

Title of the course: **Water Resources Systems**

Course Instructor: Dr. Binaya Kumar Mishra

**Course description:**

Rapid population growth, changes in lifestyle, climate, landuse etc. have made sustainable management of water resources a very complex task. This course aims to provide a broad understanding of the hydrological processes, global environment changes and how they are related to sustainability of water resources systems. This course will introduce the characteristics of major components of water cycle; rainfall, groundwater flow, unsaturated zone flow, surface runoff, river flows and the role of remote sensing, GIS, statistical techniques, and simulation models in understanding and managing water resources systems. The course will also examine issues related to water resources and sustainability through case studies; (a) climate changes to water cycle and (b) optimal water resources allocation modeling.

**Learning Outcomes:**

The students will gain a comprehensive overview of water and its relation to human and environmental well-being. The students will be able to understand water related issues and tools to manage water-related problems.

**Topics covered**

Day 1: Introduction of water resources systems

*Elements of a water system, concept of a system (basin); water budget*

Day 2: Water resources sustainability

*Concept; challenges (urbanization, hydro-meteorological extremes; climate change)*

Day 3 & 4: Acquisition and processing of water resources data

*Precipitation, streamflow, stage-discharge relationship*

Day 5: Remote Sensing and GIS applications

*Sensors; image processing; online data sources; watershed delineation; use of ArcGIS software*

Day 6: Groundwater

*Aquifer properties; Groundwater movement; Darcy's law; well hydraulics*

Day 7: Unsaturated zone

*Soil root zone; unsaturated zone flow; infiltration process*

Day 8: Surface runoff

*Rainfall-runoff process; hydrograph; flow routing; use of hydrologic model*

Day 9: Statistical techniques

*Distribution functions, frequency analysis; Risk analysis*

Day 10: Climate change

*Global warming; Global climate model projection; downscaling*

Day 11: Written examination

Day 12: Field visit

*Fukuoyamasawa Experimental Watershed, Chiba prefecture*

Day 13: Climate change impact assessment on extremes (precipitation and flood) - Case study

Day 14: Sustainable water resources management strategies

*IWRM; rainfall harvesting; infiltration measures; economic analysis; optimization*

Day 15: Water resources optimization – Case study

*Water demand and supply; Use of WEAP software*

Day 16: Report/Presentation by students

**Assessment:**

Assessment will be based on class attendance, presentation and discussion, a short final test and extended essay with the following allocations;

- Attendance: 25 %
- Assignments: 25 %
- Written examination: 25%
- Final presentation: 25%

**Reading materials:**

- Applied Hydrology by Ven Te Chow, David R. Maidment, Larry W. Mays, McGraw-Hill Publishing Company; International edition (1988).
- IPCC AR5 WG 2 Summary report for policy makers, 2014
- IPCC: Climate Change: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (2014)
- Remote sensing and GIS for Water Resources Management, Version 2, IIT, Kharagpur (<http://nptel.ac.in/courses/105105110/pdf/m6l03.pdf>)
- Example of the use of CropWat 8.0
- (<http://www.fao.org/nr/water/docs/CROPWAT8.0Example.pdf>)
- FAO Irrigation and Drainage Paper No. 56, 1998. Crop Evapotranspiration – guidelines for computing crop water requirements
- Water Evaluation and Planning System (2012): A collection of stand-alone modules to aid in learning the WEAP software (<http://www.weap21.org/index.asp?action=213>)
- “Water Resources Engineering” by Larry W. Mays, John Wiley & Sons, 2nd Edition (2010)
- “Water Resource Systems Planning and Management” by Daniel P. Loucks & Eelco van Beek, UNESCO (2005)
- “Water resources systems analysis” by Mohammad Karamouz, Ferenc Szidarovszky, and Banafsheh Zahraie, Boca Raton, CRC press, (2003)
- World Water Assessment Programme (2009): The United Nations World Water Development Report 3. Water in a Changing World, UNESCO, Part 1 (Ch. 1, 3, 5), Part 2(Ch. 7, 8), Part 3(Ch. 10,11)