Routledge. Taylor and Francis Group. New York. 5. Morris, P., &Therivel, R. (Eds.). (2001). *Methods of environmental impact assessment* (Vol. 2). Taylor & Francis. New York	
Learning Outcomes	On completion of the course, the student will be able to apply various methods to assess the impacts of developmental projects on various aspects of environment with special reference to mining.	

Title of the Course: Lab Course in Environmental Science
Course Code: ESO-302 **Number of Credits:** 03
Total Contact Hours: 72 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at the 10+2 level.	
Objectives:	1. To introduce students to basic instruments in chemistry lab, significance of calibration of glassware/ use of analytical grade reagents/ general reagents, use of analytical balance, basic laboratory practices, safety in laboratory. 2. To understand the concentration of various pollutants including trace metals in the water/soil/air. The analyses of BOD and COD are used to understand the impact organic pollution on water bodies.	
Content:	**Section –I** **Module 1 (Any 6 experiments, 3 hours each)** 1. Demonstration of instruments (colorimeter, pH meter, conductivity meter, Karl Fischer titrator, 2. Calibration of glass electrode and conductivity meter. 3. Determination of pH and conductivity of surface, ground and sea water 4. Determination of alkalinity and acidity of surface, ground and sea water sample using titrimetric analysis. 5. Estimation of total solids, dissolved solids, suspended solids of river/lake/pond water sample. 6. Estimation of total residual chlorine of water samples.	18 hours

	7. Estimation of sulfate in water samples (tap water) by turbidimetry. **Module 2 (Any 6 experiments, 3 hours each)** 1. Determination of pH and conductivity of soil samples. 2. Determination of moisture content of soil samples. 3. Estimation of hardness of water samples by complexometric method 4. Determination of chemical oxygen demand in given water sample 5. Determination of nitrite in water sample using colorimetry. 6. Determination of chromium in water sample by colorimetry. 7. Determination of elements (Fe/Mn/Zn/Pb/Cd etc) in air using high volume sampler **Section –II** **Module -3:** 1. Determination of dissolved oxygen in coastal waters. (4 hrs; Ref.1) 2. Estimation of dissolved oxygen in polluted water (6 hrs. Ref. 2, 3) 3. Determination of biochemical oxygen demand in coastal waters (4 hrs; Ref. 1) 4. Estimation of hydrogen sulfide in coastal waters (4 hrs. Ref. 3) **Module 4:** 1. Determination of chemical oxygen demand in coastal waters by $KMnO_4$ method (4 hrs; Ref. 2) 2. Pre-concentration of sea water by solvent extraction method for analysis of trace metals by AAS (6 hrs; Ref 5,6,7) 3. Estimation of Cu &Pb in coastal waters by AAS method (8 hrs; Ref 5,6,7).	18 hours 18 hours 18 hours
Pedagogy:	Pre-lab and post-lab assignments or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	**Section – I** 1. Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2002). *Chemistry for environmental engineering and science* (5th ed). McGraw-Hill Education. 2. Dey, A. K. (2018). *Environmental Chemistry* (9th ed). New Age International Publishers. 3. Jeffery, G. H., Bassett, J., Mendham, J., & Denney, R. C. (1989). *Vogel's Textbook of quantitative chemical*	

	analysis. (5th ed). Longman Scientific and Technical, U.K. 4. Moore, J. W., & Moore, F. A. (2012). *Environmental Chemistry:* (1st ed). Academic Press. 5. Lakshmi, G. S. (2010). *Environmental Science: A practical manual.*(1st ed). BS publications 6. Rattan, S. (2011). *Experimental in Applied Chemistry*. (3rd ed). S.KKataria& Sons. 7. Mitra, S., Patnaik, P., &Kebbekus, B. (2019). *Environmental chemical analysis: Laboratory Experiments in Environmental Chemistry* (2nd ed). CRC Press. 8. Henrie, S. A. (2015). *Green Chemistry: Laboratory manual for General Chemistry* (1st ed). CRC Press Taylor & Francis Group. **Section – II** 1. Martin, D. F. (1972). *Marine chemistry*, *1*. Academic Press. 2. Standard methods for the examination of water and waste water analysis. 22nd Edition. 3. Rice, E. W., & Bridgewater, L. (2012). American Public Health Association. 4. Grasskhoff, E. K. M., &Krembling, K. (1983). *Methods of Seawater analysis*. VerlagChemie, Weinneim. 5. Strickland, J. D. H., & Parsons, T. R. (1972). *A practical hand book of seawater analysis* [Fisheries Board of Canada bulletin] (2nd ed). 6. Riley, J. P., &Skirrow, G. (1975). Analytical chemistry of seawater. In *Chemical oceanography*, *3*. Academic Press. 7. Allen, S. E., Grimshaw, H. M., Parkinson, J. A., Quarmby, C., & Roberts, J. D. (1976). (eds) Chapman S. B, Chapter 8. Chemical analysis. In *Methods in plant Ecology*. Blackwell Scientific Publications.	
Learning Outcomes	1. Students will be in a position to know the basic environmental chemical processes. 2. Students will be able to explain the origin and harmful effects of toxic chemicals in the environment. 3. Student will be in position to use different techniques for qualitative and quantitative estimation of environmental samples. 4. The results of analyses of different pollutants in sea water can be used to set the limits of their discharge. 5. These concentrations will be compared with the daily intake of, or exposure to a pollutant by organism/man and it can lead to acceptable concentration of pollutant in organism. 6. These studies would help to regulate the release of a	

	particular pollutant in the marine environment.	

Titleof the Course: Marine Pollution
Course Code: ESO-303 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at 10+2 level	
Objectives:	1. To identify the type of materials added to the sea and their sources. 2. What effect these additions to the sea and animal living there. 3. What implications these effects have for human health and 4. What is being done to reduce the undesirable effects.	
Content:	**Module 1: Introduction** Introduction to Environment, Objectives of environment, Marine pollution definition, Some questions, Categories of additions, Nature of inputs, and Sources of inputs. Gross chemical composition of seawater, Sources of dissolved and particulate matter in the sea, Geochemical balance and residence times of elements in seawater **Module 2: Organic wastes** Biochemical oxygen demand, the dilution factor, Settlement, Oxygen budget, Consequences of organic discharges into Thames and Mersey estuaries. Decomposition of organic matter in oxic and anoxic environments. Sewage and sewage treatment, Disposal of sewage sludge, Industrial wastes and treatment processes with reference to wastes from paper and pulp and soap manufacturing industries. Oil spills and Consequences of oil pollution: Introduction, Inputs, major accidental spills, fate of spilled oil at sea and Treatment of spilled oil. **Module 3: Conservative pollutants** Conservative pollutants: Measures of contamination, Toxicity, Acute, Chromic exposure and Detoxication. Trace metal pollution in coastal waters (Hg, Cd, Pb, Cu and Fe),and Radioactive pollution: Sources, classification, effects of radiation, MPD concept, protection and control from radiation, Beneficial aspects of radiation and Disposal of royal wastes. Halogenated hydrocarbons; Low molecular weight compounds, High molecular weight compounds, Inputs to sea, fate in the sea, Biological effects, environmental impact, mode of poisoning of pesticides.	06 hours 10 hours 10 hours

	Module 4: Pollution indicators, marine corrosion and Assessment of pollution damage Pollution indicators: Criteria for selection of indicator organism, Quantification of pollution load, basic pre requisites, Response to different pollution load and Time integration capacity. Macro algae and Mollusc as indicators to monitor trace metal pollution in coastal waters. Monitoring strategies of Marine pollution: Critical pathway approach and Mass balance approach. Marine corrosion: Definition, Corrosion theory, Effects, classification, factors affecting corrosion of metal in seawater and control of marine corrosion. Standards in water quality and instrumental techniques, Pollution status of the North Sea. Present status of coastal pollution in India and Future strategies. Assessment of pollution damage: The need, serious ness of damage and assessment of damage.	10 hours
Pedagogy:	Lectures/tutorials/assignments/self-study	
References/ Readings	1. Riley, J. P., &Skirrow, G. (Eds.). (1975). Chemical oceanography. Academic Press Vol: 3 2. Goldberg, E. D. (1976). *The health of the oceans*. UNESCO Press. 3. Clark, R. B. (1986). *Marine pollution*. Oxford Science Publications. 4. Phillips, J. D. H. (1980). *Quantitative aquatic biological indicators.* Applied Science Publishers. 5. Sharma, B. K., &Kaur, H. (1994). *Thermal and radioactive pollution*. Krishna PrakashamMandir. 6. Sharma, B. K., &Kaur, H. (1994). *Water pollution.* Krishna Prakashammandir, Meerut. 7. Chandler, K. A. (1985). *Marine and offshore corrosion.*ButterWorths, London.	
Learning Outcomes	1. The course helps in understanding the impact of various pollutants on marine ecosystem; it analyses the factors responsible for degradation and suggests suitable corrective measures. 2. To create awareness among students, and to safeguard the marine environment 3. The course suggests policy measures to prevent marine pollution and to create sustainable marine environment and 4. To provide advisory and technical service to government and industry for pollution abatement.	

(Back to Index) (Back to Agenda)

Title of the Course: Environmental Microbiology
Course Code: ESO-304 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at the 10+2 level.	
Objective:	This course develops concepts in Environmental Microbiology: Microbial diversity in different habitats and role of microorganisms in biogeochemical cycles. Microbial remediation of pollutants and microorganisms in sustainable development.	
Content:	**Module 1: Introduction** Origin of life & 3 domains of life. Introduction to microbial world and brief history of microbiology. Microbes from diverse environments**:** Hypersaline, hydrothermal vent, sulphur springs, polar environments, Soda Lake, marine environments, deep sub surfaces, oligotrophic, deserts, garden/field soil, fresh water lakes. **Module 2:** • **Studies on microbial diversity and methods to study microbial communities:** Metabolic diversity of microbial communities. • **Role of microorganisms in biogeochemical processes:** Biogeochemical cycling of carbon, nitrogen, sulphur, iron and phosphorus; Functional diversity of microbial communities. Role of microorganisms in ecological succession; Microbial symbiotic associations; Biofilms. **Module 3: Environmental microbiology in sustainable development** Microorganisms in agriculture: Mycorrhizae, biofertilizers, composting, biocontrol agents, organic farming; Microorganisms for food security and clean energy; Microorganisms for bioremediation of oil spills, heavy metals, xenobiotics and waste water treatment. **Module 4: Impacts of microorganisms on environment and humans:** Microbiomics; Microorganisms and climate change; Climate change and occurrence of diseases; Disease causing microorganisms and antibiotics; Algal blooms and harmful algal blooms; Ballast water and significance of invasive microorganisms.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	Lectures/tutorials/assignments/online teaching /powerPoint presentations/MOODLE, case study.	
References/ Reference/	1. Willey, J. M., Sherwood, L. M., &Woolverton, C. J. (2017). *Prescott's Microbiology*. McGraw-hill Education. 10th	

Readings	Edition. 2. Medigan, M. T., Bender, K. S., Bukley, D. H., Sattley, W. M., & Stahl, D. A. (2019). *Brock Biology of Microorganisms*. Pearson. 15th Edition. 3. Munn, C. (2020). *Marine Microbiology: Ecology and applications*. Garland science. Third edition. 4. Naik, M. M., &Dubey, S. K. (2017). *Marine pollution and Microbial remediation*. Springer. 5. Satyanarayana, T., Johri, B., & Anil, T. (2012). *Microorganisms in Environmental Management*. Springer. 6. King, R. B., Sheldon, J. K., & Long, G. M. (2019). *Practical Environmental Bioremediation: The Field Guide*. CRC Press. second edition. 7. Meena, S. M., &Naik, M. M. (2019). *Advances in Biological Science Research: a practical approach*. Elsevier. 8. Bertrand, J. C., &Coumette, P. (2015). *Environmental Microbiology: Fundamentals and Applications*. Springer. 9. Yates, M., Nakatsu, C. H., Miller, R. V., &Pillai, S. D. (2016). *Manual of Environmental Microbiology*. ASM press. 10. Cavicchioli, R., Ripple, W. J., Timmis, K. N., Azam, F et al. (2019). Scientists' warning to humanity: microorganisms and climate change. *Nature reviews microbiology*, 17, 569-586. 11. Dirk, H. (2018). *The Gut microbiome in health and disease*. Springer.	
Learning Outcomes	On successful completion, course participants will be able to understand: 1. Distribution of microbes in diverse environment and their role. 2. Significance of microorganisms in biogeochemical cycling. 3. Natural bioremediation processes and sustainable development.	

Title of the Course: Environmental Biotechnology
Course Code: ESO-305 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at the 10+2 level.	
Objective:	This course will impart knowledge on biotechnological applications that can be used to tackle environmental issues emerging due to industrialization and globalization.	
Content:	**Module 1: Introduction** Environment, Biotechnology, Concepts in Environmental Biotechnology. Areas of environmental biotechnology. Development, use and regulation of biological systems for remediation of contaminated environments (land, air,	06 hours

	water), and for environment-friendly processes (green manufacturing technologies and sustainable development). Ethical issues in environmental biotechnology. **Module 2:** • **Biotechnology in agricultureand environmental sustainability** Biotechnology innovations for global food security [(Genetic engineering (GE)/recombinant DNA technology (rDNA) and transgenic organisms for biological pest, weed and disease control)]; Modern plant breeding methods for increasing crop productivity and improve soil structure. Case studies - Bt cotton, BtBrinjal, Golden Rice. Blue revolution (ocean based economy) and Sea-agriculture; Seaweed, Fish, Shrimp and Bi-valve farming. Modern marine biotechnology for the sustainable food production. Macroalgalbiorefinery for supply of resources (food or feed ingredients, chemicals, bioenergy and materials). • **Monitoring environmental pollution** Robust techniques and innovative new concepts for identifying and screening of toxins and pathogens in the environment (genetic and biochemical kits and reagents, CRISPR–Cas technology, and cellular models). **Module 3: Biotechnology in Waste handling, treatment and sustainable development** (Environmental biotechnology and human health)**:** Centralized wastewater treatment systems (primary, secondary and tertiary treatment); Decentralized wastewater treatment systems (phytoremediation in constructed wetland system, waste stabilization ponds, anaerobic digesters). Solid waste management, Plastic pollution, Rendering plastic degradation in marine environment. Genetic engineering for combating environmental pollution, bioremediation. Waste to energy power plants, recycling, reducing waste and composting & vermicomposting. Novel composting methods for sludge biomass (such as *terra preta* of the sludge); Resource recovery for sustainable development (recovery of N & P, energy, organics and clean water). **Module 4:** • **Resource management and environment conservation** Basic concept of saving of resources and energy through biotechnology; Prevention of eutrophication using	10 hours 10 hours 10 hours

	macroalgae; biological control of mosquitos. • **Bioresource technology for clean environment** Biomass (wood waste, agricultural waste, municipal solid waste, manufacturing waste, and Sewage sludge) as source of energy and bio-fuels. Microalgae as a source for Biodiesel. Biodegradable plastic.	
Pedagogy:	Lectures/tutorials/assignments/ online/self-study	
References/Readings	1. Scragg, A. (1999). *Environmental biotechnology*. Pearson Education Limited. 2. Rehm, H. J., & Reed, G. (1999). *Biotechnology- a comprehensive treatise.* VCH Verleg, Germany. 3. Chaterjee, A. K. (2000). *Introduction to environmental biotechnology*. Public Health Institute. 4. Colin, M. *Marine microbiology: Ecology and applications* (2nd ed). Garland Science. 5. Satyanarayana, T., Johri, B., & Anil, T. *Microorganisms in environmental management.* Springer Publishers. 6. King, R. B., Sheldon, J. K., & Long, G. M. *Practical environmental bioremediation: The field guide*. Lewis Publishers. 7. Meena, S. M., &Naik, M. M. *Advances in biological science research: A practical approach*. Elsevier. 8. Willey, J. M., Sherwood, L. M., Woolverton, C. J., & Prescott, S. *Microbiology* (10th ed). 9. Prabhu, M. (2016). *Resource recovery from wastewaters for sustainable development* [PhD Thesis]. Goa, B.P. Shodhganga.URL. http://hdl.handle.net/10603/124726 10. Prabhu, M. S., Israel, A., Palatnik, R. R., Zilberman, D., &Golberg, A. (2020). Integrated biorefinery process for sustainable fractionation of *Ulvaohnoi* (Chlorophyta): Process optimization and revenue analysis. *Journal of Applied Phycology*, *32*(4), 2271–2282. 11. Zollmann, M., Robin, A., Prabhu, M., Polikovsky, M., Gillis, A., Greiserman, S., &Golberg, A. (2019). Green Ttechnology in green macroalgaebiorefinery. *Phycologia*, *58*(5), 516–534.	
Learning Outcomes	At the end of this course, students will be able to apply their knowledge for the application of biotechnological processes for betterment of environment and sustainable development of the society.	

(Back to Index) (Back to Agenda)

Title of the Course: Conservation Biology

Course Code: ESO-306 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objectives:	1. To systematically understand biodiversity at global, regional and local level; threat assessment, management of biodiversity and restoration of ecosystems. 2. To appreciate the need of biodiversity conservation in the context of various developmental pathways and policy framework.	
Content:	**Module 1:Introduction** Introduction to conservation biology and biodiversity at global, regional and local levels; flagship species, umbrella species, keystone species, IUCN Red list of threatened species, endemic species, Scheduled species and their distribution. Valuing Biodiversity: ecological economics and direct use values, indirect use value, ethical values. Threats to biodiversity and human-wildlife conflicts.	06 hours
	Module 2:Diversity of mega-diversity countries Flora and fauna of Hotspots and Mega-diversity Countries (United States of America, Mexico, Colombia, Ecuador, Peru, Venezuela, Brazil, Democratic Republic of Congo, South Africa, Madagascar, India, Malaysia, Indonesia, Philippines, Papua New Guinea, China, and Australia.)	10 hours
	Module 3: In-situ and ex-situ conservation Threat assessment and management, Conservation at population and species levels; in situ conservation of migratory species across borders. Biodiversity monitoring, establishing, designing and managing protected areas; national parks, wildlife sanctuaries, biospheres, sacred groove, marine protected areas, conservation outside the protected areas, conservation in Indian culture, case studies on efforts for conservation of Indian flora and fauna. Ex situ conservation, captive breeding, microbial conservation, plant propagation (tissue culture), reestablishment and relocation, conservation of plant diversity in seed banks, germplasm reserves.	10 hours
	Module 4: Sustainable development, restoration and legislation Sustainable development at Local, National and International levels. Restoration of damaged ecosystem, endangered species	10 hours

	restoration with advanced technologies, applied population biology, manipulation of wild population, establishing new populations, control of predators, herbivores and competitors. National and International conservation organisations and Institutions. Environmental policies, environmental law and legislations.	
Pedagogy:	Use of conventional, online and ICT methods. Field visit, case study/ field work/project/self-study. Lecture/tutorials/assignments.	
References/ Readings	1. Balmford, A., Rhys Green & Ben Phalan (2012). What conservationists need to know about farming. Proc. Roy. Soc. B 279: 2714-2724. 2. Hunter M.L., Gibbs, J.B. & Sterling, E.J. (2008). Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing. 3. Milner-Gulland E.J. & J. Marcus Rowcliffe, (2007) 4. Conservation and Sustainable Use: A Handbook of Techniques. Oxford University Press. 5. Navjot S. Sodhi& Paul R. Ehrlich (Eds.) (2010). Conservation Biology for All. Oxford University Press. 6. Pandit, M.K. Sodhi N.S., Koh L. P., Bhaskar A. & Brook B. (2007). Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. Biodiversity Conservation 16: 153-163. 7. Primack R.B. (2002) Essentials of Conservation biology. Sinauer Associates, Sunderland, USA. 8. Pullin Andrew S., (2002) Conservation Biology, Cambridge University Press. 9. Stachowicz, J.J. &Tilman, D. (2005). Species invasions and the relationships between species diversity, community saturation and ecosystem function. In Species Invasions, Insights into Ecology, Evolution and Biogeography (Sax, D.F. et al. eds.), Sinauer Associates, Sunderland, MA. 10. Wheeler, T. & von Braun, J. (2013). Climate change impacts on global food security. Science 341: 508-513. 11. Woodroffe R., Thirgood, S. &Rabinowitz, A. (2005). People and Wildlife, Conflict or Co-existence? Cambridge University.	
Learning Outcomes	1. To know the value of global biodiversity. 2. Understand threat to biodiversity, threat assessment and management plans to conserve biodiversity. 3. Plan restoration of the damaged ecosystem using advanced technology.	

(Back to Index) (Back to Agenda)

Title of the Course: Water Resource Management
Course Code: ESO-307 **Number of Credits:** 03
Total Contact Hours: 36 E**ffective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at the 10+ 2 level	
Objectives:	1. To understand occurrence and circulation of water in nature. 2. To study the functioning, problems and measures that can be taken for sustainable development of water resource.	
Content:	**Module 1: Introduction** Traditional methods of water management, agriculture, sanitization systems and environment. Hydrological cycle: Evaporation, evapotranspiration, precipitation, runoff and infiltration.	06 hours
	Module 2: Aquifers characteristics and irrigation Classification of aquifers and confining layers, hydraulic properties of aquifers, water table and piezometric surface. Availability of water in Lakes, ponds, streams and rivers. Irrigation in India: Water control and crop production. Construction, technology and operation of water control system. Problems related to overexploitation and groundwater mining. Saline water intrusion in coastal aquifers and its control. Fresh-salt water interface.	10 hours
	Module 3: River flooding and rain water harvesting Nature, extent, magnitude and frequency of floods, urbanization and flooding. Impact of climate change on water availability. Concept of basin management, basin investigation. Subsurface investigation of groundwater. Drilling methods, construction, development and maintenance of wells. Rainwater harvesting and water conservation techniques and its importance. Concept of artificial recharge: methods, wastewater recharge for reuse.	10 hours
	Module 4: Pollution and water governing laws Pollution of surface and groundwater: Municipal sources, industrial sources, agricultural sources. Case studies of water pollution in India. Physical, chemical, biological properties of water. Quality criteria for different uses. Water Governance: Salient features of The Water (Prevention and control of pollution) Act, 1974 and Goa water (Prevention and Control of Pollution) Rules, 1988.	10 hours
Pedagogy:	Lectures / Assignments / Seminars/ Self-study	
References /Readings	1. Fetter, C. W. (2018). *Applied hydrogeology*. Waveland Press.	

	2. Grafton, R. Q., & Hussey, K. (Eds.). (2011). *Water resources planning and management*. Cambridge University Press. 3. Jain, S. K., Agarwal, P. K., & Singh, V. P. (2007). *Hydrology and water resources of India* (Vol. 57). Springer Science & Business Media. 4. Johnson, W. (1982). *Environmental Geology-Coates*, *DR.* 5. Keller, E. A. (2007). *Introduction to environmental geology*. Prentice-Hall, Inc. 6. Kumar, R., Singh, R. D., & Sharma, K. D. (2005). Water resources of India. *Current science*, 794-811. 7. Pennington, K. L., &Cech, T. V. (2009). *Introduction to water resources and environmental issues*. Cambridge University Press. 8. Todd, D. K., & Mays, L. W. (2004). *Groundwater hydrology*. John Wiley & Sons. 9. Vaidyanathan, A. (1999). *Water resource management: institutions and irrigation development in India*. Oxford University Press.	
Learning Outcomes	The main outcome of the course is to understand and develop information with respect to occurrence and circulation of water in nature and find solutions to the water related problems.	

Title of the Course: Disaster Management

Course Code: ESO-308 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022–23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objective:	To provide basic conceptual understanding of disasters, understand approaches of Disaster Management and build skills to respond to disasters	
Content:	**Module 1: Introduction** Understanding the Concepts and definitions of Disaster, Hazard, Vulnerability, Risk, Capacity – Disaster and Development, and disaster management Natural and Man-made disasters, Global Disaster Trends – Emerging Risks of Disasters – Climate Change and Urban Disasters – The Refugee Problem **Module 2: Types, trends, causes, consequences and control of disasters** Geological Disasters (earthquakes, volcanic eruptions, landslides, tsunami, land subsidence); Hydro-Meteorological Disasters (floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves) Biological Disasters (epidemics, pest attacks, forest fire); and	06 hours 10 hours

	Anthropogenic Disasters (building collapse, mining mishaps, rural and urban fire, road and rail accidents, oil spills, nuclear, radiological, industrial, chemicals and biological disasters, terrorism). **Module 3: Disaster management cycle and framework, and applications of science and technology to disaster management** Disaster Management Cycle and the Paradigm Shift in Disaster Management. Pre-Disaster – Risk Assessment and Analysis, Risk Mapping, zonation and Microzonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development; Awareness During Disaster – Evacuation, Disaster Communication, Search and Rescue, Emergency Operation Centre, Incident Command System, Relief and Rehabilitation Post-disaster – Damage and Needs Assessment, Restoration of Critical Infrastructure, Early Recovery, Reconstruction and Redevelopment Geo-informatics in Disaster Management (RS, GIS, GPS) Disaster Communication System (Early Warning and Its Dissemination) Land Use Planning and Development Regulations Disaster Safe Designs and Constructions Structural and Non Structural Mitigation of Disasters S&T Institutions for Disaster Management in India **Module 4: International organisations, NGOs, best practices and disaster management in India** International organisations: Red Cross, Sphere, Oxfam, World Relief, CBM International, UNDRO, UNDDR Yokohama Strategy, Hyogo Framework of Action, UNISDR Critical analysis of NGO experience. Community Based Disaster Risk Reduction (CBDRR) Disaster Profile of India – Mega Disasters of India and Lessons Learnt Disaster Management Act 2005 – Institutional and Financial Mechanism National Policy on Disaster Management, National Guidelines and Plans on Disaster Management; Role of Government (local, state and national), Non-Government and Inter-Governmental Agencies	10 hours 10 hours
Pedagogy:	Lectures/ tutorials/ assignments/ self-study	
References/Readings	1. Coppola, D. P. (2007). *Introduction to International Disaster Management*, Elsevier Science (B/H), London. 2. Gupta, M. C., Sharma. K., Gupta, L. C. &Tamini, B. K. (2001).	

	Manual on natural disaster management in India. National centre for disaster management, Govt. of India. 3. Lopez-Carresi, A., Fordham, M., Wisner, B., Kelman, I. &Gaillard, J.C. (2014). *Disaster Management: International Lessons in Risk Reduction, Response and Recovery.*Routledge. 4. Goyal, S. L. (2006). *Encyclopaedia of disaster management, Vol I, II and III.* Deep & Deep, New Delhi. 5. Gunn, A.M. (2008). *Encyclopaedia of Disasters – Environmental Catastrophes and Human Tragedies, Vol. 1 & 2.* Greenwood Press. 6. Kapur, A. (2005). *Disasters in India: studies of grim reality*. Jaipur: Rawat Publications. 7. Srivastava H. N. & Gupta, G.D. (2006). *Management of Natural Disasters in developing countries.*Daya Publishers, Delhi. 8. Alexander, D. (1999). *Natural Disasters.* Kluwer Academic London. 9. Rubin, C. B., Cutter, S. L. (2020). *U.S. Emergency Management in the 21st Century*. *From Disaster to Catastrophe.*Routledge. 10. UNISDR. (2002). *Natural Disasters and Sustainable Development: Understanding the links between Development, Environment and Natural Disasters*, Background Paper No. 5. 11. Gupta A. K., Niar S. S &Chatterjee S. (2013). *Disaster management and Risk Reduction, Role of Environmental Knowledge*. Narosa Publishing House, Delhi. 12. Modh, S. (2010). *Managing Natural Disasters.* Mac Millan publishers India LTD. 13. *Disaster Management Act 2005*. Govt. of India. 14. *Disaster Management Guidelines* (2009)–(2020), GOI-UN Disaster Risk Program. 15. *World Disasters Report*, (2009)–(2020). International Federation of Red Cross and Red Crescent, Switzerland. 16. Publications of National Disaster Management Authority (NDMA) on Various Templates and Guidelines for Disaster Management.	
Learning Outcomes	Students will acquire a comprehensive understanding of disasters and the field of disaster management, so that they understand, analyse and evaluate the relationship of disasters with development, vulnerability and environmental factors.	

(Back to Index) (Back to Agenda)

X AC-8
13.05.2022

Title of the Course:Marine Plankton Ecology
Course Code: ESO-309 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at the 10+ 2 level	
Objectives:	1. To describe the role of plankton in marine ecosystem function. 2. To understand the effects of environmental factors on plankton biogeography and their role in food web dynamics.	
Content:	**Module 1: Introduction** Marine environment zonation, Coastal and Open Ocean, Significance of oceans and its biodiversity to humans Significance of planktonic biota to the health of oceans Distribution of plankton in the Tree of Life Major groups of phytoplankton, zooplankton, picoplankton, virioplankton (viruses) their biology and significance	06 hours
	Module 2: Plankton diversity and trophic dynamics Phytoplankton: Diatoms, Dinoflagellates, Haptophytes (coccolithophores, prymnesiophytes), Prasinophytes Zooplankton (Holoplankton, Meroplankton): Chaetognaths, Cnidarians, Molluscs, Radiolarians, Foraminiferans, Crustaceans, Larvaceans Multiple marine protistan lineages in seven supergroups of eukaryotic tree of life Factors affecting primary production: light, nutrients, mixed layer depth, chelating agents, tides, turbulence, grazing, Mixotrophy Interactions within and across trophic levels (allelopathic interactions) Planktonic Food Web structure and trophic transfer efficiency, Marine microbial food webs, microbial loop, viral shunt	10 hours
	Module 3: Plankton in marine ecosystem functioning Phytoplankton C:N:P ratios, stoichiometric plasticity, phenotypic plasticity, Contribution to biogeochemical cycles, Carbon Sequestration, Biological Carbon Pump Ecological success of diatoms, Blooms, Diatom/Dinoflagellate Index as an indicator for ecosystem change Harmful Algal Blooms (HABs) and biotoxins, morphological and physiological characteristics of HAB species, HAB dynamics Implications of Climate change on plankton (global warming, ocean acidification)	10 hours
	Module 4: Quantitative observations of planktonic ecosystems	10 hours

	Techniques and instruments used in plankton studies: Advances in Automated Technology to observe and measure plankton, Pigment composition, Optical and Acoustical methods e.g. Optical Plankton Counter, Zooglider Quantitative Imaging Devices e.g. Flow Cytometry, FlowCAM, FlowCytoBot Molecular Phylogenetic Approaches, High throughput 'omics' data Monitoring plankton in oceans through various international projects: Continuous Plankton Recorder (CPR), Global Alliance of CPR Surveys (GACS), The Scientific Committee on Oceanic Research (SCOR), Global Ocean Observing System (GOOS), Global Ocean Ecosystem Dynamics (GLOBEC), Integrated Marine Biosphere Research (IMBeR), TARA Oceans, GEOHAB	
Pedagogy:	Lectures/tutorials/assignments/self-study/Moodle/Videos	
References/ Readings	1. Morrissey, J. F., Sumich, J. L., &Pinkard-Meier, D. R. (2018). *Introduction to the biology of Marine life* (11th ed). Jones and Bartlett Publishers Learning. 2. Sardet, C., &Rosengarten, R. D. (2015). *Plankton: Wonders of the drifting world*. University of Chicago Press. 3. Lalli, C. M., & Parsons, T. R. (2010). *Biological Oceanography: An introduction* (2nd ed). Elsevier. 4. Nybakken, J. W., &Bertness, M. D. (2004). *Marine biology: An ecological approach* (6th ed). Benjamin-Cummings Publishing, Co. 5. Mitra, A., Banerjee, K., &Gangopadhyay, A. (2004). *Introduction to marine plankton*. Daya Publishing House. 6. Parsons, T. R. (1990). *Biological oceanographic processes* (3rd ed). Oxford Pergamon Press. 7. Raymont, J. E. G. (1980). Plankton and productivity in the oceans, *1*. *Phytoplankton* (2nd ed) Oxford Pergamon Press. 8. Levinton, J. S. (2017). *Marine biology: Function, biodiversity, ecology* (5th ed). Oxford University Press. 9. Ormond, R. (1997). *Marine biodiversity: Patterns and processes*. Cambridge University Press. 10. Reynolds, C. S. (2006). *The ecology of phytoplankton (Ecology, biodiversity and conservation)* (1st ed). Cambridge University Press. 11. Jungblut, S., Liebich, V., & Bode, M. (2020). YOUMARES 8—Oceans across boundaries: Learning from each other. SpringerOpen.	
Learning	Students will be able to understand ecosystem processes such	

Outcomes	as grazing, productivity, and the relative importance of plankton to marine food webs and biogeochemical cycling, and also monitoring work carried out globally.	

Title of the Course:Water and Wastewater: Monitoring and Treatment Technologies
Course Code: ESO-310 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objectives:	1. Understand the water quality criteria and Standards of water for domestic, industry and agriculture consumption. 2. Learn the causes and effects of water pollution and quality deterioration. 3. Learn the principles and instrumentation for water quality control and monitoring. 4. Motivate students for designing innovative methodologies in monitoring and treatment of water and wastewater.	
Content:	**Module 1: Introduction** • **Water balance and benchmarks**: Earths water budget, Hydrological cycle, Demand -supply situation and global benchmarks for major water dependent Industries • **Water quality**: water quality standards, Standards for Package Drinking water and mineral water, Water quality standards and parameters (ISI-BIS and USPH), Water pollution: Sources and types of water pollution, Causes and impacts on Environment • **Water pollutants**: Organic (Pesticides, oil spill, tar balls and toxic organic chemicals, antibiotics), Inorganic, Sediments, Marine, Radioactive, Eutrophication, trace and heavy elements in water, Bioindicators. **Module 2: Water and wastewater analysis** • **Water and wastewater**: Characteristics, Classification of wastewater • **Sampling techniques**: Separation scheme for organic compounds in water. Preservation techniques for sample. • **Monitoring techniques and methodology**: Physical, Chemical and biological analysis of water and wastewater parameters such as pH, Conductance, Turbidity, Temperature, Total Dissolved Solids (TDS), Total Suspended Solids (TSS),TKN, Dissolved Oxygen (DO), Acidity and Alkalinity, Ammonia, Chlorides, Fluoride, Nitrate and Nitrite, Cyanide, sulphide, Sulphate, Phosphate, Total Hardness, Boron, Silica,	06 hours 10 hours

	Metal and Metalloids, Heavy metals and other pollutants, Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD). **Module 3: Water treatment** • **Treatment of water:** Conventional and modern methods of treatment, Flowchart of the Water Treatment Plant, Treatment Methods (Theory and Design). • **Treatment processes**: Screening, Oil Separation, Sedimentation, Coagulation-Flocculation, Settling tanks, Aeration and Gas transfer, Precipitation, Softening, Filtration- Sand, Charcoal, Multimedia etc., Reverse Osmosis technology, Membrane processes, Ultra filtration. Disinfection System: chemical based and other disinfection methods such as Chlorination, Ozonation, UV, Adsorption and Ion exchange, Electrochemical and other methods. **Module 4: Biological treatment** • **Types of treatment processes**: attached and submerged, aerobic and anaerobic, facultative etc., • **Aerobic processes**: Activated Sludge Process and various modified processes, SBR, MBR, UA-SBR, FAB etc, Oxidation ponds and Rotating Biological Contactors • **Anaerobic processes**: Up flow Anaerobic Sludge Blanket, Anaerobic digesters, Anaerobic filters. • **Sludge treatment**: Preliminary operation, thickening, conditioning, Dewatering, Filtration, Digesting and Drying of sludge, Sludge disposal • **Modular Sewage Treatment Plant:** Water reuse and recycling (Industry / Site visit for Water treatment plant and STP)	10 hours 10 hours
Pedagogy:	Lectures/case studies /workshops/industrial visit /documentaries and discussion/ research article analysis /mini projects / survey or mapping projects.	
References/ Readings	1. De, A.K. (2019). *Environmental Chemistry* (9th Ed.) New Age International Publishers. 2. Bennett, M.R. & Doyle, P. (2016). *Environmental Geology. In, Geology and the Human Environment*. Wiley India Pvt. Ltd. 3. Pipkin, B.W., & Trent, D.D. *Geology and the environment*. 3rd Edition. ISBN 0-534-51383-2 4. Patwardhan, A.D. *Industrial Wastewater Treatment*. (2ndEd.). Eastern Economy Edition. 5. Karia, G. L., & Christian, R.A. *Wastewater Treatment:*	

	Concepts and Design Approach, Eastern Economy Edition. 6. Bratby, J. (2006). *Coagulation and flocculation in water and wastewater treatment*. (2nd Ed.). London: IWA Publishing, 7. Grady, C. P. L. Jr., Daigger, G.T., & Lim, H.C. (1999). *Biological wastewater treatment*. (2nd Ed.). New York: Marcel Dekker, Inc. 8. Abbasi, S. A. (1998). *Environmental pollution and its control*. Pondicherry: Cogent. 9. Abbasi, S.A. (1998). *Water Quality Sampling and Analysis*. New Delhi: Discovery. 10. Aery, N.C. (2016). *Manual of Environmental Analysis*. New Delhi: Ane Books. 11. Ahluwalia, V. K. (2008). *Environmental Chemistry*. (2nd Ed). Ane, New Delhi. **Additional reading material:** 1. Chand, A. (1989). *Environmental pollution and protection*. (1st Ed.). H.K. Publishers, New Delhi. 2. Droste, R.L., &Gehr, R.L. (2018). *Theory and Practice of Water and Wastewater Treatment*. (2nd Ed). 3. Kumar, R. & Singh, R.N. *Municipal Water and Wastewater Treatment. Environmental Engineering Series*. ISBN: 9788179931882 4. Lal, B. and Sarma P.M. *Wealth from Waste: Trends and technologies*. (3rd Ed.), New Delhi : TERI press. 5. Lin, S.D. (2014). *Water and wastewater calculation manual*. McGraw-Hill Education. ISBN: 9780071819817	
Learning Outcomes	After successful completion of the course student will be able to: 1. Explain the causes and effects of water pollution. 2. Analyse the water as per BIS and international standards. 3. Identify suitable technologies for the treatment of water and wastewater. 4. Design the water and wastewater treatment plants. 5. Operate, maintain and manage treatment plants. 6. Start own enterprise.	

(Back to Index) (Back to Agenda)

Title of the Course: Industrial water and wastewater treatment technologies
Course Code: ESO-311 **Number of Credits:**03
Total Contact Hours:36 **Effective from AY:**2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objectives:	1. Elaborate the latest development in wastewater treatment technologies 2. Explain the sources and effects of water pollution from various industries 3. Understand the principles and processes in wastewater treatment technologies 4. Identify suitable technologies for wastewater treatment	
Content:	**Module 1: Introduction** Types of industrial pollutants, Industrial wastewater characterisation, Categorisation of industries- green, orange and red industries, Standards of industrial waste disposal, Minimum National Standards (MINAS) and Goa State Regulatory Framework for effluents and trade waste. **Module 2: Industrial wastewater treatment** • **Methods of industrial waste treatment**: Primary, secondary and tertiary/polishing treatment such as equalisation, neutralisation, precipitation. • **Physico-chemical and biological treatment processes**: Sedimentation, Oil separation, Floatation, Coagulation, Filtration, Ion exchange membranes. • **Biological oxidation** - Removal of organics (Sorption, Stripping, bio-degradation), Unit operations and electromechanical equipment used in the treatment processes. **Module 3: Advance wastewater treatment** • **Advance wastewater treatment process** – Removal of specific pollutants – nitrification, denitritation/Anammox process, SHARON-ANAMMOX process for treatment of ammonium rich wastewater, Biological Phosphate Removal (BPR). • **Membrane processes** – Fundamentals, Membranes – Types, classifications, Microfiltration, Ultrafiltration, Nanofiltration and reverse osmosis, Electrodialysis, Ion exchange. • **Advance oxidation process**: Photocatalysis, Ozonation – Ozone / UV, Ozone / Hydrogen peroxide, Hydrogen peroxide/ UV applications and other significant proven technologies. •	06 hours 10 hours 10 hours

	Module 4: Common Effluent Treatment Plant (CETP) & Decentralised Wastewater Treatment (DWT) • **CETP and DWT**: Requirement and objectives Planning and management of CETP and DWT, facilities for small scale industries • **Energy recovery from wastewater**: Microbial fuel cells, microbial electrolysis cell, microbial desalination cell, biohydrogen production and combination of technologies.	10 hours
Pedagogy:	Lectures/ video/ Powerpoint presentation/ Industrial visit / documentaries and discussion / research article analysis / mini projects / survey and mapping projects	
References/ Readings	1. De, A. K. (2019). *Environmental Chemistry*. (9th Ed.).New Age International Publishers. 2. Bennett, M.R. & Doyle, P. (2016). *Environmental Geology. In, Geology and the Human Environment*. Wiley India Pvt. Ltd. 3. Patwardhan, A.D. *Industrial Wastewater Treatment*. (2nd Ed.). Eastern Economy Edition. 4. Karia, G. L. & Christian, R.A. *Wastewater Treatment: Concepts and Design Approach*, Eastern Economy Edition. 5. Bratby, J. (2006). *Coagulation and flocculation in water and wastewater treatment*. (2nd Ed.). London, UK :IWA Publishing. 6. Grady, C. P., Daigger, G.T. & Lim H.C. (1999). *Biological wastewater treatment*. (2nd Ed). New York :Marcel Dekker, Inc. 7. Abbasi, S.A. (1998). *Environmental pollution and its control*. Pondicherry: Cogent. 8. Abbasi, S.A. (1998). *Water Quality Sampling and Analysis. Discovery*, New Delhi. **Additional reading material:** 1. Aery, N.C. (2016). *Manual of Environmental Analysis*. New Delhi: Ane Books. 2. Droste, R.L. &Gehr,R.L.(2018). Theory and Practice of Water and Wastewater Treatment. (2nd Ed). 3. Kumar, R. & Singh, R.N. *Municipal water and wastewater treatment. Environmental EngineeringSeries*. ISBN: 9788179931882 4. Lal, B. &Sarma, P.M. *Wealth from waste: trends and technologies*. (3rd Ed). TERI press. 5. Lin, S.D.(2014). *Water and Wastewater Calculation Manual*. McGraw-Hill Education. ISBN: 9780071819817 6. Asiwal, R.S., Sar, S.K., Singh, & S., Sahu, M. (2016). *Waste Water treatment by effluent treatment plants*. SSRG International Journal of Civil Engineering, 3 (12).	

Learning Outcomes	After successful completion of the course student will be able to: 1. Explain different pollutants from various industries. 2. Suggest suitable technologies for the wastewater treatments depending on type of pollutants. 3. Design the suitable process for wastewater treatment plants. 4. Manage and supervise the maintenance of treatment plants. 5. Adopt the principle of reduce, recycle and reuse in industries.	

Title of the Course: Water and Wastewater Analysis

Course Code: ESO-312 **Number of Credits:**04

Total Contact Hours:96 **Effective from AY:**2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objective:	Develop analytical skills of the students for water and wastewater analysis useful in wastewater and industrial treatment plants	
Content:	**Part I** • **List of the experiments (6 hour duration)** 1. Determination of pH, conductivity and Turbidity of water and wastewater samples (pH meter, conductometer, and nephelometer) 2. Determination of dissolved oxygen and total hardness of water (Ca and Mg) of water and wastewater sample. 3. Determination of BOD of wastewater samples. 4. Determination of COD of wastewater samples. 5. Determination of TSS and TDS of a given water sample. 6. Determination of Chromium in given water sample using UV-VIS spectrophotometer. 7. Determination of the metal ions (Na and K) using Flame photometer (Including working, standardization and plotting of calibration curve). 8. Estimation of Metals and metalloids (spectrophotometry / AAS). • **A visit to ETP / STP and report writing (8 hours)** **Part 2 : Waste water from industrial effluents (6 hours each)** 1. Estimation of ammonia from wastewater samples (Nessler's Method) 2. Nitrate and nitrite using spectrophotometric method 3. Determination of fluoride using spectrophotometer 4. Determination of phosphates in wastewater using spectrophotometric method 5. Estimation of total cyanide in wastewater using titrimetry and spectrophotometric method	48 hours 48 hours

	6. Estimation of tannin and lignin and surfactants from Wastewater 7. Estimation of pesticides in water sample using GC 8. Determination of *E. coli* and total bacteria in wastewater	
References/ Readings	1. Kaur, K. (2007) *Handbook of Water and wastewater Analysis* . Atlantic 2. Maiti, S.K.(2011) *Handbook of Methods in Environmental Studies: Water and Wastewater Analysis*, Oxford Book Company, ISBN-10 9380179871 3. Beenish, S.(2011)*Laboratory Skills in Water and Wastewater Analysis* , VDM Verlag 4. De, A. K. (2019*) Environmental Chemistry*, (9th Ed.). New Age International Publications ISBN-10 9789387477247	
Learning Outcomes	After successful completion of the course student will be able to: 1. Carry out analysis of wastewater and evaluate the results. 2. Design various experiments for reducing the environmental pollution. 3. Provide innovative solutions for the treatment of wastewater and recycling. 4. Analyze industrial effluent for water quality parameters and submit report to various agencies.	

Title of the Course:Occupational Work Environment and Health Hazards
Course Code: ESO-313 **Number of Credits:**02
Total Contact Hours:24 **Effective from AY:**2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objectives:	1. Recognize and evaluate occupational safety and health hazards at workplace. 2. Determine appropriate hazard controls and hierarchy of controls. 3. Analyse the effects of workplace exposures, injuries, illness, fatalities and methods to prevent incidents using effective health and safety management systems.	
Content:	**Module 1: Introduction** • **Occupational hazards**- Physical, chemical, biological and ergonomics hazards. • **Occupational diseases**- Pneumoconiosis- silicosis, Anthracosis, Byssinosis, Bagassosis, Farmer's lung, Lead poisoning, Occupational cancer, Occupational dermatitis, Radiation hazards, sick building syndrome. **Module 2: Occupational hazards of agricultural workers** Common occupational Hazards: Somatic diseases, accidents, toxic hazards, physical hazards, respiratory diseases, accidents in	06 hours 08 hours

	industry, sickness, absenteeism, health problems due to industrialization. Measures for health protection of workers: Prevention of occupational diseases, medical measures, engineering measures. Human health problems due to pollution , public health programs. Food poisoning- Types of food poisoning, prevention and control, indicators of health. **Module 3: Occupational health hazards and public health legislation** Evaluation and control of occupational health hazards; Occupational health surveillance, Control programmes in the context of Indian Factories Act- case studies. Epidemiology and public health- Principles of epidemiology, epidemiology and control of diseases caused by important microbes in water, air, milk and soil. The factories Act. 1948. Industrial safety standards and regulations. Accidents – definitions - prevention and control. Safety management system- concepts of safety management systems- EMS ISO 18000 and ISO 22000 series. OSHA- Law & regulations. Public liability insurance act, Mining act.	10 hours
Pedagogy:	Lectures/case studies /workshops/industrial visit /documentaries and discussion/ research article analysis	
References/ Readings	1. The occupational safety, health and working conditions code. (2020). Professional Book Publishers. 2. Raj, T.R. (2013). Elements of Industrial Hazards: Health, Safety, Environment and Loss Prevention. Taylor and Francis Publications. 3. Reese, C.D. (2015). *Occupational Health and Safety Management: A Practical Approach* (3rd Ed). CRC Press. ISBN 978-1482231335 4. Stranks, J. (2006). *The health and safety handbook (A practical guide to health and safety law, management policies and procedures).* ISBN:978-0749449001 5. Yates,W.D. Safety professional's reference and study guide. CRC Press publications. ISBN:978-1138892972	
Learning Outcomes	After completing the course student will be able to: 1. Evaluate workplace to determine the existence of occupational safety and health hazards. 2. Identify relevant regulatory and national standards benchmarking with best practices in industry. 3. Select appropriate control methodologies based on the hierarchy of the controls. 4. Analyze injury and illness data for trends.	

(Back to Index) (Back to Agenda)

Title of the Course: Mangrove Ecosystem and Biodiversity

Course Code: ESO-314 **Number of Credits:** 01

Total Contact Hours: 12 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at 10+2 level.	
Objective:	To introduce the students to the dynamic mangrove ecosystem, its composition – abiotic and biotic, benefits, threats and need for conservation.	
Content:	**Module 1: Introduction** Mangroves, global distribution, current status, threats, ecology and environment, relation with other ecosystems, uses of mangroves. **Module 2: Structure and function of mangrove ecosystem** Physical mangrove environment, forest types – overwashed, fringe, dwarf, riverine, basin, hammock; true mangroves – red, white, green, black; mangrove associates, adaptations in mangroves, patterns and processes in mangrove ecosystem, environmental factors - climate and habitats Biodiversity in mangrove ecosystem: flora and fauna	02 hours 10 hours
Pedagogy:	Lectures/ case studies/ tutorials/ videos/ assignments/ self-study/ visits	
References/ Readings	1. Kathiresan, K., &Ajmal Khan, S. (2005). UNU-INWEH-UNESCO International training course on Coastal Biodiversity in Mangrove Ecosystem- Course manual (pp. 410). Annamalai University, India. 2. FAO (2007). The world's mangroves: 1980–2005. FAO, Rome, Italy. 3. Sandilyan, S., &Kathiresan, K. (2012). Mangrove conservation: a global perspective. *Biodiversity Conservation*, *21*, 3523–3542. 4. Nagelkerken, I., Blaber, S.J.M., & Bouillon, S. et al. (2008). The habitat function of mangroves for terrestrial and marine fauna: a review. *Aquatic Botany, 89*, 155–185. 5. Nanjo, K., Kohno, H., Nakamura, Y., Horinouchi, M., & Sano, M. (2014). Effects of mangrove structure on fish distribution patterns and predation risks. *Journal of Experimental Marine Biology and Ecology, 461,* 216–225. 6. Shinnaka, T., Sano, M., Ikejima, K., Tongnunui, P., Horinouchi, M., &Kurokura, H. (2007). Effects of mangrove deforestation on fish assemblage at Pak Phanang Bay, Southern Thailand. *Fisheries Science, 73*, 862–870. 7. 1st International Training Course onMangrove Ecosystems in the Western Indian Ocean Region. (December 2-9, 2013) Mombasa, Kenya. UNU-INWEH-UNESCO.	

	8. Singh, V.P., &Odaki, K. (2004). *Mangrove ecosystem: structure and function.* Scientific Publishers, Jodhpur, India.	
Learning Outcomes	Students will gain knowledge about mangrove ecosystem, its floral and faunal biodiversity.	

Title of the Course: Mangrove Ecology
Course Code: ESO-315 **Number of Credits:** 01
Total Contact Hours: 12 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at 10+2 level.	
Objective:	To introduce the students to the dynamic mangrove ecosystem, its composition – abiotic and biotic, benefits, threats and need for conservation.	
Content:	**Module 1: Introduction** Mangroves, ecology and environment, uses of mangroves, threats to mangrove. **Module 2: Ecological importance of mangrove ecosystem and the impact of anthropogenic activities** Functional aspects – biomass, productivity, litter and its decomposition, carbon sink and organic carbon productivity, nitrogen and sulfur cycling, nutrient status, nurseries, biofilters for toxic pollutants, breeding grounds – fish, birds; mitigation of climate change, coastal defence mechanism Indigenous people of mangroves – livelihood dependency –Case study on Sunderban Anthropogenic destruction - deforestation, landfills, land reclamation, waste disposal sites, pollution – water quality and persistent chemicals, loss of mangrove biodiversity	02 hours 10 hours
Pedagogy:	Lectures/ case studies/ tutorials/ videos/ assignments/ self-study/ visits	
References/ Readings	1. Kathiresan, K., &Ajmal Khan, S. (2005). UNU-INWEH-UNESCO International training course on Coastal Biodiversity in Mangrove Ecosystem- Course manual (pp. 410). Annamalai University, India. 2. FAO (2007). The world's mangroves: 1980–2005. FAO, Rome, Italy. 3. Nagelkerken, I., Blaber, S.J.M., & Bouillon, S. et al. (2008). The habitat function of mangroves for terrestrial and marine fauna: a review. *Aquatic Botany, 89*, 155–185. 4. Nanjo, K., Kohno, H., Nakamura, Y., Horinouchi, M., & Sano, M. (2014). Effects of mangrove structure on fish	

	distribution patterns and predation risks. *Journal of Experimental Marine Biology and Ecology, 461,* 216–225. 5. Shinnaka, T., Sano, M., Ikejima, K., Tongnunui, P., Horinouchi, M., &Kurokura, H. (2007). Effects of mangrove deforestation on fish assemblage at Pak Phanang Bay, Southern Thailand. *Fisheries Science, 73*, 862–870. 6. 1st International Training Course onMangrove Ecosystems in the Western Indian Ocean Region. (December 2-9, 2013) Mombasa, Kenya. UNU-INWEH-UNESCO. 7. Singh, V.P., &Odaki, K. (2004). *Mangrove ecosystem: structure and function.* Scientific Publishers, Jodhpur, India.	
Learning Outcomes	1. Imprint the importance of mangroves in maintaining the global climate and balance in the nutritional as well as biogeochemical cycles. 2. Awareness about indigenous people and anthropogenic destruction	

Title of the Course: Mangrove Restoration and Conservation

Course Code: ESO-316 **Number of Credits:** 01

Total Contact Hours: 12 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at 10+2 level.	
Objective:	To introduce the students to the dynamic mangrove ecosystem, its composition – abiotic and biotic, benefits, threats and need for conservation.	
Content:	**Module 1: Introduction** Mangroves, global distribution, current status, threats, uses of mangroves. **Module 2: Restoration and conservation** Restoration and afforestation projects, ecosystem based management, protected areas, restoration tools, monitoring methods – remote sensing and GIS, awareness programmes, training programmes, community based management, role of institutions, NGOs, global conservation strategies, economic valuation (cost benefit analysis), national and global mangrove conservation policies, conservation and mangrove protection laws, international agreements – Ramsar convention, case study – mangroves of Goa.	02 hours 10 hours
Pedagogy:	Lectures/ case studies/ tutorials/ videos/ assignments/ self-study/ visits	
References/ Readings	1. Kathiresan, K., &Ajmal Khan, S. (2005). UNU-INWEH-UNESCO International training course on Coastal	

	Biodiversity in Mangrove Ecosystem- Course manual (pp. 410). Annamalai University, India. 2. FAO (2007). The world's mangroves: 1980–2005. FAO, Rome, Italy. 3. Sandilyan, S., &Kathiresan, K. (2012). Mangrove conservation: a global perspective. *Biodiversity Conservation*, *21*, 3523–3542. 4. Nagelkerken, I., Blaber, S.J.M., & Bouillon, S. et al. (2008). The habitat function of mangroves for terrestrial and marine fauna: a review. *Aquatic Botany, 89*, 155–185. 5. Nanjo, K., Kohno, H., Nakamura, Y., Horinouchi, M., & Sano, M. (2014). Effects of mangrove structure on fish distribution patterns and predation risks. *Journal of Experimental Marine Biology and Ecology, 461,* 216–225. 6. Shinnaka, T., Sano, M., Ikejima, K., Tongnunui, P., Horinouchi, M., &Kurokura, H. (2007). Effects of mangrove deforestation on fish assemblage at Pak Phanang Bay, Southern Thailand. *Fisheries Science, 73*, 862–870. 7. 1st International Training Course onMangrove Ecosystems in the Western Indian Ocean Region. (December 2-9, 2013) Mombasa, Kenya. UNU-INWEH-UNESCO. 8. Singh, V.P., &Odaki, K. (2004). *Mangrove ecosystem: structure and function.* Scientific Publishers, Jodhpur, India.	
Learning Outcomes	This paper will highlight the need to conserve and protect the mangroves.	

Title of the Course: Environmental History of India

Course Code: ESO-317 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objectives:	1. To cover in a systematic, comprehensive and critical way the nature, issues, problems and movements related to environmental history in India. 2. To enable the students to comprehend the urgent need for environmental conservation, and appreciate the policy of sustainable development. 3. To encourage an interdisciplinary approach to environmental history. To inculcate the spirit of environmental ethics.	
Content:	**Module 1:Introduction**	06 hours

	Definition of Environmental History –Historiography - Sources. **Module 2:Man and nature in pre-modern India** Hunter-Gatherer Societies to Agricultural Societies – the Eclectic Belief Systems and Cultural Ecology – Sacred Groves. **Module 3:Environmental change and conflict in modern India** Colonial Interests on Forests, Forest Acts (1865, 1878 and 1927) and Policies – Systematic Conservation vs. Exploitation Debate – Issue of Shifting Cultivation - Settled Cultivators and the State – Decline of Artisanal Industry – Deforestation – Protests Against the British Forest Acts and Policies. **Module 4:Independent India** Policies towards Forestry – Forest Policy Resolutions and Acts (1952, 1980 and 1988) – Policies towards Environment - Role of NGOs – Environmental Movements**:** Chipko Movement - Appiko Movement – Scientific Conservation of Environment – Environmental Ethics - Major International Environmental Conventions and Protocols.	10 hours 10 hours 10 hours
Pedagogy:	Lectures/tutorials/assignments/self-study/seminars/field work based write up.	
References/Readings:	1. Allchin B. and Allchin F.R. 1968. The Birth of Indian Civilisation. Harmondsworth, Penguin. 2. Alvares C. (Ed.) 2002. Fish Curry and Rice, A sourcebook on Goa, its ecology and life-style, Goa, The Goa Foundation, Revised 4th Edition. 3. Arnold D. and Guha R. (Eds.) 1996. Nature, Culture, Imperialism, Essays on the Environmental History of South Asia, Delhi, OUP. 4. Bellamy P. 2007. Dictionary of Environment, New Delhi, Academic (India) Publishers. 3rd Edition. 5. Chakrabarti R. (Ed.) 2007. Situating Environmental History, New Delhi, Manohar. 6. Dasgupta P. 1982. The Control of Resources, Delhi, OUP. 7. Desai A.R. (Ed.) 1979. Agrarian Struggles in India, Delhi, OUP. 8. Dhavalika, M.K. 1988. The First Farmers of the Deccan, Pune, Deccan College. 9. Fernandes W. and Menon G. 1987. Tribal Women and Forest Economy: Deforestation, Exploitation and Status Change, New Delhi, Indian Social Institute. 10. Gadgil M. and Guha R. 2008. The Use and Abuse of Nature (incorporating This Fissured Land An Ecological History of India and Ecology and Equity), (Omnibus edition), New Delhi, OUP, Fifth Impression. 11. Gill, Singh M., and Kewlani J. (Eds.) 2009. Environmental	

	Conscience Socio- *Legal and Judicial Paradigm*, New Delhi, Concept Publishing Co. 12. Guha R. (Ed.) 1982. *Subaltern Studies*, Vol. I, Delhi, OUP. 13. Guha R. 1983. Forestry in British and Post-British India: A Historical Analysis. Economic and Political Weekly. Vol.18, No.44, pp.1882-1896. 14. Guha R. 1983. Forestry in British and Post-British India: A Historical Analysis. Economic and Political Weekly. Vol.18, No.45/46, pp.1940-1947. 15. Guha R. and Gadgil M. 1989. State Forestry and Social Conflict in British India. Past and Present, No.123, PP.141-177. 16. Guha R. 1989. The Unquiet Woods: Ecological Change and Peasant Resistance in the Himalaya, Delhi, OUP, Berkeley: University of California Press. 17. Guha R. 1999. Sumit, Environment & Ethnicity in India 1200-1991, Cambridge, CUP. 18. Joseph B. 2009. Environmental Studies, New Delhi, Tata McGraw-Hill Pubg. Co. 2nd Edition. 19. Krishna, Murali K.V.S.G., and VenkataRao M.V. 1998. Our Environment, Kakinada, Environmental Protection Society. 1st Edition. 20. Murthy, Linga and others, (Eds.). 2008. Environmental Concerns of Economic Development, New Delhi, Serials Publications. 21. Raju A.J. and Solomon. 2007. A Textbook of Ecotourism Ecorestoration and Sustainable Development, Kolkata, New Central Book Agency. 22. Singh K.S. (Ed.). 1983. Tribal Movements in India, Vo. II, New Delhi, Manohar.	
Learning Outcomes	1. Understand the environmental history of India through the ages from the ancient to the modern. 2. Appreciate Cultural Ecology and its significance. 3. Comprehend Environmental Ethics. 4. Understand sustainable development, rational use of natural resources, renewable sources of energy, and methods of controlling pollution.	

Title of the Course: Environmental Politics
Course Code: ESO-318 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University
Objectives:	1. The course seeks to discuss the manner in which politics shapes the discourse on environment at various levels.

	2. It shall address how actors and institutions of politics impinge on decision making and outcomes in addressing environmental problems of the day. 3. While doing this it tries to expose the students to issues of power, contestation and cooperation that often emerge at local, national as well as international environmental domain.	
Content:	**Module 1:Introduction** Concept of Power, Conflict and Interests in relation to Environment, Green Political Theory, Green Political Parties **Module 2: State and environmental politics** State as repository of Power and Authority, Regulation, State as an agency of Development, **Module 3: Non-state actors and environmental politics** Non-Governmental organizations as pressure groups/advocates/partners in environmental change, Conflict with state and corporations. **Module 4: Multilateral institutions and environmental regimes** International and regional organizations relating to environment, Multilateral institutions as sites of international negotiations, goal setting and accountability.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	Lectures/tutorials/assignments/self-study/case-studies	
References/ Readings	1. John B. 1999. Rethinking Green Politics Nature, Virtue and Progress, Sage Publishers. 2. Schumacher E.F. 1993. Small Is Beautiful: A Study of Economics as if People Mattered, RHUK Publishers 3. Guha R. 2016. Environmentalism: A Global History, Penguin Random House. India. 4. Gareth P. 1995. Global Environmental Politics: Second Edition (Dilemmas in World Politics), Westview Press 5. Neil C. 2012. The Politics of the Environment: Ideas, Activism and Policy, Cambridge University Press. 6. Duit A. et al., 2014. State and Environment – The Comparative Study of Environmental Governance, MIT Press. 7. Newell P. 2006. Climate for Change: Non-State Actors and the Global Politics of the Greenhouse, Cambridge University Press. 8. Schiele S. 2014. International environmental regimes and their treaties, Cambridge University Press. 9. Gupta S.S. 2016. Caring for Nature: The River of life (The Story of the Narmada BachaoAndolan), The Energy and Resources Institute. 10. Khanna D.R., Kumar P. and Singh V. 2013. Ecology of	

	the Tehri Dam, Biotech Books. 11. Kutting G. and Herman K. 2018. Global Environmental Politics: Concepts, Theories and Case Studies, Taylor and Francis.	
Learning Outcomes	1. The student should be able to relate environment with the larger context of politics that often emerges out of it. 2. He/she would be able to look at not only the key environmental issues at stake, but also how various actors both state and non-state influence the same through both cooperation and discord. 3. The course would thus enable the student to get a grasp of how the institutions, politics and policy intersect in the domain of environment.	

Title of the Course: Global Environmental Governance
Course Code: ESO-319 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objectives:	1. To provide interdisciplinary knowledge and competences that assist in dealing with environmental governance in an international context. 2. This inter-disciplinary course provides in-depth insights to the actors, processes and problems of global environmental politics and aims to summarise debates about 'global' environmental problem. 3. It will also aim to understand the various international organisations and their role in global governance. 4. The main focus of the course is on understanding the evolution of environmental policy regimes at multiple scales and with multiple actors.	
Content:	**Module 1. Introduction** Globalization of Environmental Threats and Impact on Security, Trade, Health and Development. **Module 2. Core dimensions and key actors of global environmental governance** Actors, Institutions—International Organizations—the UN System; Sustainable Development Goals (SDGs); Environment Summits—From Stockholm to Rio to Johannesburg; India's Environmental Diplomacy. **Module 3. Environmental accords and governance** History of Environment's Lawmaking and Institution Building	06 hours 10 hours 10 hours

	Processes—1987 Brundtland Commission Report, International Environmental Agencies including UNEP, Commission on Sustainable Development, Select Multilateral Environmental Agreements-Agreements on Climate Change, Antarctica Treaty, Polar Regions and the Amazonia. **Module 4. The indigenous and environmental governance in comparative perspective: Case studies from the high north (polar region) and the Amazonia** Evolving Indigenous Governance in the Arctic; Rights of Minorities and Indigenous Peoples in the Arctic Region; Indigenous People and the Amazonia—Issues, Challenges and Governance of the Region; Role of Groups and Questions of Land and Water Rights in the High North and the Amazonia.	10 hours
Pedagogy:	Lecture classes, interactions, assignments, presentations	
References/ Readings	1. Chasek P. S., Downie D. L., and Brown J. W. 2017. Global environmental politics: dilemmas in world politics, New York: Routledge. 2. Dauvergne P. 2005. Handbook of global environmental politics. Cheltenham: Edward Elgar. 3. Elliot J. A. 2010. An introduction to sustainable development. New York: Routledge. 4. Jakobson L. and N. Melvin. 2016. The new Arctic governance. Oxford: Oxford University Press. 5. Lalfagianni A., Fuchs D., and Hayden A.. Eds. 2020. Routledge handbook of global sustainability governance. London: Routledge. 6. Nicholson S. and Wapner P. 2014. Global environmental politics: from person to planet. London: Routledge. 7. Speth J. G. and Haas P. M. Eds. 2006. Global environment governance. London: Oisland Press. 8. Delmas M. A. and Young O. R. Eds. 2009. Governance for the environment. Cambridge: Cambridge University Press. 9. Andonova L. B., and Hoffmann M. J. 2012. From Rio to Rio and beyond: innovation in global environmental governance. The Journal of Environment & Development. 21(1): 57-61. 10. Andonova L. B., Betsill M. and H. Bulkeley. 2009. Transnational climate governance.Global Environmental Politics. 9(2): 52–73. 11. Chase, V. M. 2019. The changing face of environmental governance in the Brazilian Amazon: indigenous and traditional peoples promoting norm diffusion. RevistaBrasiliera de PoliticaInternacional. 62 12. Dubash N. K. 2012. Toward enabling and inclusive global environmental governance. The Journal of Environment &	

	Development. 21(1): 48-51. 13. Esty D. C. 2009. Revitalizing global environmental governance for climate change. Global Governance. 15(4): 427-434. 14. Hey E. 2006. International institutions and global environmental governance. Proceedings of the Annual Meeting. 100 (29 March - 1 April): 310-312. 15. Johnson S. 2021. Indigeneity, environment, and governance in the Amazon: the impact of indigenous movements on environmental conservation policy in nation-states of the Amazon rainforest. https://academiccommons.columbia.edu/doi/10.7916/d8-9vvv-rk15/ 16. Rechkemmer A. 2003. Rio and the origins of global environmental governance. Security and Peace. 21(3/4): 173-178. 17. Toohey D. E. 2012. Indigenous peoples, environmental groups, networks and the political economy of rainforest destruction in Brazil. International Journal of Peace Studies. 17(1): 73-97. 18. Global environmental governance: a reform agenda.2006. Winnipeg: International Institute for Sustainable Development (IISD).	
Learning Outcomes	At the end of the course, the students can retrieve, recognize, and recall knowledge acquired from the course (including lectures, readings, and assignments) on: 1. Global environmental problems and issues. 2. Concepts and theories. 3. International organizations and regimes. 4. Different types of actors and the roles they play in global environmental governance.	

(Back to Index) (Back to Agenda)

X AC-8
13.05.2022

Title of the Course: Women and Environment
Course Code: ESO-320 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objectives:	1. This course will provide students with an understanding of the relationship between women and environment. 2. Students will be introduced to basic concepts and terms to enable the understanding of the gendered impact of environmental concerns, human-made and natural disasters, women's agency, knowledge of traditional healing systems and women's role as farmers. 3. Environmental movements and conservation both past and present particularly women's role in them will also be discussed. 4. Through this course students will get an insight into initiatives and commitments on women and the environment. 5. The course will highlight the inter-connectedness of ecosystems, environment, society and gender which are important for sustainable development.	
Content:	**Module 1: Introduction** • Gender Equality and Equity • Gendered impacts of day to day environmental concerns, human-made and natural disasters due to patriarchy, stereotypes and socially constructed division of labour.	06 hours
	Module 2:Understanding concepts • Eco-feminism • Feminist Political Ecology • Feminist Environmentalism • Gender Mainstreaming and Auditing	10 hours
	Module 3:Women's involvement in environmental movements and conservation: past and present • Movements (e.g. Chipko, Silent Valley, Green Belt, Narmada BachaoAndolan, Navdanya and contemporary movements) • Conservation: Seed cooperatives and traditional knowledge systems, community forestry.	10 hours
	Module 4: Initiatives and instruments for gender and environment • UN Environment Programme (Gender) – Gender and Water Alliance (GWA),	10 hours

	- Global Gender and Climate Alliance (GGCA), - Women's Earth and Climate Action Network, International (WECAN) • Greenpeace • 350.org • PaniPanchayat • Paani Foundation	
Pedagogy:	Lectures/assignments/workshops/ brain storming sessions/outreach programmes/campus walks/documentaries and discussion/ presentations	
References/Readings	1. Buckingham, Susan. 2020. *Gender and Environment*. 2nd Edition. London: Routledge. 2. Jiggins, Janice. 1994. *Changing the Boundaries Women-Centered Perspectives on Population and Environment*. Washington D.C.: Island Press. 3. Krishna, Sumi. 2003. *Livelihood and Gender: Equity in Community Resource Management*. New Delhi: Sage Publications. 4. Martínez-Alier, J. 2002. *The environmentalism of the poor: a study of ecological conflicts and valuation*. Cheltenham: Edward Elgar Publishing Ltd. 5. McCully, Patrick. 1996. *Silenced Rivers: The Ecology and Politics of Large Dams*. ZED books. 6. Mies, Maria, and Shiva, Vandana.2014. *Ecofeminism.* New York: Zed books. 7. Rocheleau, Dianne, Barbara Thomas-Slayter, and Esther Wangari. 1996. *"Gender and Environment A Feminist Political Ecology Perspective*." In *Feminist Political Ecology Global Issues and Local Experience*, 1st ed., 1–22. London: Routledge. 8. Shiva, Vandana. 2005 *Globalization's New Wars: Seed, Water and Life forms,* New Delhi: *Women Unlimited*. 9. Shiva, Vandana. 1998. *Staying Alive: Women, Ecology and Survival in India*. New Delhi: Kali for Women. 10. Wangari, Maathai. 2004. *The Green Belt Movement: Sharing the Approach and the Experience*. New York: Lantern Books. 11. Agarwal, Bina. 1992. "*The Gender and Environment Debate: Lessons from India" Feminist Studies, Inc.* 18 (1): 119–58. 12. Agarwal,Bina. 2000. "*Conceptualizing Environmental Collective Action: Why Gender Matters*." *Cambridge Journal of Economics* 24 (3): 283–310. https://doi.org/10.1093/cje/24.3.283. 13. Gupte, Manjusha. 2004. *"Participation in a Gendered*	

	Environment: The Case of Community Forestry in India."Human Ecology 32 (3): 365–82. https://doi.org/10.1023/B:HUEC.0000028086.63366.3d 14. Gupte,Manjusha. 2008. "*Gender, Feminist Consciousness, and the Environment".Women & Politics* 24 (1): 47–62. https://doi.org/10.1300/J014v24n01_03 15. Shobhita, Jain. 1984. "*Women and People's Ecological Movement A Case Study of Women's Role in the Chipko Movement in Uttar Pradesh."Economic & Political Weekly* XIX (41): 1788–94. https://www.epw.in/journal/1984/41/special-articles/women-and-people-s-ecological-movement-case-study-women-s-role. 16. https://panipanchayat.org/ 17. https://www.paanifoundation.in/ 18. https://350.org/ 19. OSAGI Gender Mainstreaming - Concepts and definitions (un.org) 20. https://www.unep.org/explore-topics/gender/about-gender *21. Guide on Gender Mainstreaming Environmental Management Projects.2015. United Nations Industrial Development Organization, Vienna* 22. https://www.unido.org/sites/default/files/2015-02/Gender_Environmental_Management_Projects_0.pdf	
Learning Outcomes	1. Students will understand the relationship between gender and the environment. 2. Students will acquire knowledge about global and local initiatives on gender and environment. 3. Students will understand the vital role that women play in conservation of nature, sustainable use of natural resource, mitigating environmental conflicts and addressing environmental issues through activism.	

Title of the Course:Environmental Externalities and Policy

Course Code: ESO-321 **Number of Credits:** 01

Total Contact Hours: 12 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University
Objective:	This course aims to equip the learner with tools of resource allocation using basic concepts in Economics. This will include market and non-market-based approaches to understanding problems of global and local pollution and challenges to sustainability using techniques of environmental valuation.

Content:	**Module 1: Introduction** Meaning of externalities, environmental policy in the presence of externalities. **Module 2: Theory of externalities & environmental policy** Missing Markets, Non-convexity, Non-linearity, Public Goods, Common Property Resources, Coase Theorem and Issues in Property Rights; Pigouvian Taxes, Subsidies, Tradable Permits, Price v/s Quantity tools.	02 hours 10 hours
Pedagogy:	In class/online lectures, assignments, group activities, presentations.	
References/Readings	1. 1. Harris, J.M., & Roach, B. (2021). *Environmental and Natural Resource Economics: A Contemporary Approach*. Routledge. 2. Kolstad, C. (2012). *Intermediate Environmental Economics*. Oxford University Press. 3. Perman, R, Ma Y., Common, M., Maddison, D, &McGilvray. (2011). *Natural Resource and Environmental Economics* (4th ed.). Addison Wesley. 4. Rondeau, D., & Conrad, J.M. (2020). *Natural Resource Economics: Analysis, Theory, and Applications*. Cambridge University Press. 5. Tietenberg, T. (2000). *Environmental and Natural Resource Economics* (5th ed.). Addison Wesley.	
Learning Outcomes	On successful completion, course participants will be able to: 1. Understand how the environmental resources affect human welfare. 2. Have an informed opinion on environment-development trade-offs. 3. Assess international challenges of sustainability.	

Title of the Course:Introduction to Sustainable Development

Course Code: ESO-322 **Number of Credits:** 01

Total Contact Hours: 12 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University
Objective:	This course aims to equip the learner with tools of resource allocation using basic concepts in Economics. This will include market and non-market based approaches to understanding problems of global and local pollution and challenges to sustainability using techniques of environmental valuation.

Content:	**Module 1: Introduction** Meaning of sustainable development. **Module 2: Sustainable development** Renewable and Non-renewable Resources - Optimal use under different market Structures. Strong and weak sustainability; Global agreements, Economics of ecosystems and biodiversity. Issues of climate change adaptation and mitigation.	02 hours 10 hours
Pedagogy:	In class/online lectures, assignments, group activities, presentations.	
References/Readings	1. Harris, J.M., & Roach, B. (2021). *Environmental and Natural Resource Economics: A Contemporary Approach*. Routledge. 2. Kolstad, C. (2012). *Intermediate Environmental Economics*. Oxford University Press. 3. Perman, R, Ma Y., Common, M., Maddison, D, &McGilvray. (2011). *Natural Resource and Environmental Economics* (4th ed.). Addison Wesley. 4. Rondeau, D., & Conrad, J.M. (2020). *Natural Resource Economics: Analysis, Theory, and Applications*. Cambridge University Press. 5. Tietenberg, T. (2000). *Environmental and Natural Resource Economics* (5th ed.). Addison Wesley.	
Learning Outcomes	On successful completion, course participants will be able to: 1. Understand how the environmental resources affect human welfare. 2. Have an informed opinion on environment-development trade-offs. 3. Assess international challenges of sustainability	

Title of the Course:Introduction to Environmental Valuation

Course Code: ESO-323 **Number of Credits:** 01

Total Contact Hours: 12 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objective:	This course aims to equip the learner with tools of resource allocation using basic concepts in Economics. This will include market and non-market based approaches to understanding problems of global and local pollution and challenges to sustainability using techniques of environmental valuation.	
Content:	**Module 1: Introduction** Meaning, importance of environmental valuation. **Module 2: Issues in valuation** Costs and benefits. Use values, Non-use values, Option values, Discount rates. Methods of valuation: Revealed and stated preferences; Market and non-market valuation; Applications of valuation in developing countries.	02 hours 10 hours

Pedagogy:	In class/online lectures, assignments, group activities, presentations.	
References/Readings	1. Harris, J.M., & Roach, B. (2021). *Environmental and Natural Resource Economics: A Contemporary Approach*. Routledge. 2. Kolstad, C. (2012). *Intermediate Environmental Economics*. Oxford University Press. 3. Perman, R, Ma Y., Common, M., Maddison, D, &McGilvray. (2011). *Natural Resource and Environmental Economics* (4th ed.). Addison Wesley. 4. Rondeau, D., & Conrad, J.M. (2020). *Natural Resource Economics: Analysis, Theory, and Applications*. Cambridge University Press. 5. Tietenberg, T. (2000). *Environmental and Natural Resource Economics* (5th ed.). Addison Wesley.	
Learning Outcomes	On successful completion, course participants will be able to: 1. Understand how the environmental resources affect human welfare. 2. Have an informed opinion on environment-development trade-offs. 3. Assess international challenges of sustainability.	

Title of the Course: Environment Impact Assessment IV
Course Code: ESC-401 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	The student should have completed course nos. ESC-106 (EIA I), ESC-206 (EIA II) and ESC-301 (EIA III)	
Objective:	To learn the legal and administrative aspects of EIA and its application with specific reference to industrial sector.	
Content:	**Module 1: Introduction** Traditional and modern technologies associated with mining, aquaculture, sewage treatment plant, ports, airports, roads and railways.	06 hours
	Module 2: EIA and development EIA with reference to land-use pattern, centralized land-use, procedures and methodologies, EIA plans (state and central legislation), EIA (waste management), alternate technologies and waste management strategies, remediation, guidelines for the preparation of EIA document, Quality Management System for EIA.	10 hours
	Module 3: EIA for specific projects Industrial setup and establishment - infrastructure, operation and management, effluent and waste, practices, effectiveness, practices.	10 hours

	Biodiversity assessment, inventorization of flora and fauna, impact on migratory population and existing settlement, strategic mitigation measure. **Module 4: EIA rules and notifications** Legal, policy and regulation framework- Global and Indian context. Policy and legislation: Environmental Protection Acts & Rules. EIA notification 1994 and 2006 and amendments. EIA 2020 draft notification and objections. Public hearing guidelines. Case studies and reports.	10 hours
Pedagogy:	Lectures/assignments/workshops/outreach programs/field trips and discussion/presentations.	
References/ Readings	1. Glasson, J., Therivl. R & Chadwick, A. (2005). Introduction to Environmental Impact Assessment. Published by Routledge. Taylor and Francis Group. New York 2. Arts, J., & Morrison-Saunders, A. (Eds.). (2012). *Assessing impact: handbook of EIA and SEA follow-up*. Routledge.Taylor and Francis Group. New York 3. Abaza, H., Bisset, R., Sadler, B., (2004). Environmental Impact Assessment and Strategic Environmental Assessment: towards an integrated approach. UNEP. 4. Therivel, R., & Wood, G. (Eds.). (2017). *Methods of environmental and social impact assessment*. Routledge.Taylor and Francis Group. New York. 5. Morris, P., &Therivel, R. (Eds.). (2001). *Methods of environmental impact assessment* (Vol. 2). Taylor & Francis. New York 6. Ministry of Environment and Forests, EIA Notification, 2006, S.O. 1533, 14 September 2006 <http://parivesh.nic.in/writereaddata/ENV/EnvironmentalClearance-General/18.pdf>.	
Learning Outcomes	On completion of the course, the student will be able to: 1. Independently assess EIA of past projects. 2. Participate in EIA processes and evaluate policy decisions.	

(Back to Index) (Back to Agenda)

Title of the Course: Environmental Chemistry
Course Code: ESO-403 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at the 10+ 2 level.	
Objectives:	1. To introduce fundamentals of environmental chemistry. 2. To provide basic knowledge of environmental pollution, effects of environmental pollutants and control measures. 3. Introduction of various experimental techniques for analysis. 4. Evaluate the utility of various analytical techniques as a qualitative and quantitative tool.	
Content:	**Module 1. Introduction** Environmental segments (Lithosphere, Hydrosphere, Atmosphere, Cryosphere and Biosphere). Biogeochemical cycles (hydrogen, carbon, nitrogen, oxygen, phosphorus, and sulphur). Introduction to Microplastics and Nanoplastics (harmful effects, preventive measures and control measures), E-waste (impact on environment, harmful effects and control measures), and Radioactivity (contamination of radioactivity, radiation hazards, control measures). **Module 2:Air pollution** Air pollutants (primary and secondary), photochemical reaction, Acid rain, Ozone layer depletion, global warming. Carbon monoxide, nitrogen oxides, sulphur dioxide and hydrocarbons (sources, harmful effects, analysis and control measures). Particulate matters (inorganic, organic and radioactive), health hazards, analysis, control devices (Gravitational settlings, particulate air filters, centrifugal separators, wet scrubbers). Case study: Bhopal gas tragedy, London and Los Angeles smog **Module 3: Water pollution** Water analysis (salinity, hardness, pH BOD, COD, colour, turbidity, taste and odour), Water pollutants: nitrates, phosphates, phenols, cyanides, heavy metals (Cd, Hg, Pb, Se, As) and analysis methods. Lake and river water treatment, municipal waste water treatment and industrial effluent treatment (from pesticides, pharmaceutical and electroplating). Case study: Kepone, Minamata **Module 4: Soil pollution** Inorganic and organic components in soil, Reactions in soil, waste pollutants in soil. Excess usage of agrochemicals, soil	06 hours 10 hours 10 hours 10 hours

	contamination with pollutants. Pesticides (toxicity, biochemical effects and control measures). Waste Management (sources and types of solid wastes, disposal techniques, collection methods, waste management approach).Case study: use of pesticides e.g. DDT	
Pedagogy:	1. Mainly lectures / tutorials. Seminars/assignments/ presentations/ self-study or a combination of some of these could also be used to some extent. 2. Pre-lab and post-lab assignments or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. De, A. K. (2005). *Environmental chemistry* (3rd ed). New Age International Publishers. 2. Salker, A. V. (2017). *Environmental chemistry* (1st ed). Narosa Publishing House. 3. Sharma, B. K. (2003). *Environmental chemistry* (1st ed). GOEL Publishing House. 4. O'Neill, P. (2009). *Environmental chemistry* (3rd ed). Blackie Academic & Professional. 5. Khopkar, S. M. (2005). *Environmental pollution analysis*. (1st ed.) New Age International Publishers.	
Learning Outcomes	1. Students will be in a position to know the basic environmental chemical processes. 2. Students will be able to explain the origin and harmful effects of toxic chemicals in the environment. 3. Student will be in position to use different techniques for qualitative and quantitative estimation of environmental samples.	

Title of the Course: Green Chemistry
Course Code: ESO-404 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at the 10+ 2 level.	
Objectives:	1. To learn basic knowledge and principles involved in green chemistry and create awareness of greener chemistry. 2. To understand energy saving and making green processes in chemical reactions. 3. To develop social concern for waste generated from various processes.	
Content:	**Module 1: Introduction (***Ref. 1,3)* Need for Green Chemistry; Overview of twelve green chemistry principles as proposed by Paul Anastas and John Warner;	06 hours

	Explanation with examples under each principle. Introduction to sustainable development; Why regulation is required to achieve sustainable development; Environmental policy and innovation; Future trends and challenges in sustainable development. **Module 2: Designing Greener Approaches and Waste Handling** *(Ref. 1, 4)* Safer designs for the target molecule, Minimization, Simplification, Substitution, Moderation, Limitations, Replacement of Toxic Reagents, Use of Alternative Solvents (suitable examples in each case). Problems caused by waste; Sources of waste from the chemical industry; Waste minimization techniques; On-site waste treatment; physical treatment; Chemical treatment; Biotreatment; Degradation; Rules for degradation; Polymer recycling **Module 3: Future Trends in Green Chemistry and Chemicals from Renewable Raw Materials** *(Ref. 2, 5)* Introduction to solid acid catalysts and their significance in industrial applications; phase-transfer catalysis, Biocatalysis: basic principles, enzyme catalysed reactions, Photocatalysis: Introduction and significance with examples. Renewable Raw Materials: Carbohydrates, Ethanol, Lactic acid, Indigo-natural colour, Riboflavin, Ascorbic acid, Fats and oils, Biodiesel, Fatty acid esters, Terpenes and green polymers **Module 4: Alternative energy sources for greener processes** *(Ref. 1)* Design for energy efficiency; Photochemical reactions; Advantages of and challenges faced by photochemical processes; Examples of photochemical reactions; Chemistry using microwaves; Microwave heating; Microwave-assisted reactions; Sonochemistry; Electrochemical synthesis.	10 hours 10 hours 10 hours
Pedagogy:	Mainly lectures / tutorials, seminars / assignments / presentations / self-study or a combination of some of these could also be used to some extent.	
References/ Readings	1. Lancaster, M. (2002). *Green chemistry-an introductory text* (1st ed). Royal Society of Chemistry. 2. Sheldon, R. A., Arends, I., &Hanefeld, U. (2007). *Green chemistry and catalysis* (1st ed). Wiley-VCH Verlag. 3. Afonso, C. A. M., &Crespo, J. G. (2005). *Green separation processes: Fundamentals and applications* (1st ed). Wiley-VCH Verlag. 4. Matlack, S. (2001). *Introduction to green chemistry.* Marcel Dekker, Inc. (1st ed). 5. Ahluwalia, V. K., &Kidwai, M. (2004). *New trends in green*	

	chemistry. Anamaya publishers.	
Learning Outcomes	1. Student should be in position to understand and apply the basic principles of Green chemistry in daily life. 2. Students should understand control measures of waste. 3. Students will be able to understand the green Industrial processes.	

Title of the Course: **Ecotoxicology**
Course Code: ESO-405 **Number ofCredits**: 03
Total Contact Hours: 36 **Effective from AY**:2022-23

Prerequisites for course:	Graduate in any discipline from a recognised University
Objectives:	1. Students will gain full understanding of the effects of toxic substances on ecosystems and their living components. 2. Students will also gain knowledge on the various organisms and methods used in ecotoxicological testing as well as mitigation.

Content:	**Module 1: Introduction** Important concepts of ecotoxicology,Routes by which pollutants enter ecosystems;Major classes of pollutants, their sources and Eco toxicological effects, permissible levels of toxicants in the environment. **Module 2: Concepts of toxicology** Acute and chronic toxicity**,** dose response,bioaccumulation**,** bio magnification**,** bioavailability**,** biodegradation; Toxicokinetics: Absorption, Distribution, Metabolism, Biotransformation and Elimination of Toxicants, Physiological and biochemical effects of toxic substances: Genotoxic, neurotoxic compounds, endocrine disruptors; Effects at the molecular level, cellular level, organism level (physiological, reproduction, behaviour) **Module 3: Biomonitoring** Eco-toxicity tests (lab-based and field tests) in air, water and soil, biosensors, molecular biology assays, Use of model organisms for ecotoxicology: fish, helminthes, molluscs, mice, Environmental Risk Assessment.Environmental bio-indicators of eco-toxicity with faunistic studies **Module 4: Microbial Ecotoxicology and Biotechnology for mitigating environmental toxicity** Interaction between microorganisms and pollutants; Role of microorganisms in detoxification and degradation of environmental pollutants, Metagenomic techniques to study microbial diversity in polluted environment. Biological consortia to degrade or sequester in situ toxic materials. Primary, secondary and tertiary treatment of wastewater. Ameliorating nutrient toxicity (Nitrates and Phosphates), Handling sludge toxicity, Microbial and Phytoremediation (wetlands), Treatment of domestic wastewater using wetlands – a case study.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	In class/online lectures, assignments, group activities, presentations.	
References/ Readings	1. Walker, C. H., Sibly, R. M., Hopkin, S. P., &Peakall, D. B. (2012) *Principles of Ecotoxicology. 4th Edition*. CRC Press, Taylor and Francis. 2. Jorgensen, S. E. (2010) *Ecotoxicology: A derivative of encyclopedia of ecology.* Academic Press. 3. Moriarty, F. (1999) *Ecotoxicology: The study of pollutants in ecosystems. 3rd Edition.* Academic Press. 4. Peakall, D. (2012) *Animal Biomarkers as Pollution Indicators.* Chapman and Hall. 5. Hayes, W. A. (2014) *Principles and Methods of Toxicology.* CRC Press, Taylor and Francis. 6. Naik, M. M., &Dubey, S. K. (2017) *Marine pollution and Microbial remediation.* Springer.	

	7. Cravo-Laureau, C., Cagnon, C., Duran, R., &Lauga, B. (2017) *Microbial Ecotoxicology*. Springer. 8. Scragg, A. (2005) *Environmental Biotechnology*. Oxford University Press. 9. Willey, J. M., Sherwood, L. M., &Woolverton, C. J. (2017) *Prescott's Microbiology*. *10th Edition.*McGraw-hill Education. 10. Munn, C. (2020) *Marine Microbiology: Ecology and applications. 3rd edition*. Garland science. 11. Satyanarayana, T., Johri, B., & Anil, T. (2012) *Microorganisms in Environmental Management*. Springer.	
Learning Outcomes	On successful completion, students will be able to: 1. Understand the toxic effects of pollutants in ecosystems 2. Apply concepts of ecotoxicology using model organisms and for assessing environmental risk 3. Understand mitigation strategies using micro-organisms	

(Back to Index) (Back to Agenda)

Title of the Course:Microplastics in Environment

Course Code: ESO-406 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at 10+2 level	
Objective:	This course introduces to the concept of microplastics as a pollutant and its impact on the environment and human.	
Content:	**Module 1:Introduction to microplastics** Introduction to Plastics and microplastics: Types of plastics: PET, HDPE, PVC, LDPE, PP, PS, Other; and microplastics types: fibres,microbeads, fragments, nurdles, foam. Primary and Secondary, microplastics and its formation. **Module 2:Distribution of microplastics** Global occurrence, sources of microplastics. Distribution and fate of plastic in the environment. Microplastics pollution in Land, Water- Freshwater and Marine waters, Air, Snow. **Module 3:Impacts of microplastics** Potential impacts on the environment and human health. Microplastics as carriers of trace and heavy metals and its role as pollutant. Microplastic in plants, animals and humans. **Module 4:Sampling,characterization, mitigation of microplastics and case studies** • **Sampling and characterization**	06 hours 10 hours 10 hours 10 hours

	Methods used for sampling, quantification of microplastics. Instrument for identification of microplastics- FTIR and Raman Spectroscopy. • **Mitigation** Mitigation methods for microplastics and role of Blue Flag certification- international eco-level tag Foundation for Environmental Education. G20 and United Nations Environment Assembly resolution on marine litter and microplastics. • **Case studies** Microplastics pollution studies in India-Case studies with special reference to Goa.	
Pedagogy:	Since it is a theory course, to get a strong understanding of the subject, case studies will be discussed and seminar topics other than from the syllabus will be given to students.	
References/ Readings:	1. Crawford, B.C & Quinn, B. (2016). *Microplastic Pollutants* (1st ed.). Elsevier Science. 2. Rocha-Santos, T., Costa, M. &Mouneyrac, C., (Eds.). (2022). *Handbook of Microplastics in the Environme*nt (1st ed.). Springer. 3. Rocha-Santos, T.A.P. & Duarte, A.C. (Eds.). (2017). *Characterization and Analysis of Microplastics*(1st ed.). Elsevier Science.	
Learning Outcomes	1. The course helps in understanding the formation of microplastics and its impact on environment. 2. The course will help in creating awareness among student about microplastic pollution and will help them to reflect upon mitigation of such problems.	

Title of the Course: Renewable Energy System

Course Code: ESO-407 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objective:	This course develops to understand the concept of energy and its form. Various form of energy, its conversation to electric form and relevant systems and energy management.	
Content:	**Module 1: Introduction** • Classification of energy Energy chain and common forms of usable energy, Present energy scenario, World energy status-Energy scenario in India, Introduction to renewable energy resources: Solar,	06 hours

	Wind, Hydro Power and Nuclear Energy. **Module 2: Solar energy harvesting systems** • Solar energy and systems Introduction to Solar Energy-Energy from sun-Spectral distribution of Solar radiation- Instruments for measurement of solar radiation-Solar radiation data analysis. Thermal applications -Introduction to Solar thermal collectors- Types - Principle of operation of different collectors - Flat plate- Evacuated tube collectors-Compound parabolic collectors- Solar air heaters - Solar dryers-solar cookers- solar stills - Solar ponds - concentrating collectors-line type - point type - Methods of Solar power generation - Power towers • Solar photovoltaics cells Physics of solar cells - Cell and module , Manufacturing Process:Characteristics of cells and module - Performance parameters -BoS- PV System applications - Standalone- Grid connected systems. **Module 3: Alternative energy harvesting systems** • Small hydro power, ocean and geothermal energy systems, wind energy Introduction - types - system components, discharge curve and estimation of power potential - Turbines for SHP; Power generation through OTEC systems - various types - Energy through waves and tides - Energy generation through geothermal systems – types ; Resource assessment - types of wind turbines - selection of components - blade materials - power regulation - various methods of control - wind farms - site selection - off shore wind farms - Solar Wind Hybrid energy systems. • Electric vehicles and its roadmap Electric Vehicles, Batteries design material, resources, specifications and EV roadmap. **Module 4: Energy Management** • Energy management Transmission of Energy System AC and DC Forms, Relevant issues in Transmission and Transmission lines, Engine Efficiency, Low power designs and managements, E-Waste, Worldwide Scenario and Indian Context, Rules and Regulations.	10 hours 10 hours 10 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	

References/ Readings	1. Andrews, J., &Jelley, N. (2013). *Energy science: Principles, technologies and impacts, Oxford Universities press*. 2. Fang, L. Y., & Hong, Y. (2012). *Renewable energy systems, advanced conversion technologies and applications*. CRC Press. 3. Wolfson, R. (2011). *Energy, environment, and climate, Publisher* (2nd ed). W. W. Norton, and Company. 4. Hodgson, P. E. (2010). *Energy, the environment and climate change, Publisher*. Imperial College Press. 5. Boyle, G. (2012). *Renewable energy, power for a sustainable future*. Oxford University Press. 6. Jha, A. R. (2010). *Wind turbine technology*. CRC Press. 7. Duffie, J. A., & Beckman, W. A. (2013). *Solar engineering of thermal processes, Wiley*. 8. Solanki, C. S. (2011). *Solar photovoltaics, fundamentals, technologies and applications*. Prentice Hall. 9. Global climate change reports. 10. TERI Energy Data Year Books 11. Bureau of Energy Efficiency- Volume 1	
Learning Outcomes	1. Correlate various form of energy and World energy status and various conversion system. 2. Define opportunities available for energy conservation and for use of renewable energy resources in local and regional entities.	

Title of the Course: Coral Ecology

Course Code: ESO-408 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objectives:	1. To understand the reef formation, distribution and biological/ecological processes of coral reefs. 2. To explore the coral biome and its ecological interactions 3. To study the threats, climate change adversities and restoration of coral habitats.	
Content:	**Module 1:Introduction** • **Coral reef distribution and significance** Types of coral reefs and their global distribution with special emphasis to Indian waters. Salient features of the ecosystem: Habitat characteristics, reef biodiversity and nursery grounds, interactions with seagrass ecosystem and migratory corridors, natural barriers. Economic Importance: Fisheries and marine products, tourism and recreational activities.	06 hours

	Module 2:Coral evolution and community interactions • **Coral evolution and development** Paleoecology of corals. Theories of evolution: Subsidence theory, Glacial Control Theory, Stand Still Theory, Cycle of Erosion theory. Coral reef formation, morphology and functional zones, Ocean chemistry and aragonite saturation. Hydrodynamics and lagoon circulation. • **Coral biome dynamics** Coral communities and trophic structure: Primary producers, consumers, food webs, productivity in coral reefs. Symbiotic associations: Algal-coral associations, bacterial symbiosis, multi-partner symbiosis. Internal nutrient cycling, Energy transfer/trophodynamics, Adaptive bleaching hypothesis, Coral probiotic hypothesis, Rosenberg's hologenome hypothesis. **Module 3: Threats to coral ecosystem** • **Physico-chemical and biological factors influencing coral reefs** Environmental factors (pH, temperature, salinity, sedimentation, waves, ocean currents, weather, nutrients, aerial exposure, light) and their impact. Competitors, Microbial infections, predators, parasites • **Anthropogenic threats** Tourism and its impact, pollution, overfishing, habitat destruction. Global warming, thermal bleaching, ocean acidification, sea level rise and its effect on coral health. **Module 4: Coral disease spread assessment and prophylactic measures** Coral disease survey and monitoring protocols. Disease response plan and outbreak management. Ex-situ treatment measures: Use of antibiotics, anti-oxidants and Phage therapy. Cultivation and conservation of corals: Coral Restoration and Health Consortium (CRHC), Global Coral Reef Conservation Project, Resilient Reef Initiative Project, Mithapur Coral Reef Recovery Project. Traits of climate change resilient clades. Laws and policies for conservation and management of corals in Indian seas/waters.	10 hours 10 hours 10 hours
Pedagogy:	Lectures/tutorials/assignments/self-study/case-studies	

References/ Readings	1. Sheppard, C., Davy, S., Pilling, G., & Graham, N. (2018). *The Biology of Coral Reefs (Biology of Habitats Series)* (2nd ed.). Oxford University Press. 2. Dubinsky, Z., &Stambler, N. (2014). *Coral Reefs: An Ecosystem in Transition* (1st ed.). Springer. 3. vanOppen, M. J. H., &Blackall, L. L. (2019). Coral microbiome dynamics, functions and design in a changing world. *Nature Reviews Microbiology*, *17*(9), 557–567. 4. vanOppen, M. J. H., Oliver, J. K., Putnam, H. M., & Gates, R. D. (2015). Building coral reef resilience through assisted evolution. *Proceedings of the National Academy of Sciences*, *112*(8), 2307–2313. 5. Harvell, D., Jordán-Dahlgren, E., Merkel, S., Rosenberg, E., Raymundo, L., Smith, G., Weil, E., & Willis, B. (2007). Coral Disease, Environmental Drivers, and the Balance Between Coral and Microbial Associates. *Oceanography*, *20*(1), 172–195. 6. Chakravarti, L. J., & van Oppen, M. J. H. (2018). Experimental Evolution in Coral Photosymbionts as a Tool to Increase Thermal Tolerance. *Frontiers in Marine Science*, *5*. 7. Contardi, M., Montano, S., Liguori, G., Heredia-Guerrero, J. A., Galli, P., Athanassiou, A., & Bayer, I. S. (2020). Treatment of Coral Wounds by Combining an Antiseptic Bilayer Film and an Injectable Antioxidant Biopolymer. *Scientific Reports*, *10*(1). 8. Laurie J. Raymundo, Courtney S. Couch, C. Drew Harvell. (2021). Coral Disease Handbook Guidelines for Assessment, Monitoring & Management. ISBN-13 978-1921317019.	
Learning Outcomes	1. The coral ecosystem function and its ecological and economic implications. 2. Awareness of impact of anthropogenic activities on coral health 3. Conservation and management strategies of damaged corals and their recovery.	

Title of the Course: Polar Sciences

Course Code: ESO-409 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at 10+2 level
Objective:	Lectures provide basic information about physical geographic conditions of the Arctic and Antarctic, history of discovery and colonization of these regions. The course also includes assessing the significance of the Polar Regions in context of atmospheric circulation, energy exchange, circulation in the Southern Ocean, cryosphere, biota and its sensitivity to global changes. Lectures are an integral part of information on current trends in polar research, development of tourism and its potential impacts, protection of natural resources and polar ecosystems.

Content:	**Module 1: Introduction** • Delimitation of Arctic and Antarctic, their basic differences, discovering, exploitation and scientific utilizability. • Astronomic factors and their reflexion in polar regions. **Module 2: Ecology of polar region** • Climate of polar regions - energy balance of the ground surface, water balance, baric field and atmospheric circulation, air temperature and air humidity, precipitation. Climate change and climate variation and their consequences i.e. polar regions (glacials and interglacials and their influence on the hydrosphere, geosphere, cryosphere and biosphere). • Freshwater hydrology and oceanology. Surface water and ground water. Polar oceans - submarine relief, systems of sea curents, water substitution with the lower latitudes and its energy consequences **Module 3: Glaciology** • Glaciology of polar regions - reasons of glaciation and its development, glaciation of continents and of sea surface, ice mass balance. Cryosphere as a stabilizer of Earth climate. • Development of earth surface in polar regions, glacial and periglacial geomorphologic processes - permafrost and its energy roots, regional structure, active layer of permafrost, frost weathering, slope dynamics. Soil in polar regions. **Module 4: Flora and fauna** • Vegetation in polar regions - limiting by abiotic factors (microclimate, nutrients, water), soil flora, space structure of polar vegetation (subpolar, polar, polar deserts and semideserts, polar wetlands). Origin of polar (alpine) plants, vascular plants and their adaptation and acclimatization on the polar environment. Cryptogams in polar regions. • Stress physiology of polar plants. • Fauna of polar regions - invertebrates, evolution and space structure, physiological adaptation on polar conditions, nutrient succession. • Microbial diversity - Anthropogenic impacts on polar ecosystems - heat pollution of planetary geosystem, changes in chemical composition of atmosphere and their consequences (global transport of pollutants, anthropogenic change in greenhouse effect, ozone depletion and its consequences), changes in biodiversity.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	Online/offline lectures, tutorials, assignments and visit to research laboratory	

References/Readings	1. Holdgate, M.W. (1970). Antarctic Ecology. *Academic Press, London*, New York. 2. King, J.C. & Turner, J. (1997). Antarctic meteorology and climatology. *Cambridge University Press.*xi, 409. 3. Oke, T. R. (1987). Bounrady Layer Climates. *Routledge, London and New York*, 435. 4. Przybylk, R. (2003). The climate of the Arctic. *Dordrecht: Kluwer Academic Publishers,* 270. 5. Richard, S., Per, M. (2006). BuffaloA complete guide to Arctic wildlife. *N.Y.: Firefly Books*, 464. 6. Stonehouse, B. (1989). Polar Ecology. *Blackie, Glasgow – London*. 7. Thurman, H.V. & Alan, P.T. (2005). Oceánografie: [tajemnýsvětmořía oceánů]. *Praha: Computer Press*, viii, 479. 8. Warwick, F., Johanna, V., Parry, L. (2008). Polar lakes and rivers: limnology of Arctic and Antarctic aquatic ecosystems. *Oxford: Oxford University Press*, xviii, 327.	
Learning Outcomes	Polar ecosystems are comparatively simple from point of view of their internal structure. On the other hand they exist as a result of long development whose effect is perfect adaptation of their biotic component to the extremal living conditions. It enables their existence on the bounds of energy, climate and food requirement. Polar ecosystems were form under influence of specific astronomic, geographical, oceanographic, atmospheric and geochemical factors. They have influenced their inanimate components (georelief and its substratum, atmosphere, hydrosphere, kryosphere, pedosphere) and subsequently biosphere. Nevertheless, arised ecosystems impact backward as a complex the whole planet - notably from the energetic point of view. Its reflexion is first of all global change of ocean water, global climate and consequently complicated cascade of processes, which form the development of shape of Earth surface and development of the biosphere.	

Title of the Course: Marine Biodiversity and Conservation

Course Code: ESO-410 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the Course:	Graduates in any discipline with science subjects at the 10+2 level.	
Objective:	Addresses basic concepts of marine biodiversity at all levels, IPR, life patenting, values and its implications on the environment and human life with respect to the anthropogenic inputs.	
Content:	**Module 1:Introduction**	06 hours

	Biodiversity, definition, concept, types; Biodiversity measurements - taxic, phylo-genetic and molecular approaches. **Module 2: Genetic variance and dynamics** Intra-specific Genetic variance and factors affecting, biodiversity and intra-specific variations, dominance and over-dominance hypothesis, adaptive polymorphism, genetic variations, loss and increase dynamics of biological diversity, conceptual models, hypothesis proposed in deep sea biodiversity. **Module 3: Ecological processes and ecosystem stability** Marine Biodiversity and ecosystem functions, competition, predation and heterogeneity as biodiversity determinants; ecosystem approach, functions and keystone species, engineer organisms, diversity-stability, rivet, drivers and passenger, idiosyncratic hypothesis, co-operative relations, top down and bottom up theories, cascade effects and fishing through the food webs. **Module 4: IPR and biodiversity conservation** Biodiversity and Intellectual Property Rights (IPR) and bio-piracy, life patenting and implications, impact of GATT/WTO on farmer's right, indigenous, traditional knowledge. Biodiversity conservation - Biological diversity Act, sanctuaries, marine parks, protected areas, hotspots and marine biosphere reserves of India	10 hours 10 hours 10 hours
Pedagogy:	Lectures / tutorials / assignments / self-study	
References/ Readings	1. Hiscock, K. (2014). *Marine biodiversity conservation: A practical approach*. Routledge Taylor & Francis Group. 2. Kumar, A. (2004). *Biodiversity & environment*. A.P.H. Pub. Corp. 3. *Ormond, R., Gage, J. D., & Angel, M. V. (1997). Marine biodiversity: Patterns and processes. Cambridge University Press.* 4. Queiroga, H. (2006). *Marine biodiversity: Patterns and processes, assessment, threats, management and conservation*. Springer. 5. Shiva, V. (1994). *Cultivating diversity: Biodiversity conservation and the politics of the seed*. Research Foundation for Science, Technology & Natural Resource Policy.	
Learning Outcomes	The students will be able to understand holistic view of the marine biodiversity with emphasis on ecosystem functions, IPR, life patenting and conservation policies.	

(Back to Index) (Back to Agenda)

Title of the Course: Ecotourism
Course Code: ESO-411 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduation in any discipline from a recognised University	
Objectives:	To understand ecotourism potential, resources and management issues.	
Content:	**Module 1:Introduction** Definition, history, scope, principles, and characteristics of ecotourism. Tourist motivation, tourist interaction, and intensity of interaction with nature. Ecotourist, eco-sensitivity, ecocentrism, ethics of ecotourism, local participation benefits, and conservation. **Module 2:Resource potentials** Flora and fauna of Wildlife Sanctuaries, Bird Sanctuaries, National Park, sacred grooves, mangroves, backwater, waterfalls, springs, beaches, hill stations, deserts, butterfly parks, spice plantations. Taxonomy and ecology of aquatic faunal resources (Dolphin, crocodile, corals, mollusca) and terrestrial faunal resources (birds, butterflies, other insects). **Module 3: Ecotourism Management** Marketing of ecotourism, Economic impact, development, governance and policy, programme planning, codes of practice carrying capacity, resource management and impact of ecotourism, impact assessment and management analysis. Visitor activity and impact management, role of interpretation centre. Safety measures on field and first aid. **Module 4: Designing ecotourism projects** Designing, interpretation centres, ecotourism websites, portals and documentaries, Identification of site-specific flora and fauna.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	Use of conventional, online and ICT Methods.Field visit Case study/ ecotourism project proposal/project/self-study Lecture/Tutorials/Assignments	

References/ Readings	1. Bhatia, A.K. (2014) Tourism development: principles and practices, New Delhi: Sterling Publishers Pvt. Ltd. 2. Cooper, Chris (1994) Tourism Principles and practice. Great Britain Pitman publishing. 3. Fennell David S. (2004) Ecotourism 4th edition Routledge Taylor & Francis group 4. Fennell, David A. (2007) Ecotourism policy and planning. CABI Publishing, Wallingford, Oxon, UK 5. Hill Jennifer, Gale Tim (2009) Ecotourism and Environmental sustainability Principles and practice, Aghgateebook. 6. Raju, Aluri Jacob Solomon (2007) A Textbook of Ecotourism Ecorestoration and Sustainable Development by New Central Book Agency (P) Ltd, Kolkata. 7. Sinha, P (2003) Encyclopaedia of ecotourism, Anmol Publications, New Delhi. 8. Singh, Ratandeep (2003) Indian Ecotourism: Environmental Rules and Regulations Kaniskha Publishers, New Delhi. 9. Trivedi, PriyaRanjan (2006) Encyclopaedia of the Ecotourism (Vol. 1): Introduction to the Ecotourism, JnanadaPrakashan, New Delhi. 10. Wearing Stephen, Neil John Ecotourism, impacts, potentials and possibilities 2nd edition Elsevier.	
Learning outcomes	1. To identify ecotourism potential sites, assess ecoresources. 2. Design and execute visitor management plan and promotional material for ecotourism.	

(Back to Index) (Back to Agenda)

Title of the Course: Mineral resources, environmental problems and management

Course Code: ESO-412 **Number of Credits:** 01

Total Contact Hours: 12 **Effective from AY:** 2022-23

Prerequisites for the course:	Bachelor's degree of this University or an examination of any other University recognised as equivalent.	
Objective:	To understand the interaction of humans with the geological environment.	
Content:	**Module 1: Introduction** • Earth in space and time • Internal structure of the earth and Geological time scale **Module 2: Earth, its resources and the management** • Geological evolution of earth: plate tectonics and seafloor spreading • Mineral resources and reserves; UNFC. • Mining: surface and underground mining, mine ventilation, mine drainage, environmental effect of mining, environmentally sensitive green mining, mine closure. Trace elements and their implications on health.	02 hours 10 hours
Pedagogy:	Lectures, case studies, discussions and assignments.	
References/ Readings	1. Merrits. D., De Wet, A., &Menking, K. (1997). *Environmental Geology: an earth system science approach.* W. H. Freeman, New York. 2. Keller, E. A. (2012). *Introduction to Environmental Geology* (5th ed.). Prentice Hall. 3. Montgomery, C. W. (2010). *Environmental geology*. (9th ed.). Professor Emerita, Northern Illinois University. 4. Montgomery, C. W. (2020). *Environmental geology*. (11th Ed.). Professor Emerita, Northern Illinois University. 5. Pipkin, B. W., Trent, D. D., Hazlett, R., &Bierman, P. (2013). *Geology and the Environment*. Cengage Learning. 6. Valdiya, K. S. (1987). *Environmental geology, Indian context*. Tata McGraw-Hill Pub. Co.	
Learning Outcomes	In this course a student will learn about: 1. Concepts of environmental geology and its interaction with the human beings, 2. Management of geological resources.	

Title of the Course: Pollution and environment

Course Code: ESO-413 **Number of Credits:** 01

Total Contact Hours: 12 **Effective from AY:** 2022-23

Prerequisites for the course:	Bachelor's degree of this University or an examination of any other University recognised as equivalent.
Objective:	• To understand the interaction of humans with the geological

	environment. • To study pollutants in the environment and to find the suitable remedial measures to cover harmful effects.	
Content:	**Module 1: Introduction** • Human and geological environment **Module 2: Types of pollution and remedial measures** • Hydrology and pollution – Impact assessment of degradation and contamination of surface water and groundwater quality due to industrialization and urbanization; remedial measures. • Soil Science - Soil profile, soil types and their classification and formation; soil quality degradation, control measures Waste and its disposal - surface and subsurface disposal of toxic, metallic and radioactive wastes. Planning and management of hazardous waste. Domestic refuse and landfill.	02 hours 10 hours
Pedagogy:	Lectures, case studies, discussions and assignments.	
References/ Readings	1. Keller, E. A. (2012). *Introduction to Environmental Geology* (5th ed.). Prentice Hall. 2. Montgomery, C. W. (2010). *Environmental geology*. (9th ed.). Professor Emerita, Northern Illinois University. 3. Montgomery, C. W. (2020). *Environmental geology*. (11th Ed.). Professor Emerita, Northern Illinois University. 4. Pipkin, B. W., Trent, D. D., Hazlett, R., &Bierman, P. (2013). *Geology and the Environment*. Cengage Learning. 5. Valdiya, K. S. (1987). *Environmental geology, Indian context*. Tata McGraw-Hill Pub. Co.	
Learning Outcomes	In this course a student will learn about: 1. Concepts of environmental geology and its interaction with the human beings, 2. Management of geological resources, 3. Appropriate use of the geological site for waste disposal.	

(Back to Index) (Back to Agenda)

Title of the Course: Natural and manmade hazards
Course Code: ESO-414 **Number of Credits:** 01
Total Contact Hours: 12 **Effective from AY:** 2022-23

Prerequisites for the course:	Bachelor's degree of this University or an examination of any other University recognised as equivalent.
Objective:	1. To understand the interaction of humans with the geological environment. 2. To impart knowledge about different natural as well as manmade

	hazards with deterrent measures.	
Content:	**Module 1 : Introduction** • Life on Earth **Module 2 : Geological hazards** Assessing geological hazards and risks: Earthquakes, volcanic eruptions, floods and droughts, mass movement-landslides, rock fall, preventive and mitigation measures.	02 hours 10 hours
Pedagogy:	Lectures, case studies, discussions and assignments.	
References/ Readings	1. Keller, E. A. (2012). *Introduction to Environmental Geology* (5th ed.). Prentice Hall. 2. Montgomery, C. W. (2010). *Environmental geology*. (9th ed.). Professor Emerita, Northern Illinois University. 3. Montgomery, C. W. (2020). *Environmental geology*. (11th Ed.). Professor Emerita, Northern Illinois University. 4. Pipkin, B. W., Trent, D. D., Hazlett, R., &Bierman, P. (2013). *Geology and the Environment*. Cengage Learning. 5. Valdiya, K. S. (1987). *Environmental geology, Indian context*. Tata McGraw-Hill Pub. Co. 6. Valdiya, K. S. (2013). *Environmental Geology: Ecology, Resource and Hazard Management*. McGraw-Hill Education.	
Learning Outcomes	In this course a student will learn about recognition of natural hazards and mitigation.	

Title of the Course: Environmental Security: Dimensions and Perspectives
Course Code: ESO-415 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the Course:	Graduate in any discipline from a recognised University
Objectives:	The course beholds the following objectives: 1. Aims to disseminate rudimentary knowledge in the realm of environmental security, aligned with concurrent analytical comprehension of the natural and human induced environmental mutations, plausibly impacting human security and well-being. 2. Disseminating knowledge and information coalesced around conflicts impelled by environmental resources-scarcity and instituted peace-building processes. 3. Endeavouring to emphasise on typologies and taxonomies of environmental stresses, such as demographics and migration, the dialectic choices between conventional and renewable energy sources, and socio-economic underpinnings of poverty-led insecurity, contextualised to national, region and global environs.

Content:	**Module 1: Introduction** Conceptual-Construct and Topical Phenomenon – Definitions, Narratives in Discourse, Schools of Thought. **Module 2: 'Environmental Security' qua 'Conventional' and 'Non-Conventional' security** Typologies of Armed Conflicts &Analysis; Inter-State Conflicts in the Global South (Case Studies from Africa, West Asia, South Asia); Population Pressures and Migration Patterns in Conflict; Role of Non-State Actors; Socio-Economic Issues (Poverty, Occupation and Livelihoods, Infectious Diseases, Industrialisation and Urbanisation Trends). **Module 3: Environmental security and sustainability imperatives for ecological harmony and development** Food Security; Water Scarcity; Energy Security and Independence; Coastal, Marine, and Blue Economy Resources; Climate Change; Natural Resources Administration; Disaster Management; Land and Forests Vulnerability. **Module 4: Environmental security as global commons and global good** Perspective on Challenges; Template for Cooperation; Environmental Peace-building Movements, Environmental Justice.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	Classroom lectures, written and oral assignments, audio-visual presentations	
References/ Readings	1. Das O. 2013. Environmental protection, Security and Armed Conflict: a sustainable development perspective, Edward Elgar Publishing Ltd. 2. Hough P. 2021. Environmental security: an introduction, Routledge (2nd Ed.). 3. Lanicci J. et. al. 2020. Environmental security – concepts, challenges and case studies, AMS. 4. Lee J. 2019. Environmental conflict and cooperation: premise, purpose, persuasion and promise, Routledge (1st Ed.). 5. Pirages D. et al. 2011.Ecological and non-traditional security challenges in South Asia, NBR Special Report. 6. Richard M. 2010. Global environmental change and human security, London: MIT Press.	

	7. Scheffran J. et al. 2012. Climate change, human security and violent conflict: challenges for societal stability, Springer.	
Learning Outcomes	Upon completion of instruction and pedagogy, the course will render students, the following takeaways: 1. Acquaint and introduce them, to the latest thought-process discourse, in terms of theory and praxis, on environmental security and peace-building, in a manner that helps internalise the conceptual phenomenon, as cross-cutting generations, policy-axes, and vectors of human endeavour. 2. Glean as to how environmental harness and the excesses of it materially impinge, on the natural security calculus of individual nation-states, inducing the imperative for responsible and sustainable recourses, by sovereign and institutional actors, alike. 3. Internalise how environmental preservation and protection remains pivotal, to beneficently shaping critical sustainable development concerns, of water, food and energy security, that intimately segue with existential aspects of upholding livelihoods and fostering societal-uplift, vide ecological sentience. 4. Students can emerge as stakeholder-contributors to wide-ranging policy analysis in environmental security and peace, through requisite appraisal and appreciation of policy formulations and interventions, beyond their chosen domain of scientific core competence.	

Title of the Course:Global Environmental History
Course Code: ESO-416 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022–23

Prerequisites for the course:	Graduate in any discipline from a recognised University	
Objective:	Global Environmental History focusses on the interactions that humans have with nature. Natural world comes in many forms, scales, and styles—forests, rivers, mountains and climate, which makes it a remarkable tool for understanding science, society and nation. This course examines natural world as active, rather than passive; how nature influences humans, how humans intervene in nature and how is nature shaped by human action.	
Content:	**Module 1: Introduction** Humans and nature in a time-dimension: IbnKhaldun; Montesquieu; George Perkins Marsh; FernandBraudel.	06 hours
	Module 2: Early human condition: Ecological process	10 hours

	Historicizing climate; Early humans; Early agriculture; the metal ages.	10 hours
	Module 3: Commodity frontiers and natural assets Columbian exchange; Industrial world; Fossil fuels; Environmental relationships.	10 hours
	Module 4: Nations and nature Environment and empire—Imperialism and environmental change; Significance of *Silent Spring*; science and the discourse of ecological crisis; the ideology of scientific conservation, the environmental debate, green capitalists, environmental justice.	
Pedagogy:	Lectures (traditional, problem-based, discussion-based); tutorials; assignment-based; seminars; cooperative learning and self-study.	
References/ Readings	1. Anker, P. (2002). *Imperial Ecology: Environmental order in the British empire, 1895–1945*. Harvard University Press. 2. Arnold, D., &Guha, R. (1995). *Nature, Culture, and Imperialism: Essays on the Environmental History of South Asia*. Oxford University Press. 3. Beinart, W., and Hughes, L. (2009). *Environment and Empire*. Oxford University Press. 4. Crosby, A. (1972). *The Columbian Exchange: Biological and Cultural Consequences of 1492.* Greenwood Publishing Company. 5. ————————. (1986). *Ecological Imperialism: The Biological Expansion of Europe, 900–1900.* Cambridge University Press. 6. Diamond, J. (1997). *Guns, Germs, and Steel: The Fates of Human Societies*. W. W. Norton. 7. ————————. (2005). *Collapse: How Societies Choose to Fail or Succeed*. Penguin Books. 8. Grove, R. (1995). *Green Imperialism*. Cambridge University Press. 9. Guha, R. (2000). *Environmentalism: A Global History.* Longman. 10. Hornborg, A., McNeill J. R., &Martínez–Alier, J. (2007). *Rethinking Environmental History*. Altamira Press. 11. Hughes, J. D. (2001). *An Environmental History of the World*. Routledge. 12. Khaldun, I. (1967). *The Muqaddimah: An Introduction to History.* Princeton University Press. 13. Marks, R. (2002). *The Origins of the Modern World*. Rowman& Littlefield Publishers. 14. Marsh, G. P. (1864). *Man and Nature*. Cambridge. Scribner.	

	15. McNeill, J. R. (2003). Observations on the Nature and Culture of Environmental History, *History and Theory*, *42*(4), 5–43. 16. McNeill, J. R., &Engelke, P. (2015). *An Environmental History of the Anthropocene since 1945*. Belknap Press. 17. McNeill, W. H. (1980). *The Human Condition: An Ecological and Historical View*. Princeton University Press. 18. Ponting, C. (1991). *A Green History of the World*. Sinclair-Stevenson. 19. Radkau, J. (2008). *Nature and power: a global history of the environment*. Cambridge University Press. 20. Richards, J. F. (2014). *The world hunt: an environmental history of the commodification of animals*. University of California Press. 21. Simmons, I. G. (2008). *Global Environmental History 10,000 BC to AD 2000*. Edinburgh University Press. 22. Tucker, R., & Russell, E. (2004). *Natural Enemy, Natural Ally*. Oregon State University Press.	
Learning Outcomes	1. Understand the historical relationship between humans and the environment. 2. Recognise the ways in which humans modified and adapted nature. 3. Analyse the nature of environmental change that world has gone through historically and how they have impacted nations and different segments of society. 4. An ethic which applies to the whole of nature, including humans.	

(Back to Index) **(Back to Agenda)**

Title of the Course: Environment and Literature
Course Code: ESO-417 **Number of Credits:** 02
Total Contact Hours: 24 **Effective from AY:** 2022-23

Prerequisites for the course:	Bachelor's degree in any discipline	
Objectives:	4. To highlight the symbiotic relationship between environment and literature beginning from the Vedic times. 5. To focus on the preoccupation of modern writers with issues related to environmental degradation, consumerist culture etc. 6. To encourage the students to adopt an interdisciplinary perspective while dealing with the large spectrum of issues pertaining to environment and literature. 7. To drive home the idea that questions related to aesthetics cannot be divorced from ethics.	
Content:	**Module 1:Introduction** Tracing the Trajectory of Environmental Concerns in Indian & Western Literature: Moments & Movements **Module 2:Paradigms & Categories** Romanticism Martin Heidegger on Technology Ecocriticism Ecofeminism Environmental Humanities Externality Deep Ecology **Module 3:Indian Perspective** *The Upheaval* by PundalikNaik (Novel) **Module 4:Western Perspective** *The Road* by Cormac McCarthy (Novel)	04 hours 08 hours 06 hours 06 hours
Pedagogy:	Lectures/tutorials/assignments/seminars.	
References/ Readings:	1. Bellamy P. 2007. *Dictionary of Environment*, New Delhi, Academic (India) Publishers. 3rd Edition. 2. Blanning, Timothy.2010. *The Romantic Revolution*, London, George Weidenfield& Nicholson Publishers. *3.* Broswimmer, Franz. 2002. *Ecocide: A Short History of Mass Extinction of Species* Pluto Press Publishers. 4. Buell, Lawrence.1998. *The Environmental Imagination: Thoreau, Nature Writing, and the Formation of American Culture* Cambridge: Harvard University Press. 5. Garrard, Greg.2004. *Ecocriticism: The New Critical Idiom* Oxford, Blackwell. 6. McCarthy, Cormac. 2006. *The Road*, London, Pan	

	Macmillan. 7. Vacoch, Douglas A & Mickey, Sam.ed.2018. *Literature and Ecofeminism: Intersectional and International Voices*, London, Taylor & Francis. 8. Naik, Pundalik N. *The Upheaval*. 2002.Translated by VidyaPai, New Delhi,Oxford University Press.	
Learning Outcomes	5. Understand the relationship between literature and environment. 6. Appreciate and recognise the aesthetic as well as the ethical dimensions of literature. 7. Make an independent analysis of literary texts in the context of issues related to environment.	

Title of the Course:Gender Sensitivity and Equity

Course Code: ESO-418 **Number of Credits:** 02

Total Contact Hours: 24 **Effective from AY:** 2022-23

Prerequisites for the course:	Student should be registered with Goa University Post Graduate Programme	
Objective:	This course aims to develop the basic understanding of gender related issues in the society among students with multidisciplinary approach.	
Content:	**Module 1: Introduction** The universal commitment to Gender Equality and Social Equity – SDGs, Provisions in the Indian Constitution, Towards Equality Report and the creation of the discipline of Women's Studies in India. Sex and Gender: Non-duality of these terms. Nature vs Nurture debate, socialisation, stereotyping. **Module 2: Social Equity** Power, Intersectionality. Marginalised sections based on caste, class, abilities, religion etc. Women's rights as human rights. Women's issues in Goa. **Module 3: Introduction to Laws** Sexual Harassment at Work Place (Protection, Prohibition, and Redressal Act of 2013) and Protection of Women from Domestic Violence Act of 2005. Forms of violence against women: a review.	08 hours 08 hours 08 hours
Pedagogy:	This course will be taught through workshops/ lectures/ group discussions/assignment/quiz games/ tutorials/ assignments/ films/ documentaries/ group	
References/Readings	1. Government of India. 2005. DV Act 2005 http://ncw.nic.in/acts/TheProtectionofWomenfromDomesticViolence Act2005.pdf 2. Government of India, 2013, Sexual Harassment of Women at the Workplace (Prevention, Prohibition and Redressal) Act of 2013.http://www.iitbbs.ac.in/notice/sexual-harrassment-ofwomen-act-and-rules-2013.pdf 3. Pilcher Jane and Imelda Whelehan. 2005. 50 Key Concepts	

	in Gender Studies. New Delhi: Sage Publications. 4. UNDP. 2014. Women's Rights are Human Rights. file:///C:/Users/admin/Desktop/WomenRightsAreHR.pdf	
Learning Outcomes	1. Students will be enabled to develop the sensitive approach towards gender issues. 2. Students will have an understanding of equity, its importance in our society.	

(Back to Index) **(Back to Agenda)**