COURSE CURRICULUM

FOR

POST GRADUATE PROGRAMMES

UNDER

CENTRE FOR RIVER STUDIES
2017

सत्यधर्माय दृष्टये

आर्यभट्ट ज्ञान विश्वविद्यालय
ARYABHATTA KNOWLEDGE UNIVERSITY

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PATNA

Scope, Motivation and Rationale

Rivers, particularly large river systems, constitute one of the most fundamental life-support systems that have sustained civilisations; and are projected to be a critical determinant for the future sustenance of human civilisations. In a world that is expected to witness a near doubling of the human population by the middle of the century, and a world that is likely to be impacted by an unprecedented rate of global change, one of the main sustainability agendas will be the construction of dynamic strategies for the management of natural freshwater systems. For more than 5000 years, civilisations have flourished in the South Asian Region, leading up to a population hotspot that hosts almost a fifth of the globe's human population. In turn, this has led to significant human intervention and impacts on the freshwater systems of the region. Therefore, the understanding of water problems and water security in this region has to be embedded in holistic approaches that stress the inter–relationships of earth, water, and humans. As river systems constitute a lifeline for the future of human populations, it is important to understand the large river systems, with the aim of securing their futures and thereby our own futures. In India amongst other issues, surface runoff and stream flow and discharge patterns of both the Himalayan and the peninsular rivers need detailed rigorous scientific studies. Rigorous analysis of the discharge data of the past few decades of the river systems of our country are required to build reliable time series that can be used for an improved forecasting of the future discharge trends of these systems. Water pollution, ecological loss, and degradation of the health of a river system in all its forms, confers a universal burden on all river users, uses, and system processes. As such, there is a clear imperative to provide strategic sustainable river management options for rivers experiencing poor health.

The human relationship to any given river system is a key factor for ensuring healthier river futures, and the importance of place in designing rehabilitation initiatives cannot therefore be underestimated. In the past, humans have made interventions at different scales in river systems in order to use them. These interventions are largely through river engineering which is a discipline that stresses the utilitarian aspects of river systems rather than their evolutionary and their multi-disciplinary aspects. It is now increasingly being realised that river engineering should be practiced on a platform of *River Science*. River Science is an integrative multi-disciplinary subject that includes the study of interactions amongst hydrological, geological, chemical, and ecological processes; and their influence on the form and dynamics of river ecosystems (Figure 1). Also, river science 'includes the study of relationships between watersheds, riparian zones, floodplains, groundwater, headwaters and downstream rivers' (USGS, 2010).

Human disturbances of different types at different scales in river systems are a consequence of the perceived needs of human populations; however, these needs have to be in consonance with the needs of the river itself. For instance, the river requires its own space to perform such functions like flooding and floodplain development. Technological interventions should therefore be

Prof. Vikrant Jain	Prof. Ramakar Jha	Prof. Rajiv Sinha	Prof. S.K. Tandon
Mr. Anand Bijeta	Er. Rajeev Ranjan	Prof. (Dr.) Madan Koirala	Dr. Om Prakash

implemented on the basis of a sound understanding of river processes and their long-term implications on river health. One of the tenets of river science states that it is important to respect the inherent diversity, complexity, and variability of river systems. This however cannot be done in a reductionist discipline-specific mode.

In this complex environment, any institutional response needs to be welfare-driven but ecology-facing, multi-sectoral, integrative and evidence-based. As such, the private sector, stakeholders across civil society, and national river managers need to have access to a comprehensive evidence base, as well as have the opportunity to engage with, debate and discuss the implications of this information both nationally and trans-nationally. Through such stakeholder engagement, information support, and public wide debate, such program of teaching and research will provide the opportunity to allow the people of this country to consider the possible consequences of interventions on the health of the rivers in India and enhance the potential for cooperation in the management of the vital economic and ecological services the river provides. Unfortunately, there is a general lack of awareness of such issues in India, both at user/academic and policy makers' level. We need to expose both these communities to secure the health of our rivers.

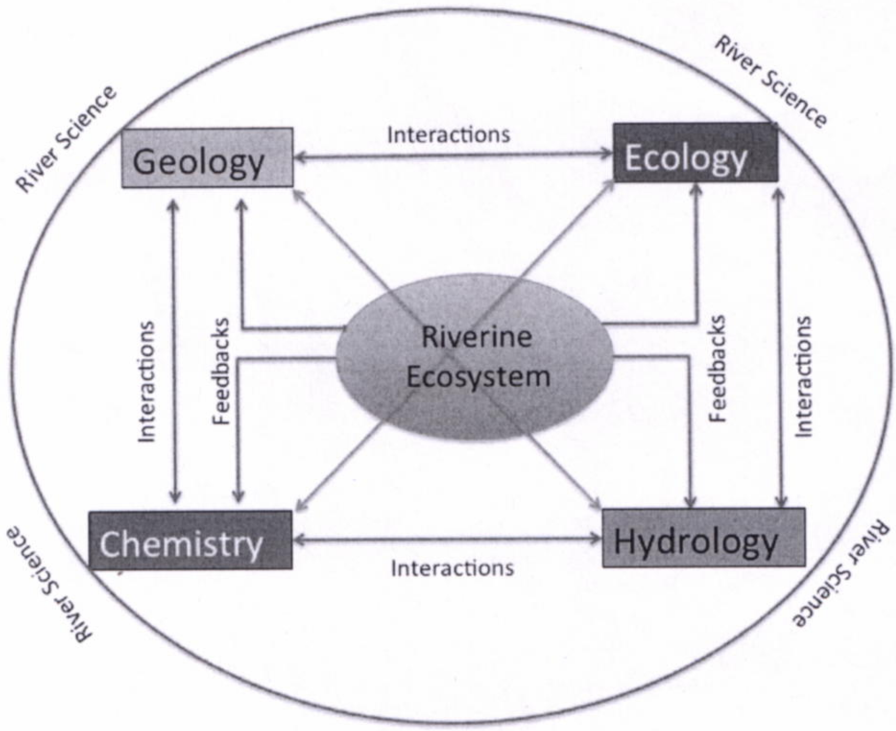

Figure 1: Conceptualisation of River Science (after Sinha et al., 2012)

Prof. Vikrant Jain	Prof. Ramakar Jha	Prof. Rajiv Sinha	Prof. S.K. Tandon
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The Aryabhatta Knowledge University at Patna has set up a **Center for River Studies** to address these issues and to prepare human resources to handle the problems related to rivers with a clear emphasis on community participation and extensive application of information technology. This document outlines the proposed structure of the academic programs envisaged under this center.

Academic Programs and Eligibility Criteria:

Master of Science (MSc) in River Science and Management (2 years)

The applicant must have a Bachelor's degree in Engineering (Civil/environmental/water resources), A Bachelor's degree in sciences and Allied Subjects, with not less than 60% marks for General Category and 55% for all reserved categories in the absolute system or equivalent CGPA.

Six months certificate programme in River Management

The applicant must have a Bachelor's degree in Engineering (Civil/environmental/water resources), A Bachelor's degree in sciences, social sciences (economics, sociology, political science, geography) and Allied subjects, with not less than 60% marks for General Category and 55% for all reserved categories in the absolute system or equivalent CGPA.

The University may relax the above eligibility criteria for working professionals in water sector with a minimum relevant experience of 2 years.

Doctor of Philosophy in River Science

M.Sc./M.Tech. or Equivalent Master degree in Allied subjects / appropriate discipline with not less than 55% aggregate marks for General category and 50% for all reserved categories in the absolute system or equivalent CGPA.

Prof. Vikrant Jain	Prof. Ramakar Jha	Prof. Rajiv Sinha	Prof. S.K. Tandon
Mr. Anand Bijeta	Er. Rajeev Ranjan	Prof. (Dr.) Madan Koirala	Dr. Om Prakash

Course Structure

MSc in River Science and Management (2 years)

Semester I (20 credits)	Semester II (23 credits)
1. Introduction to River Science (3-1-0-4) 2. Surface and Ground Water hydrology (3-0-3-4) 3. River ecosystem processes (3-1-0-4) 4. Remote Sensing and GIS applications in river studies (3-0-3-4) 5. Data analysis (3-0-4-5)	1. River engineering (3-0-3-4) 2. Essentials of River Management (3-1-0-4) 3. River geomorphology and sediment transport (3-0-3-4) 4. Ecosystem services and economic valuation (3-1-0-4) 5. Water policy, law and governance (3-1-0-4) 6. Field training* (2 credits)
Summer term: Thesis (5 credits) - Minimum of 8 weeks	
Semester III (21 credits) 1. Climate change and its impacts on river systems (3-1-0-4) 2. Elective 1 3. Elective 2 4. Elective 3 5. Seminar course (2 credits) 6. Thesis (3 credits)	Semester IV: Thesis (18 credits)

*To be conducted during winter vacation between Sem I and II

List of Electives

1. Environmental chemistry of river systems (3-0-3-4)
2. WQ assessment and monitoring (3-0-3-4)
3. River modeling (3-1-0-4)
4. Watershed management and sustainable agriculture (3-1-0-4)
5. River hazards (3-1-0-4)
6. EIA and ecological economics (3-1-0-4)
7. River Ecology (3-1-0-4)
8. Flood plain management (3-1-0-4)
9. Water security and IWRM (3-1-0-4)
10. Human dimension of river management (3-1-0-4)
11. Wireless sensor network (3-1-0-4)

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Six-month Certificate programme

(a) River Data analysis and methods (I Sem)

- Introduction to River Science (3-1-0-4
- Remote Sensing and GIS applications in river studies (3-0-3-4)
- Data analysis (3-0-4-5)
- Wireless sensor network
- Project (5 credits)

(b) Water quality (III sem)

- Introduction to River Science (3-1-0-4)
- Environmental chemistry of river systems (3-0-3-4)
- WQ assessment and monitoring (3-0-3-4)
- EIA and ecological economics (3-0-3-4)
- Project (5 credits)

(c) River governance and management (II Sem)

- Introduction to River Science (3-1-0-
- Essentials of River Management (3-1-0-4)
- Ecosystem services and economic evaluation (3-1-0-4)
- Water policy, law and governance (3-1-0-4)
- Project (5 credits)

(d) Integrated Water resource management (I and III sem)

- Introduction to River Science (3-1-0-4)
- Climate change and its impacts on river systems (3-1-0-4)
- Watershed management and sustainable agriculture (3-1-0-4)
- Water security and IWRM (3-1-0-4)
- Project (5 credits)

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Doctor of Philosophy in River Science

A minimum of six courses from list of compulsory courses and electives as above

Comprehensive examination

State of the Art Seminar

Detailed Course Content

Introduction to River Science (3-1-0-4)

This course will focus on the science of rivers particularly on the geomorphic processes in river systems and their relationship with river ecology. The course will aim to develop awareness about rivers and their sustainable management through process-based understanding.

Lecture topics: Introduction to River Science, spatial and temporal considerations; Fundamental Principles; River form and connectivity; Rivers as a geomorphic system: creating channel and channel network; River processes, channel form and geometry; River hydrology and sediment transport; River Ecology; River hazards – river dynamics bank erosion and floods; Geomorphological changes in river systems; Environmental flows, River health; Human impacts on river systems; Impact of climate change on rivers and role of glacial melt contribution; Rivers and human civilization, river-culture hypothesis, River futures; Case studies.

Surface and Ground Water hydrology (3-0-3-4)

This course has been designed as fundamental course on surface and groundwater hydrology both of which will eventually control river hydrology. All basic concepts of surface water flows and groundwater flows would be discussed and methods of their measurement will be taught.

Lecture topics: Introduction to Hydrologic Cycle and Processes, Hydro-meteorological parameters, analysis and interpretation of hydro-meteorological data; Surface runoff: factors affecting runoff, flow duration curve; Measurement of infiltration; Hydrograph and unit hydrograph theory; Floods and flood routing: Groundwater analysis: Formation of groundwater, occurrences and distribution, aquifer parameters, principles governing groundwater movement, well hydraulics, groundwater exploration; Advanced techniques for surface and ground water analysis.

River ecosystem processes (3-1-0-4)

This course will focus on the biodiversity and ecosystem processes of energy flow, nutrient dynamics and stream metabolism. The flow-ecology relationships and the contribution of the

Prof. Vikrant Jain	Prof. Ramakar Jha	Prof. Rajiv Sinha	Prof. S.K. Tandon
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catchment, particularly the floodplain in regulating stream ecology will be emphasised, along with their implications for river management.

Lecture topics: Introduction to River Ecosystem: Stream Environment; Flow & Substrate; Concepts – Connectivity, Patches; Spiraling; Biotic Communities; Primary Production: Phytoplankton and Benthic algae; Macrophytes; Detrital energy sources: POM & DOM; Trophic Interactions : Herbivory; Invertebrates, Hyporheic fauna; Fish; Birds and other Vertebrates; Secondary Production; Species Interactions – Competition, Predation; Nutrient dynamics: N; P; Transport and Spiraling: Factors; Nutrient Budgets; Stream metabolism: Autochthonous Production; Allochthonous Inputs; Processes; Floodplains (Riparia) and Stream Interaction; Riverscape and River basin.

Remote Sensing and GIS applications in river studies (3-0-3-4)

This course will focus on the fundamentals of remote sensing and GIS techniques with a focus on application for river studies. The course will cover the various digital image processing methods and case studies from different parts of the world will be discussed.

Lecture topics: Introduction to Remote sensing platforms and satellite remote sensing; Basic principles of image processing techniques: georectification, image enhancement, image classification methods; Fundamentals of GIS- vector and raster data, overlay operations, Analytical Hierarchical Process (AHP); Remote sensing of water bodies – spectral characteristics and interpretation; Catchment delineation using remotely sensed remote sensing data; Mapping geomorphology of rivers from space – methods and protocols, examples and case studies; Assessment of catchment hydrology (including rainfall) and river discharge from satellite based observation systems; Mapping river dynamics – principles and case studies; Flood hazard mapping and flood risk assessment aided by remote sensing (including use of microwave data), case studies; Water quality mapping using remote sensing data – modern developments and examples

Labs: Image processing; GIS database; Catchment delineation; Geomorphic mapping; Planform dynamics; Flood hazard mapping;

River geomorphology and sediment transport (3-1-0-4)

This course will focus on the appearance and behavior of river systems at different spatio-temporal scales. The first part of the course will be focused on the basin and reach scale appearance and processes i.e. drainage network and channel patterns. The second part of the course will provide details about site/local scale processes i.e. sediment transport and erosion processes. The course will provide an in-depth understanding of river appearance and behavior and its significance in stream management practices.

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Lecture topics: Introduction to geomorphic concepts: threshold, sensitivity, connectivity, hierarchy and complexity; River basin and drainage network, geomorphic indices and its applications; River fluxes, energy distribution and patterns of alluvial rivers, controls on channel patterns, significance of channel patterns in river health assessment; geomorphic classification schemes of rivers and their applications in stream management; River response to external controls specially to anthropogenic and climate change, Resilience and sensitivity of river system to external controls; Rivers at millennial time scale, river response to climate change and tectonics in past; Sediment transport – types of sediment load, sediment load and sediment yield; Bed load, its measurement and models to study bedload dynamics; Sediment source and catchment erosion processes; Geochemical proxies to study sediment dynamics; Erosion and External forcings i.e. climate, tectonics and anthropogenic forcings

River engineering (3-0-3-4)

This course will focus on the planned human intervention both structural as well as non structural measures in the course, characteristics, or flow of a river. The course also focuses on the various hydraulic structures, its design principles and its suitability and sustainability in a catchment system.

Lecture topics: Introduction to River Engineering; Design Principles - Bed regulation, Discharge control, Water level control, Water quality control; Design of Hydraulic Structures - Canal Head Works; River training works, Energy Dissipation Structures, Dams and Spillways, Cross Drainage Works, Weirs and Barrages, Turbines, valves & other turbo machinery; River engineering for different purposes - Flood control and drainage, Navigation, Hydropower, Water supply, Waste discharge, Crossings of other infrastructure, Soil conservation, Nature preservation and restoration; Multipurpose River Engineering Projects and design Considerations; Environmental Impact and Non Structural Solution -Cost benefit Analysis, PPP Model of Impact Assessment, Sustainability, Modern Techniques for River Engineering.

Climate Change and its impact on river systems (3-1-0-4)

This course will focus on the science of climate change and its impacts on rivers in particular and water resources in general. The course will cover the forcing functions of climate change operating at various spatio-temporal scales and their impacts.

Lecture topics: Introduction to climate science; Climate system and interactions; Earth's radiation budget, factors controlling heat receipt, climate system response, climate feedbacks; Water in climate system; Climate forcings, feedbacks and climate sensitivity; Carbon cycle and climate change; Energy-climate Nexus; Historical-scale climate change – concepts and fundamental principles; Observed variability and long term rainfall and temperature over India including extreme events; Hydrology of extremes and its impact; Proxy climate records of past millennium; Regional

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climate change scenarios; Climate change impacts on Rivers; downscaling of RCMs to river basin scale; prediction of hydrographs under climate change scenario; impact on river hydrology, sediment transport and morphodynamics, and nutrient transport; River – Cryosphere interactions; variability of glacier and snow cover and their downstream impacts on rivers including river infrastructure such as hydropower, dams and barrages.

Ecosystem services and economic valuation (3-1-0-4)

This course focuses on how the natural ecosystems contribute to the quality of life, health, prosperity and overall wellbeing of humans, and contributes to national economies. Various methods of valuing the benefits we derive from natural ecosystems are also discussed.

Lecture topics: Introduction to Ecosystem services (ES); Historical development of the Concept; The Millennium Ecosystem Assessment Approach; Recent Typologies of ES; Identification and Indicators of ES; Biodiversity-ES linkages; ES of different ecosystems –forests, agriculture, urban; ES of Lakes and Wetlands; ES of Rivers – Provisioning, Regulating, and Cultural; Economic Valuation – Introduction; Values: Use & Non Use; Direct and Indirect use; Bequest, Option, Existence Values; TEV; Methods: Revealed Preference-Market, Travel Cost, Hedonic Pricing; Methods: Stated Preference; Contingent Valuation (with questionnaire formulation); Benefit Transfer & Cost-benefit analysis; Case Studies.

Water policy, law and governance (3-1-0-4)

This course will focus on the historical development of water policy and law in India. The focus would be on the implication of these policies on river systems, livelihood and some of the hazards related to rivers.

Lecture topics: Water security: Definition, Freshwater Threats, regional, national and international water security regulations; Demand and Supply Estimates of Surface and Groundwater; Drinking Water and Sanitation in rural and urban areas; Magnitude and Challenges, Programs since Independence; India's Water Policy: Governing Laws-Water security laws; Basin action plan; Water Governance Reforms in India; Issues of Transboundary River; Environmental management of rivers Recycling and reuse of wastewater for river protection; Decentralised Wastewater Treatment: implications for river water quality; Protection of local water bodies and Revival of Rivers; River flood management policies; river zoning concept; Managing Urban floods; Legal Architecture of Water Governance; Water Regulators.

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Data Analysis (3-0-4-5)

This course is designed as a basic mathematics course and will mainly focus on the commonly used mathematical methods and statistics in river science. Emphasis will be given on the basic algebra and numerical methods.

Lecture topics: Probability and statistics; Data and errors, measures of central tendency and spread, correlation and regression, and probability distributions, examples of multivariate data analysis in river science. Time series analysis, ANOVA, ARMA, ARIMA, error estimation; sensitivity analysis; Differential equations; solution to ODEs and PDEs; Numerical methods for solution of PDEs; MATLAB applications.

Environmental chemistry of river systems (3-0-3-4)

This course is designed to expose the students to river water chemistry and its environmental implications. Fundamental chemical processes responsible for determining water quality of rivers will be discussed and applications of mathematical techniques for assessment of flows and nutrient transport.

Lecture topics: Introduction: Review of basic concepts in chemistry, Acid and base, polyprotic acids and bases, acidity, alkalinity, carbonate system, pH-CT, buffers, solubility reactions; Chemical analysis: Chemical thermodynamics, concept of chemical equilibrium, Equilibrium constants and activity, reaction kinetics; Advanced chemistry: Electrochemistry and electrochemical cells, nuclear chemistry, nitrogen chemistry; Introduction to environment transport process: Advection, Diffusion and Dispersion, Fick's law and its applications in natural systems.

Water Quality assessment and monitoring (3-0-3-4)

This course will focus on water quality standards of river water and tools and techniques of their assessment. All standard measurements of water quality measurements will be discussed and modeling techniques will be taught.

Lecture topics: Introduction to water quality; status of water quality of river in India, groundwater quality, factors affecting water quality, sources of pollution (point and non-point), sources of pollution; Water quality monitoring: physical, chemical and biological parameters, Standard methods for water quality measurement, selection of site for measurement, effect of water quality variables, accepted and desirable limits, CPCB guidelines; Water quality assessment: Assessment of different water quality variables and its impact, anthropogenic activities and its impact in water quality, impact of climate change in water quality, water quality assessment for drinking, irrigation and other purposes; Water quality processes: Self-purification, assimilation, dilution, diffusion, dispersion, reaction, and settling phenomena; Surface Water quality modelling: Oxygen-Sag Curve, BOD model, DO model, Reaeration model, waste load allocation model, nutrient models, and best

Prof. Vikrant Jain	Prof. Ramakar Jha	Prof. Rajiv Sinha	Prof. S.K. Tandon
Mr. Anand Bijeta	Er. Rajeev Ranjan	Prof. (Dr.) Madan Koirala	Dr. Om Prakash

management practices models; Remedial measures: removal of pathogens, chemicals and metal ions using different techniques, removal of Arsenic, Fluoride, nutrients and salinity from water.

River Modeling (3-1-0-4)

This course will focus on the equations governing the hydrodynamics of river flow and associated processes as a prerequisite for determining the flow behavior in rivers. The course also aims to introduce numerical methods often applied in modeling the hydrodynamics of river flow with software based application for predictive modeling of river flow behavior.

Lecture Topics: Introduction to Flow in Watersheds and Channels; Hydrodynamic Processes in Rivers - Causes of Flow and Transport, Impacts of River Flow on Water Quality, Sediment and Contaminants in Rivers, Watershed Modeling; Governing Equations of Flow in Rivers and Streams; Hydrologic Data; Deterministic Modeling of Flow in Channels - Geometric Representation, Governing Equations, Sources and Sinks, Initial and Boundary Condition, Simplification of Boundary Conditions, Applicability of Simplified Representations, Solution of St. Venant Equation; Numerical Modeling (Finite Difference Method); Flow Modeling Design using industry standard Software; Emerging Technologies for Flow Modeling.

Watershed management and sustainable agriculture (3-1-0-4)

This course will follow mainly soil erosion and how to control the soil erosion and management of agricultural resource towards sustainability.

Lecture Topics**:** Introduction to watershed management, Types of soil erosion, Estimation of soil erosion, Controlling soil erosion, Water harvesting; Watershed prioritization; Command area development; Need for sustainable agriculture; Diverse aspects of agriculture and agricultural sustainability; Resources and conditions required by agriculture; Intended and unintended consequences of agricultural resources on environment; Management of agricultural resources towards sustainability; Best Management Practice; Conjunctive use; Irrigation efficiency; watershed management for possible climate change impact on agriculture practice.

River Hazards (3-1-0-4)

This course will provide exposure to different kinds of river hazards, its causes and management strategies. It will include case studies from Indian river basins. The course will also relate hazards with assessment of risk and vulnerability.

Lecture topics: Introduction to River Hazards, types of river hazards; Flood hazards – types of flood hazards. Analysis of flood data – Methods of estimating flood magnitude; Causes of different types of flood hazards; Structural and non-structural measures for flood management, flood hazard zonation mapping; River dynamics and channel shifting; Processes responsible for river dynamics – cut off processes, avulsion process; Controls on river dynamics and its management; Bank erosion processes; Remote sensing based models for bank erosion analysis and prediction; Hydraulic and

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Mr. Anand Bijeta | Er. Rajeev Ranjan | Prof. (Dr.) Madan Koirala | Dr. Om Prakash bank material analysis for bank erosion; Management of bank erosion; Paleoflood analysis from Indian river basins; Hazard, risk and vulnerability assessment; River hazards – Indian scenario; Critical review and comparison of the river hazard management practices in India and at global scale.

EIA and ecological economics (3-1-0-4)

This course introduces the impacts of development projects on different components of the environment, and how the EIA is required to mitigate these impacts. The course focuses on the river valley projects (incl. hydropower). Further, the course provides an insight into the relation ecology and economics for sustainable resource utilization and ecological balance.

Lecture topics: Introduction to EIA - purpose and aims; Law, Policy & Institutional Arrangement: Indian EIA Notification and Rules; Stakeholder Participation & Public Hearing; Screening of Projects; Scoping: Methods and TOR; EIA Studies: Impacts on physical, biological, economic and socio-cultural environment; Mitigation of Impacts, Alternatives; Environ. Management Plan; EIA Report; Public Hearing and Response; EIA quality, Decision Making, and Monitoring; Case Studies – River Valley Projects; Basic Economic theory: macro- and microeconomics; Environmental Economics; Ecological Economics; Methods of Ecological Economics; Sustainable Development.

Essentials of river management (3-1-0-4)

This course will elaborate on the earlier course on river ecosystem processes to focus on aspects of specific importance to management of rivers and river basins.

Lecture topics: Introduction to river management; Management strategies at different scales; LULC, soil-erosion, mass wasting processes, sediment sources and transport pathways at Catchment scale; Water in the 3D landscape and restoration of hydrological connectivity; Concept of river space and floodplain mapping; Analysis of river health: Riverine biodiversity; Stream morphology-biota relationships; Sediment-Biota interactions; Stream flow-biota relations; River-Groundwater Interaction (Hyporheic zones); Nutrient Spiralling and waste assimilation potential;

Intrabsin water management- Environmental flows: Definition, need of environmental flows for Indian rivers, hydrologic models, hydraulic models, ecological models; Interbasin water-transfer.

Floodplain management (3-1-0-4)

This course will focus on the management of floodplains as ecosystems. Recognising the failure of decades old practices of river and floodplain management with focus on flood control and navigation through channel engineering and embankments, the course focuses on floodplain

Prof. Vikrant Jain	Prof. Ramakar Jha	Prof. Rajiv Sinha	Prof. S.K. Tandon
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management that avoids flood risk and enhances their ecosystem services for sustainability. It excludes flood hazards, flood zone mapping and management for flood control which are covered in the course on River Hazards.

Lecture Topics: Introduction: Floodplains & their historical role; Floodplain development and typology; Mapping floodplain using remote sensing; Floodplain Hydrology; Floodplain soils and geomorphic processes; Floodplain Vegetation & distribution pattern; Floodplains (Riparian) ecology; Primary production; Floodplain fauna; Floodplain nutrient dynamics; Floodplain functions; Floodplain-River interactions; Historical management approaches for floodplain protection; Recent Ecological management approach; Conserving floodplains for Ecosystem Services; World's large floodplains-Case Studies.

Integrated Water Resource Management (IWRM) (3-1-0-4)

This course will focus on the concepts of integrated water resource management including rivers and all associated water bodies will be introduced.

Lecture topics: Water resources: Introduction, freshwater resources rivers, wetlands, lakes, groundwater, reservoirs, tanks, ponds, Springs, Water uses for different purposes; Role of Basin organizations, Establishing basin management system; IWRM: Evolution, prospects and future challenges, cropping pattern and climate change impact; Modern techniques in river data collection; Modelling: Different models for integrated water resources management and good governance; Early warning systems; Water resources structures, their impacts and operation policies, Cost-benefit analysis; Water quality management; Socio-economic analysis.

Human dimension of river management (3-1-0-4)

This course is aimed at expositing the participants to river-human interactions and impact of humans on rivers and vice-versa. The objective is to also trace the relationship of humans with the rivers since ancient civilizations to modern times and emphasize the importance of participatory river management.

Lecture topics: River-human interactions – from water use to livelihood; traditional water management practices; social and religious practices relate to rivers; ancient river civilizations and water management practices; participatory water management for rivers; sustainable fisheries and wildlife management; river panchayats and river scouts; community –based river water quality monitoring: tools and techniques; quantifying human impacts on rivers; river health; impact of rivers on humans – river hazards; gender issues, rights to access river water.

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Endnote

The course curriculum proposed in this document is expected to synergize traditional knowledge and modern science about Indian river systems through innovative teaching and research. The students of this program will learn new tools and techniques for monitoring, protecting and developing river systems in India in general, and water resources in particular with application of IT. Finally, a competent manpower should develop in the country for building information and decision support system for preserving and developing river system in India.

Prof. S.K. Tandon
Former Pro Vice-Chancellor, Delhi University, Delhi
Visiting Professor.
Indian Institute of Sciences Education and Research, Bhopal

Prof. Rajiv Sinha
Department of Earth Sciences, I.I.T, Kanpur

Prof. Ramakar Jha
Dept. of Civil Engineering, National Institute of Technology, Patna

Prof. Vikrant Jain
Dept. of Earth Sciences, I.I.T, Gandhinagar, Gujarat

Dr. Om Prakash
Department of Civil Engineering, IIT, Patna

Prof. (Dr.) Madan Koirala
Tribhuvan University, Nepal

Er. Rajeev Ranjan
Controller of Examinations, AKU, Patna

Mr. Anand Bijeta
ICIMOD, Representative