DEPARTMENT & PROGRAM: *Department of Space Science*

COURSE CODE-COURSE NAME: Advanced Environmental Systems Analysis **Credit-Hours:** 3-0

COURSE DESCRIPTION:

This course will introduce you to the topic of Environmental Systems Analysis. It provides an introduction to systems analysis and process that are involved in Earth Atmosphere, focusing on overview to Global Climate impact assessment studies with the help of different hydro climatic models used in environmental sciences. *Global environmental change* (or global change) entails the systemic and cumulative consequences of humans and their activities on the atmospheric system. The effects of greenhouse gas emissions and the consequent climate change exemplify systemic global change. These more diffuse cumulative global changes are other widespread problems, such as climate change induced health problems like waterborne issue, groundwater depletion, deforestation, and species extinction. In the course 'Environmental Systems Analysis' you will be introduced to many aspects of Environmental Systems from a multidisciplinary and interdisciplinary perspective. Physical, biological, social and economic issues will be discussed and the main topics of the weeks are: introduction, drivers, modeling and scenarios, impacts, assessments and policy options. Most lectures will focus on general themes that set the scene and are relevant globally.

In this course, we shall discuss

We describe here the topics with the key issues of each week. We expect you to reproduce these key issues discussed in lectures and the literature and apply the newly acquired understanding on methodology to different examples of Environmental Systems Analysis using literature and examples across the globe.

- **Introduction to Environmental Systems Analysis**

The definition of Environmental Systems Analysis and other important definitions are discussed. Furthermore, a conceptual framework of environmental change that will be used throughout the course will be presented. This conceptual framework helps to understand what environmental change entails. The causes, impacts, processes, interactions (e.g. feedbacks) and solutions of environmental change are introduced, together with a discussion on scaling issues. This introduction will set the scene.

- **Modeling and scenarios of Systems Analysis**

Environmental systems analysis started centuries ago but only now has become apparent and will surely intensify in the future. To understand the underlying process and their complex interactions, and to be able to determine future trends, models are essential tools. One of the applications is the quantification of future scenarios. Climate models data downscaling its error removal will also be discussed in detail. Also uncertainties in modeling and scenario analysis are discussed.

- **Impacts of Climate Change dynamics**

Climate changes causes large problems, such as biodiversity loss. Changes in the atmosphere, land, water, biodiversity and chemicals and waste impact on water, ecosystems, agriculture, food and human health. These impacts will be presented and discussed. Also the use of models and multiple scenarios to study impacts in the future will be presented. Moreover, integrative concepts, such as vulnerability and resilience, and how these can be quantified will be discussed. Finally, reducing vulnerabilities by adaptation policies will be introduced.

PRE-REQUISITE: *Introduction to Environmental Sciences*

CO-REQUISITE: *Fundamentals of Environmental Systems*

TEXT AND MATERIALS:

Textbook

- *The Climate Modelling Primer (Fourth Edition) by Kendal McGuffie and Ann Henderson-Sellers*
- *Thermodynamics Foundations of the Earth System by Axel Kleidon*
- *Global Change and the Earth System (A Planet Under Pressure) by Steffen*
- *Distributed Hydrological Modeling using GIS (Second Edition) by Baxter E. Vieux*
- *Hydrological Modelling and The Water Cycle: Coupling the Atmospheric and Hydrological Models*

References Tutorials / Material

- Steffen et al (2007) http://dx.doi.org/10.1579/00447447(2007)36[614:TAAHNO]2.0.CO;2
- http://www.unep.org/geo/pdfs/geo5/GEO5_report_C1.pdf
- Nordhaus (1993) http://dx.doi.org/10.1016/0928-7655(93)90017-O
- Dahan (2010) http://dx.doi.org/10.1016/j.shpsb.2010.08.002
- O'Neill et al (2012) http://dx.doi.org/10.1016/S0140-6736(12)60958-1
- Van Vuuren et al (2012) http://dx.doi.org/10.1016/j.gloenvcha.2012.06.001
- http://www.nap.edu/napcgi/report.cgi?record_id=11868&type=pdfxsum
- http://earthobservatory.nasa.gov/Features/CarbonCycle/
- http://www.eoearth.org/article/biodiversity
- http://gbo3.cbd.int/

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course contributes towards achievement of following program outcomes at the completion of the course:

PLO-01 Students will demonstrate knowledge of domains of space science and be able to apply this knowledge to analyze a variety of scientific problems.

PLO-02 Students will be able to acquire, analyze and interpret data as well as synthesize Information to derive Valid conclusions.

PLO-03 Students will be able to identify, formulate, research literature, and investigate scientific problems

COURSE LEARNING OUTCOMES (CLOs):

Upon successful completion of the course:

CLO-01 The students will be able to apply basic knowledge of Earth Systems Dynamics tools for the solution of real world problems related to Climate Change, Climate models, and downscaling.

CLO-02 The students will be able to critically analyze and evaluate different methodologies and scenarios for

The development of Climate Change scenarios.

CLO-03 The students will be able to formulate various research problems in Earth systems dynamics and climate impact studies.

MAPPING BETWEEN PLO VS CLO:

PLO No. / CLO No.	1	2
1	x	
2		x
3		x

LECTURE PLAN:

Exercises/Tutorial *35%*
Discussion *35%*
Instruction *30%*

Module	Topic	Reference	Week/ Lecture
I	Introduction to Environmental Systems 1. Water Cycle 2. Global Warming 3. Climate Change Profile of Pakistan 4. Climate Change impact on Agriculture 5. Climate Change and Disasters 6. Disaster Risk Reduction 7. Disaster Risk Management	*The Climate Modelling Primer (Fourth Edition) by Kendal McGuffie and Ann Henderson-Sellers*	3-4

II	**Climate Change and Scenario Analysis** 1. Importance of Transboundry water issues 2. Benefits of Sharing concept over Transboundry water issues 3. Integrated Assessments of adaptation and mitigation (trade-offs and costs) 4. Difference between Predictions, Projections and Scenarios 5. IPCC Scenarios and SRES Scenarios 6. Detail about RCP(Representative Concentration Pathways) 7. Shared Socioeconomic Pathways (SSPs)	*The Climate Modelling Primer (Fourth Edition) by Kendal McGuffie and Ann Henderson-Sellers* *Global Change and the Earth System (A Planet Under Pressure) by Steffen*	4-7
III	**Models of Global Environmental Change** 1. Application, Strengths and weakness of Models 2. Differentiate different modelling approach ➢ Lumped / Distributed Models ➢ Integrated Assessment Models ➢ Climate Models 3. Solving Climate Change: Mitigation and Adaptation 4. Introduction to the outcomes of the IPCC and MEA assessment ➢ IPCC Assessment Reports ➢ MEA Assessment	*Distributed Hydrological Models using GIS by Baxter E. Vieux* *Hydrological Modelling and The Water Cycle: Coupling the Atmospheric and Hydrological Models*	7-10
IV	**Model Errors and Bias Corrections** 1. Importance of synthesizing global change 2. How to define uncertainties to policy makers 3. General Circulation Models and Regional Circulation	*Global Change and the Earth System (A Planet Under Pressure) by Steffen* *Methods of*	11-14

	Models differences 4. Climate Model Short-comings 5. Climate Model Downscaling 6. Statistical Downscaling 7. Bias Correction Methods 8. Class Project Discussions 9. Class Project Presentations	*Climate Data downscaling by Markku Rummukainen* *Thermodynamics Foundations of the Earth System by Axel Kleidon*	
	Final Assessment		

COURSE TARGETS:

Module No.	CLO No.	Teaching Methodology	Assessment Methodology	Learning Domain with Level
1	*CLO-01*	Instruction Discussion Problems	Quiz One Hour Test Final	C-2
2	*CLO-02*	Instruction Discussion Exercises	Quiz One Hour Test Final	C-3
3	*CLO-03*	Instruction Discussion Exercises	Quiz One Hour Test Final	C-4

ASSESMENT:

Quizzes	15%
Assignments	15%
Midterm Exam	25%
Project and Presentation	10%
Final Exam	35%
Total	100%

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