NEP SYLLABUS FOR FOUR YEARS UNDER-GRADUATE COURSE IN ENVIRONMENTAL SCIENCE
(w.e.f. 2023-2024)

BANKURA UNIVERSITY
BANKURA
WEST BENGAL
PIN722155

Curriculum and Credit Framework for Undergraduate Program (CCFUP), as per NEP-2020 w.e.f. 2023-24

Objectives of the programme: -

The prime objective of the programme is:-

1. To reach the unreached and help to provide environmental education at the doorstep of the learners and according to their convenience.
2. To contribute to eco-sustainability and efficient use of natural resources through integrated nexus for the long-term benefit and welfare of society through quality education, innovative research, outreach and grass root activities and overall networking with the environment.
3. To attract young minds to choose a career in broad areas of Environmental Science and applications .
4. To fulfill the requirement of technical manpower in various sectors including academia-industry linkage and elsewhere.

PROGRAMME OUTCOME (PO):

PROGRAMME NAME	PROGRAMME OUTCOME (PO)
PO1	To Demonstrate rational understanding of rudimentary concepts, principles and processes underlying the academic field of Environmental Science with its various subfields like Ecology, Biodiversity, Earth Sciences, Pollution Control Technology, Environmental Physics and Chemistry, Environmental Health & Safety, Atmospheric Sciences, Environmental Laws, Environmental Impact Assessment, Environmental Biotechnology, Toxicology, Waste Treatment Techniques, Renewable and Non-Renewable Energy, Restoration, Environmental Economics, Environmental Statistics, Remote sensing and GIS, Climate Change and Sustainability, etc.
PO 2	To know about different types of professionals in the field of Environmental Science and related subfields.
PO 3	To address the environment related issues and challenges for the protection and conservation of available natural resources and environment.
PO 4	To identify, formulates, review research literature, and analyze current environment related problems. Use of laboratory and field techniques relevant to academia and industry, generic skills, and global competencies, including knowledge and skills that enable students to undertake further studies in the field of Environmental science.
PO 5	To create, select, and apply appropriate techniques, and to model environmental activities with an understanding of the limitations. Ability to use high end equipments for the analysis of environmental resources.
PO 6	To create, select, and apply appropriate techniques, and to model environmental activities with an understanding of the limitations. Ability to use high end equipments for the analysis of environmental resources.
PO 7	To identify and appreciate the importance of the Environmental Science and its application in academic, industrial, economic, and social context.
PO 8	To undertake research and on field activities which develop problem solving abilities required for successful career in Environmental Science. Impart Communication Skills; Ability to work effectively as individual or team; Ability to handle project and to manage finance related issues.

PROGRAMME SPECIFIC OUTCOME (PSO):

PROGRAMME NAME	PSO
PSO1	The course provides wide range of knowledge on various aspects of different spheres of the environment viz. atmosphere, hydrosphere, lithosphere and biosphere and generate awareness on Environmental Pollution along with their inter linkages to human health, Climatic Change.
PSO2	The course conveys education among students on Environmental Impact Assessment study of various environmental components, environmental laws, their affectivity and their long term outcome from environmental point of view.
PSO3	The course provides knowledge on concepts, tools and modern techniques and instruments for analysis of various components of eco-environment and their management. Also enable to tackle various environmental challenges in friendly and sustainable manner and educate students on Natural Resource Management for Sustainable Development.
PSO4	The course includes training for capacity building, to offer professional and job-oriented course curricula, to strengthen R & D activities and extension activities.

SEMESTER–III

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
S/ENV/301/MJC-3	Water and Water Resources Water and Water Resources (Practical)	4	10	25 15	50	3	NA	2
S/ENV/302/MJC-4	Land and Soil Conservation and Management Land and Soil Conservation and Management (Practical)	4	10	25 15	50	3	NA	2
S/ENV/303/MN-3	Water and Water Resource Water and Water Resources (Practical)	4	10	25 15	50	3	NA	2
S/ENV/304/MD-3	Gender and Environment	3	10	40	50	2	NA	2
S/ENV/305/SEC-3	Soil Conservation Management and Ecotourism. Soil Conservation Management and Ecotourism (Practical)	3	10	25 15	50	2	NA	2
ACSHP/306/AEC-3	MIL -2 Bengali, Sanskrit, Santali	2	10	40	50	2	NA	NA
Total in Semester - III		**20**	**60**	**240**	**300**	**15**		**14**

N.B. MI – Minor Paper; MD – Multidisciplinary Paper; Theory: - 1 Credit= 1 hour/Week, Practical: - 1 Credit = 2 hours/Week, Tutorial: - 1 Credit= 1hour/Week

SEMESTER–IV

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
S/ENV/401/MJC-5	Ecology and Ecosystem Ecology and Ecosystem (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/402/MJC-6	Environmental Biotechnology Environmental Biotechnology(Practical)	4	10	25 15	50	3	NA	 2
S/ENV/403/MJC-7	Atmosphere and Global Climate Change Atmosphere and Global Climate Change (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/404/MJC-8	Systematics and Biogeography Systematics and Biogeography (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/405/MN-4	Ecology and Ecosystem Ecology and Ecosystem (Practical)	4	10	25 15	50	3	NA	 2
ACSHP/406/AEC-4	AEC-4 Compulsory English: Literature Language and Communication	2	10	40	50	2	NA	NA
Total in Semester - IV		**22**	**60**	**240**	**300**	**17**		**10**
TOTAL in SECOND YEAR		**42**	**120**	**480**	**600**			

N.B:- MJC-Major Paper, MI – Minor Paper; ML– Multidisciplinary Paper; Theory: 1 Credit = 1 hour/Week, Practical:- 1Credit = 2 hours/Week, Tutorial:- 1 Credit = 1 hour/Week.
* Diploma in Physiology will be awarded to a student if he or she completes Summer Internship of 4 credits at least 1 in 2 years in addition to total 82 credits in Semester.

SEMESTER –III

Major T- 3
WATER AND WATER RESOURCES
(S/ENV/301/MJC-3)

Total credit- 04

COURSE OUTCOME (CO)

1. Students will grasp the fundamental concepts of the hydrological cycle, including precipitation, evaporation, condensation, and the movement of water through different reservoirs.
2. Students will learn about the strategies and practices involved in managing water resources, including water conservation, allocation, and sustainable usage.
3. Students will be able to identify and analyze key global and local issues related to water resources, such as water scarcity, pollution, climate change, and the socio-economic impacts of water management.

Theory (50 Lectures) Marks-25

Unit1: Introduction (04 Lectures)
Sources and types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapotranspiration; classification of water resources (oceans, rivers, lakes and wetlands). Lentic and Lotic water.

Unit 2: Properties of water (08 Lectures)
Physical: temperature, colour, odour, total dissolved solids and total suspended solids; Chemical: major inorganic and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity,pH, electrical conductivity, sodium adsorption ratio; Biological: phytoplankton, benthos, zooplankton, micro and macro- invertebrates.

Unit 3: Surface and subsurface water (8 Lectures)
Introduction to surface and ground water; surface and ground water pollution; water table; vertical distribution of ground water; formation,types and properties of aquifers;artificial techniques for ground water recharge; river structure and patterns; importance of watershed and watershed management; rain water harvesting in urban settings.

Unit 4: Wetlands and their management (06 Lectures)
Definition of a wetland; types of wetlands (fresh water, tidal, estuarine and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention, 1971 major wetlands of India. Ramsar sites of India.

Unit 5: Marine resource management (04 Lectures)
Marine resources; commercial use of marine resources; threats to marine ecosystems and resources; resource management of marine ecosystem (planning approach, construction techniques and monitoring of coastal zones). drinking water quality standards of India, latest water conservation initiatives in India, Amrit sarovar yojona.

Unit 6: Water resources in India (06 Lectures)
Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; role of state in water resources management.

Unit 7: Water resources conflicts (08 Lectures)

Water resources and sharing problems, case studies on Kaveri and Krishna river water disputes; Multi- purpose river valley projects in India and their environmental and social impacts; case studies of dams- Narmada and Tehri dam – social and ecological losses versus economic benefits; International conflicts on water sharing between India and her neighbours; agreements to resolve these conflicts.

Unit 8: Major laws and treaties (06 Lectures)

National water policy; water pollution (control and prevention) Act 1972; Indus water treaty; Ganges water treaty, Teesta water treaty; National River linking plan: ecological and economic impacts.

Major P-3
WATER AND WATER RESOURCES
(S/ENV/301/MJC-3)

Practical: Marks: 15

1. Estimation of Surface water parameters - DO, combined CO2, salinity. BOD.
2. Estimation of Ground water parameters- hardness, alkalinity, acidity, chloride.

Suggested Readings

1. Bansil, P.C. 2004. Water Management in India. Concept Publishing Company, India.
2. Brebbia, C.A. 2013. Water Resources Management VII. WIT Press.
3. CEA. 2011. Water Resources and Power Maps of India. Central Board of Irrigation & Power.
4. Grumbine, R.E. & Pandit, M.K. 2013. Threats from India's Himalaya dams. Science 339: 36-37.
5. Loucks, D.P., Stedinger, J.R. & Haith, D. A. 1981. Water Resource Systems Planning and Analysis. Englewood Cliffs, NJ, Prentice Hall.
6. Mays, L.W. 2006. Water Resources Sustainability. The McGraw-Hill Publications.
7. Schward & Zhang, 2003. Fundamentals of Groundwater. John Willey and Sons.
8. Souvorov, A.V. 1999. Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource Management. Elsevier Publications.
9. Vickers, A. 2001. Handbook of Water Use and Conservation. Water Plow Press.

SEMESTER –III

Major T- 4
LAND AND SOIL CONSERVATION AND MANAGEMENT
(S/ENV/302/MJC-4)

Total credit- 04

COURSE OUTCOME (CO)

1. Students will become familiar with the fundamental principles of land and soil conservation, including erosion control, soil degradation, and sustainable land management practices.
2. Students will develop practical skills in soil management techniques such as soil testing, soil amendment, and the use of cover crops and conservation tillage to enhance soil health and productivity.
3. Students will understand the causes and consequences of soil erosion and degradation. They will learn to identify signs of soil erosion, assess its impact, and implement strategies to mitigate and prevent it.

Theory (50 Lectures) Marks-25

Unit1: Introduction (05 Lectures)
Land as a resource, soil health; ecological and economic importance of soil; types of soil in India, soil profile, types and causes of soil degradation; impact of soil loss and soil degradation on agriculture and food security; need for soil conservation and restoration of soil fertility.

Unit 2: Fundamentals of soil science (10 Lectures)
Soil formation; soil weathering processes (physical, chemical and biological). Classification of soil; soil architecture; physical properties of soil; soil texture; soil erosion, soil water holding capacity; soil temperature; soil colloids; soil acidity and alkalinity; soil organic matter. Development of soil profile: Laterite and Pedzol.

Unit 3: Soil degradation and causes (10 Lectures)
Soil resistance and resilience; nature and types of soil erosion; non-erosive and erosive soil degradation; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, industrial and urban development, toxic organic chemicals, and organic contaminants in soils; recycling of soil nutrients.

Unit 4: Land use changes and land degradation (10 Lectures)
Land resources: types and evaluation; biological and physical phenomena in land degradation; visual indicators of land degradation; drivers of land degradation - deforestation, desertification; habitat loss, loss of biodiversity; land salinization; human impact.

Unit 5: Costs of land degradation (10 Lectures)
Economic valuation of land degradation; onsite and offsite costs of land degradation; loss of ecosystem services; effects on farming communities; effects on food security; effects on nutrient cycles; future effects of soil degradation; emerging threats of land degradation to developing countries.

Unit 6: Controlling land degradation (05 Lectures)
Sustainable land use planning; role of databases and data analysis in land use planning control and management; land tenure and land policy; legal, institutional and sociological factors; participatory land degradation assessment; integrating land degradation assessment into conservation.

Major P-4
WATER AND WATER RESOURCES
(S/ENV/302/MJC-4)

Practical: Marks: 15

1. Characterization of soil: Laterite, Pedzol— texture, bulk density, porosity
2. Determination of soil physical parameters—pH and colour, conductivity.

Suggested Readings

1. Brady, N.C. & Well, R.R. 2007.The Nature and Properties of Soils (13thedition A); Characterization of soil Laterite, Pedzol— Texture, Bulk density, Porosity), Pearson Education Inc.
2. Gadgil, M. 1993. Biodiversity and India's degraded lands. Ambio 22: 167-172.
3. Johnson, D.L. 2006. Land Degradation (2ndedition).Rowman&Little field Publishers.
4. Marsh, W. M. & Dozier, J. 1983. Landscape Planning: Environmental Applications. John Wiley

and Sons.
5. Oldeman, L. R. 1994. The global extent of soil degradation. Soil resilience and sustainable land use, 9. (http://library.wur.nl/isric/fulltext/isricu_i26803_001.pdf).
6. Pandit, M.K. et al., 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. Biodiversity Conservation 16:153-163.
7. Pandit, M.K. & Kumar, V. 2013. Land use and conservation challenges in Himalaya: Past, present and future. In: Sodhi, N.S., Gibson, L. & Raven, P.H. Conservation Biology: Voices from the Tropics. pp. 123-133. Wiley-Blackwell, Oxford, UK
8. Peterson, G. D., Cumming, G. S. & Carpenter, S. R. 2003. Scenario planning: a tool for conservation in an uncertain world. Conservation Biology 17:358-366.
9. Scherr, S. J. 1999. Soil degradation: A threat to developing-country food security by 2020 (Vol. 27). International Food Policy Research Institute.
10. Mahua Basu& S. Xavier: Fundamentals of Environmental Studies. Cambridge University press.
11. Chapman: Ecology. Cambridge University press.

SEMESTER –III

Minor T- III:
WATER AND WATER RESOURCES
(S/ENV/303/MN-3)

Total credit - 04

COURSE OUTCOME (CO)

1. Students will recognize the ethical and social dimensions of water resource management, including issues related to equity, access, and community involvement.
2. Students will understand the principles of water quality, including the identification and measurement of contaminants, water purification processes, and the impact of pollutants on ecosystems and human health.

Theory (50 Lectures) Marks-25

Unit1: Introduction (04 Lectures)
Sources and types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapotranspiration; classification of water resources (oceans, rivers, lakes and wetlands). Lentic and lotic water.

Unit 2: Properties of water (08 Lectures)
Physical: temperature, colour, odour, total dissolved solids and total suspended solids; Chemical: major inorganic and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity,PH electrical conductivity, sodium adsorption ratio; Biological: phytoplankton, benthos, zooplankton, micro and macro- invertebrates.

Unit 3: Surface and subsurface water (10Lectures)
Introduction to surface and ground water; surface and ground water pollution; water table; vertical distribution of ground water; formation, types and properties of aquifers; artificial techniques for ground water recharge; river structure and patterns; importance of watershed and watershed management; rain water harvesting in urban settings.

Unit 4: Wetlands and their management (06 Lectures)
Definition of a wetland; types of wetlands (fresh water tidal, estuarine and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar

Convention, 1971; major wetlands of India, Ramsar sites of India.

Unit 5: Marine resource management (06 Lectures)

Marine resources; commercial use of marine resources; threats to marine ecosystems and resources; resource management of marine ecosystem (planning approach, construction techniques and monitoring of coastal zones). Drinking water quality standards of India, latest water conservation initiatives in India, Amrit sarovar yojona.

Unit 6: Water resource in India (06 Lectures)

Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; role of state in water resources management.

Unit 7: Water resources conflicts (06 Lectures)

Water resources and sharing problems, case studies on Kaveri and Krishna river water disputes; Multi- purpose river valley projects in India and their environmental and social impacts; case studies of dams- Narmada and Tehri dam – social and ecological losses versus economic benefits; International conflicts on water sharing between India and her neighbors; agreements to resolve these conflicts.

Unit 8: Major laws and treaties (04 Lectures)

National water policy; water pollution (control and prevention) Act 1972; Indus water treaty; Ganges water treaty; Teesta water treaty; National River linking plan: ecological and economic impacts.

Minor P- III:
WATER AND WATER RESOURCES
(S/ENV/303/MN-3)

Practical: Marks: 15

1. Estimation of Surface water parameters - DO, combined CO2, salinity, BOD.
2. Estimation of Ground water parameters- hardness, alkalinity, acidity, chloride.

Suggested Readings

1. Bansil, P.C. 2004. Water Management in India. Concept Publishing Company, India.
2. Brebbia, C.A. 2013. Water Resources Management VII. WIT Press.
3. CEA. 2011. Water Resources and Power Maps of India. Central Board of Irrigation & Power.
4. Grumbine, R.E. & Pandit, M.K. 2013. Threats from India's Himalaya dams. Science 339: 36-37.
5. Loucks, D.P., Stedinger, J.R. & Haith, D. A. 1981. Water Resource Systems Planning and Analysis. Englewood Cliffs, NJ, Prentice Hall.
6. Mays, L.W. 2006. Water Resources Sustainability. The McGraw-Hill Publications.
7. Schward& Zhang, 2003. Fundamentals of Groundwater. John Willey and Sons.
8. Souvorov, A.V. 1999. Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource Management. Elsevier Publications.
9. Vickers, A. 2001. Handbook of Water Use and Conservation. Water Plow Press.

SEMESTER –III

MD T- III:
GENDER AND ENVIRONMENT
S/ENV/304/MD-3

Total Credits: 3

COURSE OUTCOME (CO)

1. Students will become familiar with key theoretical frameworks and concepts related to gender and the environment, such as ecofeminism, gender and sustainability, and environmental justice.
2. Awareness of Gendered Impacts of Environmental Change: Students will understand how environmental changes and policies differentially impact men, women, and non-binary individuals, including the roles they play in both causing and mitigating environmental issues.
3. Students will learn about gender-sensitive approaches to environmental management and policy, including strategies to ensure equitable participation and benefit-sharing in environmental initiatives.

Theory (40 Lectures) Marks- 40

Unit 1: Introduction (02 lectures)
The socially constructed 'gender'concept.

Unit 2: Gender and society (04 lectures)
Gender existence in society; gender: matriarchy and patriarchy (case studies in an Indian context); gender equity issues in rural and urban settings.

Unit 3: Gender and the environment (08 lectures)
Relevance of the concept in an environmental context; evolution of gender hierarchies in historical and contemporary perspective; gendered division of roles in cultural, social and economic perspective; gender inequalities.

Unit 4: Gender, resources and the environment (08 lectures)
Human –Environment relationship; Relationship between gender and environment, differential dependencies on environmental resources; implications of gendered responses to environmental degradation.

Unit 5: Gender and environmental management (08 lectures)
Women's participation in environmental movements and conservation; Role of women in environmental education, awareness and sustainable development. Case study of Chipko movement.

Unit 6: Strategies for change (10 lectures)
Need for gender equity; Instruments for change: education, media, action groups, policy and management; role of ICT in resource availability and consumption.

Suggested Readings

1.Agarwal, B. 1992. The Gender and Environment Debate: Lessons from India. Feminist Studies (Minnesota).
2. Agarwal, B. 1997. Gender, Environment and Poverty Interlinks: Regional Variations and Temporal Shifts in Rural India: 1971-1991. World Development 25: 1-42.
3. Agarwal, B. 2001. Participatory exclusions, community forestry, and gender: An analysis for

South Asia and a conceptual framework. World Development 29: 1623-1648.
4. Jackson, C.1993.Doingwhatcomesnaturally? Women and environment in development World Development 21: 1947-63.
5. Krishna, S. 2004. Livelihood and Gender. New Delhi, Sage.
6. Leach, M. 2007. Earth Mother myths and other ecofeminist fables: How a strategic notion rose and fell. Development and Change 38: 67-85.
7. Miller, B. 1993. Sex and Gender Hierarchies. Cambridge University Press.
8. Stein, R. (ed.). 2004. New Perspectives on Environmental Justice: Gender, Sexuality, and Activism. Rutgers University Press.
9. Steingraber, S. 1998. Living Downstream: A Scientist's Personal Investigation of Cancer and the Environment. New York: Vintage Books.
10. Zwarteveen, M.Z. 1995. Linking women to the main canal: Gender and irrigation management. Gatekeeper Series 54, IIED.

SEMESTER-III

SEC-T 3
SOIL CONSERVATION, MANAGEMENT AND ECOTOURISM
S/ENV/305/SEC-3

Total credit-03

COURSE OUTCOME (CO)

1. Students will be able to explain the importance of soil conservation and the factors affecting soil erosion.
2. They will understand the principles of ecotourism and its role in sustainable development
3. Students will design ecotourism initiatives that promote soil conservation and environmental stewardship.
4. They will assess the socio-economic and environmental impacts of ecotourism activities on local communities and ecosystems.

Theory (40 Lectures) Marks-25

Unit 1: Fundamentals of soil science (10 lectures)
Soil formation; classification of soil; soil architecture; physical properties of soil; soil texture; soil water holding capacity; soil temperature; soil colloids; soil acidity and alkalinity; soil organic matter. Development of soil profile: Laterite and Pedzol, need for soil conservation and restoration of soil fertility.

Unit 2: Soil degradation – causes (10 lectures)
Soil resistance and resilience; nature and types of soil erosion; non-erosive and erosive soil degradation; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, industrial and urban development.

Unit 3: Controlling land degradation (10 lectures)
Sustainable landuse planning; role of databases and data analysis in landuse planning control and management; land tenure and land policy; legal, institutional and sociological factors; participatory land degradation assessment; integrating land degradation assessment into conservation.

Unit 4: Ecotourism (10 lectures)
Elementary idea of Mass tourism and its Impact on environment and culture; Concept of Ecotourism, Guideline and policy (National and International) of ecotourism; Planning of

ecotourism; Ecotourism circuit development; Types of Alternative Tourism, Elementary idea of Rural truism, Adventure tourism; Development, economical benefits and impacts of Ecotourism; Management of ecotourism; Ecotourism potentiality in India - Case study (ecotourism in Kenya, India and Australia)

SEC-P 3
SOIL CONSERVATION, MANAGEMENT AND ECOTOURISM
S/ENV/305/SEC-3

Practical: Marks: 15

1. Characterization of soil: Laterite, Pedzol— texture, bulk density, porosity.
2. Determination of soil parameters—pH, colour, and conductivity.

Suggested Readings

1. Brady, N.C. & Well, R.R. 2007.The Nature and Properties of Soils (13th edition), Pearson Education Inc.
2. Gadgil, M. 1993. Biodiversity and India's degraded lands. Ambio22: 167-172. Bankura University B.Sc.(Programme)Environmental Science CBCS w.e.f. 2017-18.
3. Johnson, D.L. 2006. Land Degradation (2 nd edition). Rowman&Little field Publishers.
4. Marsh, W. M. & Dozier, J. 1983. Landscape Planning: Environmental Applications. John Wiley and Sons.
5. Oldeman, L. R. 1994. The global extent of soil degradation. Soil resilience and sustainable land use, 9. (http://library.wur.nl/isric/fulltext/isricu_i26803_001.pdf).
6. Pandit, M .K. et al., 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. Biodiversity Conservation 16: 153-163.
7. Pandit, M.K. & Kumar, V. 2013. Land use and conservation challenges in Himalaya: Past, present and future. In: Sodhi, N.S., Gibson, L. & Raven, P. H. Conservation Biology: Voices from the Tropics. pp. 123-133. Wiley-Blackwell, Oxford, UK.
8. Peterson, G. D., Cumming, G. S. & Carpenter, S. R. 2003. Scenario planning: a tool for conservation in an uncertain world. Conservation Biology 17: 358-366.
9. Scherr, S. J. 1999. Soil degradation: A threat to developing-country food security by 2020 (Vol. 27). International Food Policy Research Institute.

SEMESTER-IV

Major T-5
ECOLOGY AND ECOSYSTEM
(S/ENV/401/MJC-5)

Total credit- 04

COURSE OUTCOME (CO)

1. Students will gain a solid foundation in key ecological concepts such as energy flow, nutrient cycling, population dynamics, and community interactions.
2. Students will learn about the structure and functioning of various ecosystems, including the roles of producers, consumers, decomposers, and the impact of abiotic factors on ecosystem processes.

Theory (50 Lectures) Marks-25

Unit1: Introduction (05 Lectures)
Basic concepts and definitions: ecology, landscape, habitat, biosphere, ecosystems, autecology; synecology; major terrestrial biomes.

Unit 2: Ecology of individuals (8 Lectures)
Liebig's Law of the Minimum; Shelford's Law of Tolerance; ecotypes; ecoclines; acclimation; ecological niche; types of niche.

Unit 3: Ecology of populations (8 Lectures)
Concept of population; r- and K-selection; characteristics of population: density, dispersion, natality, mortality, life tables, survivorship curves, age structure; population growth: geometric, exponential, logistic, density dependent; limits to population growth.

Unit 4: Ecology of communities (8 Lectures)
Community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; species interactions: mutualism, symbiotic relationships, commensalism, amensalism, proto-cooperation, predation, competition, parasitism, mimicry, herbivore; ecological succession: primary and secondary successions types of successions, climax community concepts.

Unit 5: Ecosystem ecology (8 Lectures)
Types of ecosystem (Terrestrial and aquatic), ecosystem structure and function; abiotic and biotic components of ecosystem; primary and secondary production; ecosystem connections: food chain, food web; models of energy flow; ecological efficiencies; ecological pyramids: pyramids of number, biomass, and energy.

Unit 6: Biogeochemical cycles and nutrient cycling (08 Lectures)
Carbon cycle; nitrogen cycle; phosphorous cycle, hydrological cycle; nutrient cycle models; ecosystem input of nutrients; biotic accumulation; nutrient supply and uptake; role of mycorrhizae; decomposition and nutrient release; nutrient use efficiency; nutrient budget; nutrient conservation strategies.

Unit 7: Biological invasions (5 Lectures)
Concept of exotic and invasive; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities. .

Major P-5
ECOLOGY AND ECOSYSTEM
(S/ENV/401/MJC-5)

Practical: Marks: 15
1. Identification with reasons of the following:
a) Study of micro fauna of water viz., plankton(e.g., *Keratella, Cyclops, Cypris, Nauplius* larva, *Bosmina, Moina*).
b) Study of aquatic flora, e.g., *Spirogyra, Zygnema, Pistia, Eichhornia, Hydrilla, Ipomoea, Azolla, Lemna* (minor and major), *Marselea, Nymphae, Nelumbo*.
2. Study of life tables and plotting of survivorship curves of different types from the hypothetical /real data provided.

Suggested Readings

1. Groom. B. & Jenkins. M. 2000.Global Biodiversity: Earth's Living Resources in the21stCentury. World Conservation Press, Cambridge, UK.
2. Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2002. The Ecology of Plants. Sinauer associates incorporated.
3. Loreau, M.& Inchausti,P.2002.Biodiversity and Ecosystem functioning: Synthesis and Perspectives. Oxford University Press, Oxford, UK.
4. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders.
5. Pandit, M.K., White, S.M.& Pocock, M.J.O. 2014. The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis. New Phytologist 203:697-703.
6. Pimentel, D. (Ed.). 2011. Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species. CRC Press.
7. Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications.
8. Wilson, E. O. 1985. The Biological Diversity Crisis. Bio Science 35:700-706.

SEMESTER-IV

Major T- 6
ENVIRONMENTAL BIOTECHNOLOGY
(S/ENV/402/MJC-6)

Total credit- 04

COURSE OUTCOME (CO)

1. Students will understand the role of microorganisms in bioremediation processes, including the mechanisms by which microbes degrade or detoxify pollutants and the design of microbial treatments for contaminated environments.
2. Students will explore the use of plants for environmental cleanup, including the mechanisms of phytoremediation, the selection of appropriate plant species, and the design of phytoremediation systems.
3. Students will learn about biotechnological approaches to waste management, including the treatment of solid waste, liquid waste, and hazardous waste using biological methods.

Theory (50 Lectures) Marks-25

Unit 1: Cell and Cellular Organelles (10 Lectures)
Cell, types of cell, cell cycle, Genetic material of prokaryotes, eukaryotes and organelles(mitochondria and chloroplast); Chromosomal organization (euchromatin, heterochromatin-constitutive and facultative heterochromatin).

Unit 2: The Structure and Function of DNA, RNA and Protein (15 Lectures)
DNA: structural forms and their characteristics (B, A, Z); RNA: structural forms and their characteristics (rRNA, mRNA, tRNA), types of amino acids; post- translational modifications and their significance; synthesis; types and their role: structural, functional (enzymes). Central dogma of biology, Fundamentals of Recombinant DNA Technology.

Unit 3: Ecological restoration and bioremediation (15 Lectures)
Wastewater treatment: Primary, Secondary and Tertiary; solid waste treatment: sources and management (vermiculture and methane production, landfill. hazardous waste treatment); specific

bioremediation technologies: land farming, biopiles, composting, bioventing.

Unit 4: Ecologically safe products and processes (10 Lectures)
PGPR bacteria: biofertilizers, microbial insecticides and pesticides, bio-control of plant pathogen, Integrated pest management; development of stress tolerant plants, biofuel.

Major P- 6
ENVIRONMENTAL BIOTECHNOLOGY
(S/ENV/402/MJC-6)

Practical: Marks: 15 Credit: 02

1. Cytological preparation and Identification of Mitosis of *Alium* sp and Meiotic stages from Onion root tips (*Allium* sp)
2. Estimate ABO blood grouping.

Suggested Readings

1. Evans, G.G. & Furlong, J. 2010. Environmental Biotechnology: Theory and Application (2nd edition). Wiley-Blackwell Publications.
2. Jordening, H.J. & Winter J. 2005. Environmental Biotechnology: Concepts and Applications. John Wiley & Sons.
3. Lodish, H.F., Baltimore, D., Berk, A. Zipursky, S.L. Matsudiara, P. & Darnell, J.1995. Molecular Cell Biology. W.H. Freeman.
4. Nelson, D.L. & Cox, M.M. 2013. Lehninger's Principles of Biochemistry. W.H. Freeman.
5. Rittman, B.E. & McCarty, P.L. 2001. Environmental Biotechnology. Principles and Applications. L. McGraw-Hill, New York.
6. Scagg, A.H. 2005. Environmental Biotechnology. Oxford University Press.
7. Snustad, D.P. & Simmons, M.J. 2011. Principles of Genetics (6th edition). John Wiley & Sons.
8. Wainwright, M. 1999. An Introduction to Environmental Biotechnology. Springer.
9. B.C. Bhattacharyya & Rintu Banerjee: Environmental Biotechnology. Oxford University Press.

SEMESTER-IV

Major T- 7
ATMOSPHERE AND GLOBAL CLIMATE CHANGE
(S/ENV/403/MJC-7)

Total credit- 04

COURSE OUTCOME (CO)

1. Students will gain a solid foundation in the principles of atmospheric science, including the composition, Structure, and dynamics of the Earth's atmosphere.
2. Students will learn about climate systems and processes, including how atmospheric components interact with the Earth's surface, oceans, and biosphere to influence climate patterns.
3. Students will understand the mechanisms of climate change, including the role of greenhouse gases, aerosols, and natural climate variability in driving changes in global and regional climates.

Theory (50 Lectures) Marks-25

Unit1: Introduction (04 Lectures)
Evolution and development of Earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the Earth, Milankovitch cycles.

Unit 2: Global energy balance (04 Lectures)
Earth's energy balance; energy transfers in atmosphere; Earth's radiation budget; green house gases(GHGs); greenhouse effect; global conveyor belt.

Unit 3: Atmospheric circulation (10 Lectures)
Movement of air masses; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; El Nino and La Nina; tropical cyclone; Indian monsoon and its development.

Unit 4: Meteorology and atmospheric stability (08 Lectures)
Meteorological parameters (temperature, relative humidity, wind speed and direction, precipitation); atmospheric stability and mixing heights; temperature inversion; plume behavior; Gaussian plume model.

Unit 5: Atmospheric chemistry (06 Lectures)
Chemistry of atmospheric particles and gases; smog –types and processes; photochemical processes; ions and radicals in atmosphere; acid-base reactions in atmosphere; atmospheric water; role of hydroxyl and hydroperoxyl radicals in atmosphere.

Unit 6: Global warming and climate change (6 Lectures)
Earth's climate through ages; trends of global warming and climate change; drivers of global warming and the potential of different green house gases (GHGs) causing the climate change; atmospheric windows; impact of climate change on atmosphere, weather patterns, sea level rise.

Unit 7: Ozone layer depletion (8 Lectures)
Ozone layer or ozone shield; importance of ozone layer; ozone layer depletion and causes; Chapman cycle; process of spring time ozone depletion over Antarctica; ozone depleting substances (ODS); effects of ozone depletion; mitigation measures and international protocols.

Unit 8: Climate change and policy (04 Lectures)
Environmental policy statement; International agreements; Montreal protocol 1987; Kyoto protocol 1997; Convention on Climate Change; carbon credit and carbon trading.

Major P- 7
ATMOSPHERE AND GLOBAL CLIMATE CHANGE
(S/ENV/403/MJC-7)

Practical: Marks: 15

Submit a Project or Review work or Term-paper on
1. Global warming. or
2. Ozone layer depletion or
3. Global environmental crisis or
4. Catastrophic changes.

Suggested Readings:

1. Barry, R. G. 2003. Atmosphere, Weather and Climate. Rout ledge Press, UK.
2. Lal D.S. 2006, Climatology, Sharda Pustak Bhawan, Allahabad.
3. Singh S. 2009, Climatology, PrayagPustak Bhawan, Allahabad .
4. Siddhartha K. 2005, Atmosphere, Weather and Climate, Kisalaya Publications Pvt. Ltd, New Delhi
5. Gillespie, A. 2006. Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries with Policy and Science Considerations. Martinus Nijhoff Publishers.
6. Hardy, J.T. 2003. Climate Change: Causes, Effects and Solutions. John Wiley & Sons.
7. Harvey, D. 2000. Climate and Global Climate Change. Prentice Hall.
8. Manahan, S.E. 2010. Environmental Chemistry. CRC Press, Taylor and Francis Group.
9. Maslin, M. 2014. Climate Change: A Very Short Introduction. Oxford Publications.
10. Mathez, E.A. 2009. Climate Change: The Science of Global Warming and our Energy Future. Columbia University Press.
11. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. & Sen, K. 2004. Climate Change and India. Universities Press, India.
12. Philander, S.G. 2012. Encyclopedia of Global Warming and Climate Change (2nd edition) Sage Publications.

SEMESTER-IV

Major T- 8
SYSTEMATICS AND BIOGEOGRAPHY
(S/ENV/404/MJC-8)

Total credit- 04

COURSE OUTCOME (CO)

1. Students will gain a thorough understanding of the principles and methods of taxonomy and systematics, including how organisms are classified and the criteria used to determine their relationships.
2. Students will understand the evolutionary processes that drive diversification and speciation, including natural selection, genetic drift, and gene flow.
3. Students will explore the distribution patterns of organisms across different geographic regions and the factors that influence these patterns, such as historical events, climate, and ecological interactions.

Theory (50 Lectures) Marks-25

Unit 1: Concept and systematic approaches (06 Lectures)
Definition of systematics; taxonomic identification; keys; field inventory; herbarium; museum; botanical gardens; taxonomic literature; nomenclature; evidence from anatomy, palynology, ultra structure, cytology, numerical and molecular methods; taxonomy databases.

Unit2: Taxonomic hierarchy (06 Lectures)
Concept of taxa (species, genus, family, order, class, phylum, kingdom); concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); categories and taxonomic hierarchy.

Unit 3: Nomenclature and systems of classification (06 Lectures)
Principles and rules (International Code of Botanical and Zoological Nomenclature); ranks and names; types and typification; author citation; principle of priority and its limitations; names of hybrids; classification systems of Bentham and Hooker; Angiosperm Phylogeny Group (APG III)

classification.

Unit 4: Numerical and molecular systematic (06 Lectures)
Characters; variations; Operational Taxonomic Units; character weighting and coding; phenograms; cladograms; DNA barcoding; phylogenetic tree; clades: monophyly, paraphyly, polyphyly; homology and analogy; parallelism and convergence.

Unit 5: Introduction to Biogeography (06 Lectures)
Genes as unit of evolutionary change; mutation; genetic drift; gene flow; natural selection; geographic and ecological variation; biogeographical rules – Gloger's rule, Bergmann's rule, Allen's rule, Geist rule; biogeographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species.

Unit 6: Speciation and extinction (06 Lectures)
Types and processes of speciation – allopatric, parapatric, sympatric; ecological diversification; adaptive radiation, convergent and parallel evolution; dispersal and immigration; extinction.

Unit 7: Historical Biogeography (06 Lectures)
Earth's history; paleo-records of diversity and diversification; continental drift and plate tectonics and their role in biogeographic patterns – past and present.

Unit 8: Ecological Biogeography (06 Lectures)
Species' habitats; environment and niche concepts; biotic and abiotic determinants of communities; species-area relationships; concept of rarity and commonness; Island Biogeography theory; Equilibrium theory of insular biogeography; geography of diversification and invasion; phylogeography.

Unit 9: Conservation Biogeography (02 Lectures)
Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning.

Major P- 8
SYSTEMATICS AND BIOGEOGRAPHY
(S/ENV/404/MJC-8)

Practical: Marks: 15

1. Analysis of OTU.
2. Listing the procedure of Typification.
3. Preparation of Phylogenetic tree from hypothetical data.

Suggested Readings

1. Lomolino, M.V., Riddle, B.R., Whittaker, R.J. & Brown, J.H. 2010. Biogeography (4th edition). Sinauer Associates, Sunderland.
2. Mani, M.S. 1974. Ecology and Biogeography in India. Dr. W Junk Publishers. The Hague.
3. Singh, G. 2012. Plant Systematics: Theory and Practice (3rdedition). Oxford & IBH Pvt. Ltd., New Delhi.
4. Wheeler, Q.D. & Meier R. 2000. Species Concepts and Phylogenetic Theory: A Debate. Columbia University Press, New York.

5. Williams, D. M., Ebach, M.C. 2008. Foundations of Systematics and Biogeography. Springer.
6. Wilkins, J. S. 2009. Species: A History of the Idea (Vol. 1). University of California Press.

SEMESTER-IV

MN-T 4
ECOLOGY AND ECOSYSTEM
(S/ENV/405/MN-4)

Total credit 04

COURSE OUTCOME (CO)

1. Students will gain a comprehensive understanding of ecological principles, ecosystem dynamics, and the relationships between organisms and their environments. Here are some common course outcomes for such a class.
2. Students will assess the impacts of human activities on ecosystems, including habitat destruction, pollution, climate change, and invasive species, and explore strategies for mitigating these impacts.
3. Students will study different types of ecosystems, both global (e.g., tropical rainforests, deserts) and local (e.g., wetlands, grasslands), and understand their specific characteristics and ecological processes.

Theory (50 Lectures) Marks-25

Unit1: Introduction (06 Lectures)
Basic concepts and definitions: ecology, landscape, habitat, biosphere, ecosystems, autecology, synecology, major terrestrial biomes.

Unit 2: Ecology of individuals (06 Lectures)
Liebig's Law of the Minimum, Shelford's Law of Tolerance, ecotypes, ecoclines, acclimation, ecological niche, types of niche.

Unit 3: Ecology of populations (08 Lectures)
Concept of population; r- and K-selection; characteristics of population: density, dispersion, natality, mortality, life tables, survivorship curves, age structure, population growth: geometric, exponential, logistic; density dependent, limits to population growth.

Unit 4: Ecology of communities (10 Lectures)
Community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect, species interactions: mutualism, symbiotic relationships, commensalism, amensalism, proto-cooperation, predation, competition, parasitism, mimicry, herbivore; ecological succession: primary and secondary successions types of successions, climax community concepts.

Unit 5: Ecosystem ecology (8 Lectures)
Types of ecosystem: forest, grassland, lotic, marine, ecosystem structure and function; abiotic and biotic components of ecosystem; primary and secondary production; ecosystem connections: food chain, food web; models of energy flow; ecological efficiencies; ecological pyramids: pyramids of number, biomass, and energy.

Unit 6: Biogeochemical cycles and nutrient cycling (06 Lectures)
Carbon cycle; nitrogen cycle; hydrological cycle; nutrient cycle models; ecosystem input of nutrients; biotic accumulation; nutrient supply and uptake; role of mycorrhizae; decomposition and nutrient release; nutrient use efficiency; nutrient budget; nutrient conservation strategies.

Unit 7: Biological invasions (06 Lectures)

Concept of exotic and invasive; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities. .

MN-P-4
ECOLOGY AND ECOSYSTEM
(S/ENV/405/MN-4)

Practical: Marks: 15

Identification with reasons of the following

1. Study of microfauna of water viz., plankton, (e.g., *Keratella, Cyclops, Cypris, Nauplius* larva, *Bosmina, Moina*).
2. Study of aquatic flora, e.g., *Spirogyra, Zygnema, Pistia, Eichhornia, Hydrilla, Ipomoea, Azolla, Lemna* (minor and major), *Marselea, Nymphae, Nelumbo*.
3. Study of life tables and plotting of survivorship curves of different types from the Hypothetical/real data provided.

Suggested Readings

1. Groom. B. & Jenkins. M. 2000. Global Biodiversity: Earth's Living Resources in the21stCentury. World Conservation Press, Cambridge, UK.
2. Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2002. The Ecology of Plants. Sinauer associates incorporated.
3. Loreau, M. & Inchausti,P.2002. Biodiversity and Ecosystem functioning: Synthesis and Perspectives. Oxford University Press, Oxford, UK.
4. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders.
5. Pandit, M.K., White, S.M. & Pocock, M.J.O. 2014. The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis. New Phytologist 203:697-703.
6. Pimentel, D. (Ed.). 2011. Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species. CRC Press.
7. Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications.
8. Wilson, E. O. 1985. The Biological Diversity Crisis. Bio Science 35:700-706.