Department of Technology,
Savitribai Phule Pune University
(Formerly University of Pune)

STRUCTURE OF ONE YEAR FULL TIME POST GRADUATE DIPLOMA IN WATER TECHNOLOGIES AND MANAGEMENT (PGD-WTM)

This course is in association with
IHE-Delft, The Netherlands; Unity Knowledge, Pune, India.

This initiative is a part of the MoU signed on 30th October 2017 between the above-mentioned parties with SPPU for multiple education and research initiatives in the sector of WATER.

A module system will be followed as the course will run parallel to the course happening at IHE Delft. The teaching medium will be a combination of online sessions in real-time and classroom teaching.
Each module will be of 3 weeks. After 2 modules, an examination shall be conducted in the subsequent week.
The course shall run full time on weekdays between Monday-Friday only.

Sr.	Course Code	Course Name	Teaching Scheme			Credits
No.			L	T	P	
1	WTM01	Induction + Introduction	--	13	2	1
2	WTM02	Unit Operations in Water Treatment, Coagulation, Sedimentation, Floatation and Filtration	6	12	12	2
3	WTM03	Disinfection, Adsorption & Natural Processes for Water Treatment	7	28	10	3
4	WTM04	Resource Oriented Wastewater Treatment & Sanitation	--	23	22	3
5	WTM05	Water Transport & Distribution	--	30	15	3
6	WTM06	Water and Waste-water treatment processes and plant design with desalination and membrane technology	--	15	30	3
7	WTM07	ASSIGNMENT BASED FIELD WORK	--	7	38	3
8	WTM08	Drought Management and Reservoir Operations (elective I)	--	21	24	3
8	WTM08	Partnerships for Water Supply and Sanitation (elective I)	--	20	25	
9	WTM09	Data Analytics and GIS for Water Management (elective II)	--	27	18	3
9	WTM09	Data Analytics and Advanced Water Transport and Distribution (elective II)	--	18	27	
9	WTM09	Data Analytics and Decentralised Water Supply and Sanitation (elective II)	--	21	24	
9	WTM09	Data Analytics and Water Sensitive Cities (elective II)	--	18	27	
10	WTM10	SUMMER COURSE	--	10	5	1
11	WTM11	APPLIED PROJECT WORK	--	--	45	3
12	WTM12	INTERNSHIP	--	--	180	12
		Total Credits				40

Week	Topic
1-6	WTM01 + WTM02
7	Exam on previous modules
8-13	WTM03 + WTM04
14	Exam on previous modules
15-20	WTM05 + WTM06
21	Exam on previous modules
22-24	WTM07
24 - 29	WTM08 + WTM09
30	Exam on previous modules
31	WTM10
32-34	WTM11
35-48	WTM12
49-52	REPORT + VIVA

WTM01	Induction + Introduction	
Learning Objectives	Setting up the Context and getting familiar with basic concepts. Understanding - Norms and regulations of the sector of water. Adaptation measures and application in the water sector for SMART cities and SMART villages and overall master planning for regional development. Getting familiar with technical aspects of global innovative concepts like heat island, water foot print, rainwater management, urban farming and circular economy.	
Assessments	50%	MCQ written examination (Closed book)
	50%	Attendance + Presentation based on case studies (10 research papers)
Topics	• Components of Urban Infrastructure, SMART cities, SMART villages. • Current plans and future projections for SMART cities and SMART villages. (Objectives and Policies) • Leadership for WASH - Changes in S.E.P.T. and its impact on urban growth from the context of Water and Sanitation. (S E P T – Social-Economical-Political-Technological) • Heat Islands Cause and Effect • Water footprint • Rain Water Management • Urban Farming and Circular Economy • Basics of Hydrology and Water Cycle • Basics of Chemistry and Microbiology related to Water. • Introduction of Regulatory Authorities (e.g – CPHEEO and other policy framework)	
Education Material	CPHEEO Manual C. N. Sawyer and P. L. McCarty, Chemistry for Environmental Engineers, McGraw Hill, Latest Powar & Daginawala, General Microbiology Vol. I &II, Himalaya Publishing House, Latest Reference material from IHE Delft	
Scientific Software		

Topic Table and Workload Distribution

Sr. No.	WTM01 Induction + Introduction	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Components of Urban Infrastructure, SMART cities, SMART villages.	--	1	--	
2	Current plans and future projections for SMART cities and SMART villages. (Objectives and Policies)	--	1	--	
3	Introduction of Regulatory Authorities (e.g – CPHEEO and other policy framework)	--		--	
4	Changes in S.E.P.T. and its impact on urban growth from the context of Water and Sanitation. (S E P T – Social-Economical-Political-Technological)	--	1	--	
5	Heat Islands Cause and Effect, Water footprint, Rain Water Management, Urban Farming and Circular Economy	--	4	2	
6	Basics of Hydrology and Water Cycle	--	2	--	
7	Basics of Chemistry and Microbiology related to Water	--	4	--	
	TOTAL HOURS	--	13	2	1

<table>
<tr><td>WTM02</td><td colspan="2">Unit Operations in Water Treatment
(Coagulation, Sedimentation, Flotation and Filtration)</td></tr>
<tr><td>Learning Objectives</td><td colspan="2">• Describe the theoretical principles of the unit processes: coagulation, filtration, sedimentation and dissolved air flotation in conventional surface water treatment
• Apply theoretical principles to practical aspects of coagulation, filtration, sedimentation, and dissolved air flotation
• Determine design parameters for coagulation, filtration, sedimentation, and dissolved air flotation from laboratory experiments
• Design a sedimentation tank
• Be able to judge the performance of the unit processes: coagulation, filtration, sedimentation, and dissolved air flotation</td></tr>
<tr><td rowspan="3">Assessments</td><td>20%</td><td>Assignment</td></tr>
<tr><td>20%</td><td>Lab. Report</td></tr>
<tr><td>60%</td><td>Written Examination</td></tr>
<tr><td>Topics</td><td colspan="2">Topic 1: Coagulation
Theory of coagulation and flocculation processes: colloidal stability and mechanisms of destabilization, rapid and slow mixing, coagulation in practice and natural coagulants.

Topic 2: Sedimentation
Hydrodynamic principles of sedimentation and flotation, Stokes Law, principles of discrete settling, flocculent settling and hindered settling. Horizontal and vertical continuous flow basins, settling tanks, shape of inlets and outlets. Design of a rectangular sedimentation tank

Topic 3: Dissolved air flotation
Key design parameters, Henry's law, nucleus theory, Stokes law, rate of rise theory, hydraulic loading rate, solids loading

Topic 4: Filtration
General introduction to various types of filtration systems, Mechanical filtration, Slow sand filtration, Rapid sand filtration (pilot experiments, removal mechanisms, hydraulics, filter elements, rate control, backwashing, multi- layer filtration, application

Topic 5: Field trip to conventional water treatment plant

Upon completion, the participant should be able to:
• Design a sedimentation tank
• Determine design parameters for coagulation, filtration, sedimentation, and dissolved air flotation from laboratory experiments
• Apply theoretical principles to practical aspects of coagulation, filtration, sedimentation, and dissolved air flotation
• Describe the theoretical principles of the unit processes: coagulation, filtration, sedimentation and dissolved air flotation in conventional surface water treatment
• Be able to judge the performance of the unit processes: coagulation, filtration, sedimentation, and dissolved air flotation</td></tr>
</table>

Education Material	Manual	CPHEEO Manual, Govt of India
	Books	J.P. Buiteman: Surface Water Treatment Laboratory Manual (part 1) (LN 0466/17/1)
	Books	JP Buiteman, J Schippers: Coagulation/Flocculation (LN00460/18/1)
	Books	M.W. Blokland, N. Trifunovic and S.K Sharma: Sedimentation: Workshop problems (LN0009/07/1)
	Handout	S.K. Sharma (2018), Filtration (Handouts); S.K. Sharma: Sedimentation (LN 0007/18/1)
	Books	Metcalf and Eddy, Wastewater Engineering, Treatment, Disposal and Reuse, McGraw Hill, Fourth Edition,2002. S.J. Arceivala, Wastewater Treatment and Disposal, Marcel Dekker, 1981
Scientific Software		

Topic Table and Workload Distribution

Sr. No.	WTM02 Unit Operations in Water Treatment (Coagulation, Sedimentation, Flotation and Filtration)	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Coagulation	2	3	3	
2	Sedimentation	2	3	3	
3	Dissolved Air Floatation	--	1	--	
4	Filtration	2	5	2	
5	Field Trip to conventional water treatment plant	--	--	4	
	TOTAL	6	12	12	2

<table>
<tr><td>WTM03</td><td colspan="2">Disinfection, Adsorption and Natural Processes for Water Treatment</td></tr>
<tr><td>Learning Objectives</td><td colspan="2">• Explain the principles of disinfection, drinking water quality, natural treatment systems, adsorption and activated carbon filtration processes
• Integrate theoretical principles of disinfection with practical aspects of evaluation of disinfection systems
• Prepare conceptual design of appropriate processes following the evaluation of water quality characteristics and the intended use of the treated water

Upon completion, the participant should be able to:
• Explain the principles of disinfection, drinking water quality, natural treatment systems, adsorption and activated carbon filtration processes
• Integrate theoretical principles of disinfection with practical aspects of evaluation of disinfection systems
• Prepare conceptual design of appropriate processes following the evaluation of water quality characteristics and the intended use of the treated water</td></tr>
<tr><td rowspan="3">Assessments</td><td>10%</td><td>Assignment</td></tr>
<tr><td>20%</td><td>Lab. Report</td></tr>
<tr><td>70%</td><td>Written Examination</td></tr>
<tr><td>Topics</td><td colspan="2">Topic 1: Drinking water quality

Topic 2: Surface water collection and storage

Topic 3: Disinfection
Basic principles of disinfection; chemical disinfection; disinfection by products; ozone disinfection; UV disinfection.

Topic 4: Adsorption
Theoretical background of adsorptive processes.

Topic 5: Activated carbon
Granular and powdered activated carbon, modelling and design.

Topic 6: Natural treatment systems</td></tr>
<tr><td rowspan="2">Education Material</td><td>Manual</td><td>Buiteman, J.P. and Ferrero, G. Surface Water Treatment Laboratory manual - part 2 - (LN0469/13/4)</td></tr>
<tr><td>Books</td><td>Ferrero, G., Schippers, J.C., Buiteman, J.P., Kruithof, J.C., Martijn, B.J., Schurer, R. Disinfection of Drinking Water and Water Quality (LN0461/14/4)</td></tr>
<tr><td>Scientific Software</td><td colspan="2"></td></tr>
</table>

Topic Table and Workload Distribution

Sr. No.	WTM03 Disinfection, Adsorption And Natural Processes for Water Treatment	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Drinking water quality		4	2	
2	Surface water collection and storage		4	1	
3	Disinfection	4	8	4	
4	Adsorption	1	4	1	
5	Activated carbon	2	4	2	
6	Natural Treatment Systems		4		
	TOTAL	7	28	10	3

<table>
<tr><td>WTM04</td><td colspan="2">Resource Oriented Wastewater Treatment and Sanitation</td></tr>
<tr><td>Learning Objectives</td><td colspan="2">• Describe the physical, chemical and microbiological processes occurring in anaerobic reactors and a number of natural systems
• Critically reflect on the current sanitation systems encountered in many urban areas and to indicate ways to improve this situation in a sustainable manner;
• Evaluate the possibilities for closing cycles of energy, water and nutrients
• Evaluate the feasibility of the application of the technologies studied in this module in urban settings in the developing world
• Carry out preliminary process design of treatment and reuse systems to assess the needs for capital, land, equipment and operation and maintenance

Upon completion, the participant should be able to:
• Carry out preliminary process design of treatment and reuse systems to assess the needs for capital, land, equipment and operation and maintenance
• Describe the physical, chemical and microbiological processes occurring in anaerobic reactors and a number of natural systems
• Evaluate the feasibility of the application of the technologies studied in this module in urban settings in the developing world
• Critically reflect on the current sanitation systems encountered in many urban areas and to indicate ways to improve this situation in a sustainable manner
• Evaluate the possibilities for closing cycles of energy, water and nutrients</td></tr>
<tr><td>Assessments</td><td>100%</td><td>Written Examination</td></tr>
<tr><td>Topics</td><td colspan="2">Topic 1: Introduction into resource orientation in wastewater treatment and sanitation

Topic 2: Anaerobic Wastewater Treatment
Fundamentals about anaerobic degradation and its application in wastewater treatment.

Topic 3: Waste Stabilisation Ponds

Topic 4: Urine Treatment

Topic 5: Field trip

Topic 6: Effluent reuse

Topic 7: Algae photobioreactors</td></tr>
<tr><td rowspan="4">Education Material</td><td>Manual</td><td>CPHEEO Manual, Govt of India</td></tr>
<tr><td>Book</td><td>Chapter 16 _Biological wastewater treatment, Innovative Wastewater Treatment & Resource Recovery Technologies</td></tr>
<tr><td>Books</td><td>Waste stabilization ponds</td></tr>
<tr><td>Books</td><td>WHO_Guidelines for Water Reuse_2004</td></tr>
<tr><td>Scientific Software</td><td colspan="2"></td></tr>
</table>

Topic Table and Workload Distribution

Sr. No.	WTM04 Resource Oriented Wastewater Treatment and Sanitation	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Introduction into resource orientation in wastewater treatment and sanitation	--	3	1	
2	Anaerobic Wastewater Treatment	--	8	15	
3	Waste Stabilisation Ponds	--	3	--	
4	Urine Treatment	--	3	2	
5	Field trip	--	0	4	
6	Effluent reuse	--	3	--	
7	Algae photobioreactors	--	3	--	
	TOTAL	--	23	22	3

<table>
<tr><td>WTM05</td><td colspan="2">Water Transport and Distribution</td></tr>
<tr><td>Learning Objectives</td><td colspan="2">• Distinguish between different network configurations and supplying schemes; recognise various consumption categories and their growth patterns, including water leakage; define the relation between the main hydraulic parameters
• Demonstrate understanding of the steady-state hydraulics by being able to select appropriate pipe diameters, indicate optimum location of reservoirs and identify pumps capable to supply the demand;
• Apply the above theoretical knowledge by learning to perform computer-aided hydraulic calculations and predict the consequences of demand growth on the hydraulic performance of particular WTD system
• Propose preliminary hydraulic design that will integrate economic aspects, choose adequate components, and judge technical solutions dealing with the network maintenance, rehabilitation, and expansion;
• Distinguish between the main components of non-revenue water and methods of leakage assessment, survey, detection and control;
• Understand the basic corrosion mechanisms and suggest the list of preventive and reactive measures</td></tr>
<tr><td rowspan="3">Assessments</td><td>40%</td><td>Assignment – Design Exercise</td></tr>
<tr><td>20%</td><td>Written Examination (Closed Book) MCQ Type Exam</td></tr>
<tr><td>40%</td><td>Written Examination (Open Book)</td></tr>
<tr><td>Topics</td><td colspan="2">Topic 1: Introduction to Water Transport and Distribution
Main objectives and components of WTD systems; water demand categories, patterns, calculation and forecasting; steady state hydraulics of pressurized flows, single pipe calculation, branched and looped networks, pressure driven demand; hydraulics of storage and pumps; hydraulic design: choice of supply scheme, network layouts, design of pumping stations, power requirements and energy consumption; engineering design: choice of pipe materials, valves and other equipment; network construction: pipe laying, testing and disinfection; operation & maintenance: regular & irregular supply, network cleaning and rehabilitation.

Topic 2: Water Loss Management and Control
Definition of non-revenue water and IWA terminology used in the sector, components of water losses, methods of reducing and controlling real- and apparent network losses; quantification of leakage in distribution systems, leak location and repair techniques, pressure management.

Topic 3: Corrosion in Water Distribution Networks
Corrosion of pipe materials, indices of measure, corrosion assessment, prevention and control, optial water composition, principles of water quality modelling of distribution networks, modelling of chlorine residuals.</td></tr>
<tr><td rowspan="2">Education Material</td><td>Manual</td><td>CPHEEO Manual, Govt of India</td></tr>
<tr><td>Digital Files</td><td>Electronic materials: slide presentations (MS PowerPoint), design assignment, design network model (EPANET Ver.2), spreadsheet hydraulic lessons (MS Excel)</td></tr>
</table>

	Book	N.Trifunovic - Introduction to Urban Water Distribution, Taylor & Francis, 2006, reprint 2008
	Books	S.Sharma - Corrosion of Pipe Materials, Books UNESCO-IHE 2009 (LN/0310/09/1)
	Books	S.Sharma - Water Losses in Distribution Systems, Books UNESCO-IHE 2010 (LN/0346/10/1)
Scientific Software	EPANET	

Topic Table and Workload Distribution

Sr. No.	WTM05 Water Transport and Distribution	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Introduction to Water Transport and Distribution	--	20	13	
2	Water Loss Management and Control	--	6	2	
3	Corrosion in Water Distribution Networks	--	4	--	
	TOTAL	--	30	15	3

WTM06	Water and Waste-Water Treatment Processes and Plant Design with Desalination and Membrane Technology	
Learning Objectives	• Select the most suitable and cost-effective treatment process technologies, given it's composition and characteristics and taking into account the required standards. • Carryout a preliminary design of a treatment system including engineering process layout, hydraulic profile and process flow diagram • Identify and estimate the construction, operational and maintenance costs of a treatment plant, and the investments required to secure It's satisfactory operations throughout the expected life span of the system. • Describe the mean and components involved in the project planning, project management and project administration for design engineering, construction, start-up and operation of the treatment plant.	
Assessments	25%	Assignment – Design Exercise
	25%	Oral Exam – Based on development of the design project.
	50%	Written Examination (Closed Book)
Topics	Topic 1 : Technology selection Technology selection and introduction to desalination and membrane technology. Review of the most commonly applied treatment process technologies. Criteria for selection and guidelines for determination of a suitable treatment process to meet the required standards taking into account local conditions and resources availability. Topic 2: Engineering Economics Fundamentals and principles of economics (such as cash-flow, interest factors, return of investment and benefit-cost analyses, among others). Evaluation, comparison and selection of cost-effective treatment system alternatives. Topic 3: Costing Fundamentals and principles of costing. Identification and estimation of direct and indirect costs involved in the design, construction, operation and maintenance of treatment systems. (Project) budgeting. Topic 4: Engineering process layouts and process flow diagrams Design and calculation of engineering process layouts and process flow diagrams for the design and operation of treatment plants. A detailed design exercise will be carried out on a selected treatment processes lay-out. Topic 5: Hydraulic design Calculation and design of hydraulic profiles (based on the behaviour and performance of hydraulic structures and elements) for the design and operation of treatment plants. Topic 6: Design and Engineering of Conventional Treatment Systems Preliminary design, including influent characteristics, sizing and dimensioning of a conventional treatment plant. Design and selection of equipment for monitoring,	

	operation and control. Review of case-studies including planning, project management, and project administration of the construction and operation.	
Education Material	Manual	CPHEEO Manual, Govt of India
	Books	Metcalf & Eddy, McGraw Hill
Scientific Software		

Topic Table and Workload Distribution

Sr. No.	WTM06 Water and Waste-Water Treatment Processes and Plant Design with Desalination and Membrane Technology	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Technology selection	--	2	4	
2	Engineering Economics	--	1	3	
3	Costing	--	1	3	
4	Engineering process layouts and process flow diagrams	--	1	4	
5	Hydraulic design	--	2	4	
6	Design and Engineering of Conventional Treatment Systems	--	8	12	
	TOTAL	--	15	30	3

WTM07	Assignment Based Field Work	
Learning Objectives	• Before the start of this module, the student shall have selected a challenge of their choice presented by one of the host company • This challenge will be worked upon starting this module and culminates at the end of the PDG with the internship at the same host company • The student shall get accustomed to newer technologies and software's available in the sector of Water Management. • The students shall get familiar to the new sector of Data Analytics for Water Management. • The above-mentioned activities are immediately applied in the field / lab as an assignment-based understanding	
Assessments	50%	Project Report
	50%	Attendance + Presentation of the field work and project.
Topics	• Introduction to Bentley • Introduction to GIS software's used for Water Management • Introduction to Data Analytics for Water Management • Relevant Assignment either Field Based or Laboratory Based involving Data Collection methods and basic analysis and interpretations and conclusions	
Education Material	Manual	Work Book Exercises
Scientific Software	Bentley – WaterGEMS, SewerCAD QGIS, ARCGIS	

Topic Table and Workload Distribution

Sr. No.	WTM07 Assignment Based Field Work	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Introduction to Bentley and GIS Software's Assignment on Data setting	--	2	8	
2	Introduction to Data Analytics for Water Management	--	2	-	
3	Field Work / Lab Work – Basic Data collection and analysis	--	3	27	
	TOTAL	--	7	38	3

<table>
<tr><td>WTM08</td><td colspan="2">Drought Management and Reservoir Operations</td></tr>
<tr><td>Learning Objectives</td><td colspan="2">• Be able to identify and describe the concept of drought, and describe the different types of drought, the influence of society on drought, and the relationship between drought and water scarcity
• Be familiar with concepts of drought monitoring and forecasting, and data and modelling systems used.
• Be able to describe the principles of reservoir operations and optimisation, and develop operational rules for (multi-purpose) reservoir systems.</td></tr>
<tr><td rowspan="4">Assessments</td><td>30%</td><td>Written Examination (Closed Book)</td></tr>
<tr><td>30%</td><td>Written Examination (Closed Book)</td></tr>
<tr><td>20%</td><td>Assignment</td></tr>
<tr><td>20%</td><td>Assignment</td></tr>
<tr><td>Topics</td><td colspan="2">Topic 1: Drought and Drought Management
Introduction to the concept of drought and the different types of drought. How these are related in time. Drought as a natural phenomenon and the influence of society on drought. Concepts of drought risk, and the constituent components of drought hazard and drought vulnerability. Drought Management and the development of drought management planning. This topic will include lectures and

Topic 2: Drought Monitoring and Forecasting
Concepts of drought indicators and the use of drought indicators in monitoring different types of drought. Drought Monitoring systems. Drought Forecasting and drought Forecasting systems. Data requirements. Exercise in using global data to characterise drought in different parts of the world.

Topic 3: Reservoir Control and Optimisation
Principles of reservoir operation rules, including standard operation policy, hedging and flood control rules. Designing reservoir operation policies using optimisation techniques such as linear and (stochastic) dynamic programming. Long term versus short term reservoir operation. Establishing objective functions for multiplie- purpose reservoirs. Planning and implementation of environmental flows.

Exercise using reservoir simulation package (HEC-ResSim) to model a reservoir system, and developing operational rule curves through dynamic programming and testing these through simulation.</td></tr>
<tr><td rowspan="5">Education Material</td><td>Manual</td><td></td></tr>
<tr><td>Scientific Journal</td><td>Selected scientific papers</td></tr>
<tr><td>Handout</td><td>Handouts on drought and drought management</td></tr>
<tr><td>Books</td><td>Reader on reservoir operations</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Scientific Software</td><td colspan="2">HEC-ResSim</td></tr>
</table>

Topic Table and Workload Distribution

Sr. No.	WTM08 Drought Management and Reservoir Operations	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Drought and Drought Management	--	8	8	
2	Drought Monitoring and Forecasting	--	5	8	
3	Reservoir Control and Optimisation	--	8	8	
	TOTAL	--	21	24	3

WTM08	Partnerships for Water Supply and Sanitation	
Learning Objectives	• Discuss the rational for implementing partnerships in the water sector. • Evaluate the type of partnership suitable for a given context. • Explain the solutions needed to address the challenges at different partnership stages. • Evaluate the needs tensions and trade-offs in achieving water provision that is both efficient and equitable.	
Assessments	20%	Group Assignment
	30%	Individual assignment
	50%	Attendance + Oral Examination
Topics	Topic 1: Introduction to the module and historical perspective in water partnership Topic 2: Public private partnerships. Setting up a PPP program, risk identification assignment and mitigation. Planning and implementation, assessment and regulation, public and private finance. Efficiency and equity concepts. Topic 3: Other Water partnerships. Water operator partnership. Water delivery in small towns, rural areas. Topic 4: Skill Development for Water Partnership. Managing Partnerships, negotiating contracts and managing conflicts. Topic 5: Field Trip to PPP project.	
Education Material	Manual	
	Scientific Journal	Selected scientific papers
	Handout	Handouts on drought and drought management
	Books	Reader on reservoir operations
Scientific Software		

Topic Table and Workload Distribution

Sr. No.	WTM08 Partnerships for Water Supply and Sanitation	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Introduction to the module and historical perspective in water partnership	--	2	6	
2	Public private partnerships	--	10	8	
3	Other Water partnerships	--	5	3	
4	Skill Development for Water Partnership	--	3	4	
5	Field Trip to PPP project	--	--	4	
	TOTAL	--	20	25	3

<table>
<tr><td>WTM09</td><td colspan="2">Data Analytics and GIS for water management</td></tr>
<tr><td>Learning Objectives</td><td colspan="2">• The students will be able to explain RS theory and GIS application, technology, typical applications, and be able to identify and download relevant data and products
• The students will be able to pre-process, extract and analyse common indices, design and collect ground-truth points, and conduct land cover classification
• The students will be able to extract biophysical, infrastructure and management features of the region
• The students will be able to assess the various performance indexes using GIS and remote sensing, interpret them to identify gaps, diagnose water management problems, and attribute to relevant factors for improvements
• The students will be able to produce water accounts for a hydrological system for a given region using GIS and remote sensing information and evaluate the performance of the system.
• Setting the context of generating data from various sources through the cycle of water management
• Analysing historical data, understand the changes happening through the years and develop adaptive solutions for future
• Develop the ability to provide meaningful information and generate the possibility to take informed decisions based on big data generation in water sector.
• Scoping of operationalising neural networks in water management
• Develop a smart integrated infrastructure through the tools for data analysis</td></tr>
<tr><td rowspan="2">Assessments</td><td>60%</td><td>Assignment</td></tr>
<tr><td>40%</td><td>Written Examination (Open Book)</td></tr>
<tr><td>Topics</td><td colspan="2">Topic 1: Introduction to Remote sensing
Basics of GIS & RS, introduction to common data portal, satellites, typical application of GIS & RS and existing products, Hands-on exercises on need analysis and acquiring of relevant data.

Topic 2: Data analysis for land cover classification
Overview of the data processing flow, common indices, and classification theory; Ground Truthing methods; Hands-on exercises (1) GT collection, (2) Landsat data pre-processing, extracting common indices, categorize them, and (3) Land cover classification and accuracy assessment. A case study is introduced to which these skills will be applied by the students.

Topic 3: Mapping existing infrastructure systems
Hands-on exercise on mapping infrastructure, land use patterns, water resources, water networks, ground water data for the catchment, integrating the primary data and secondary data

Topic 4: Data Analytics in GIS and RS for infrastructure development
Acquire historical data for catchments, generate data points and source data, generate adaptive tools based on the data being generated through the data points</td></tr>
</table>

	Develop strategies based on micro data for water management – interlinks for water for irrigation and agriculture and urban / rural development Topic 5: GIS & Remote sensing for enhancing performance of water management systems Assessment of the system performance using GIS and remote sensing tools, interpret various performance indicator results to identify gaps, diagnose water management problems, and attribute to relevant factors for improvements Topic 6: GIS & Remote Sensing for Water Accounting Theory of producing water accounts for a water management system using remote sensing information is discussed. The knowledge will be applied to the hands-on and form the concluding section of the assignment.	
	Scientific Journal	Selected scientific papers
	Books	Fundamentals of GIS & Remote sensing
	Book	Wegmann, M., B. Leutner, and S. Dech. Remote Sensing and GIS for Ecologists: Using Open Source Software. Data in the Wild. Pelagic Publishing, 2016
Scientific Software	QGIS & ARCGIS	

Topic Table and Workload Distribution

Sr. No.	WTM09 Data Analytics and GIS for water management	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Introduction to Remote sensing	--	4	1	
2	Data analysis for land cover classification	--	4	3	
3	Mapping existing infrastructure systems	--	3	2	
4	Data Analytics in GIS and RS for infrastructure development	--	4	6	
5	GIS & Remote sensing for enhancing performance of water management systems	--	8	4	
6	GIS & Remote Sensing for Water Accounting	--	4	2	
	TOTAL	--	27	18	3

<table>
<tr><td>WTM09</td><td colspan="2">Data Analytics and Advanced Water Transport and Distribution</td></tr>
<tr><td>Learning Objectives</td><td colspan="2">• Understand the theory of advanced hydraulic and water quality modelling; apply state-of-the-art network software for assessment of irregular operational scenarios and develop a reliability-based and cost-effective design using computer model.
• Select modern tools for monitoring of operation, and planning of maintenance of WTD systems.
• Recognise the GIS and remote sensing technologies, and familiarise with the GIS-based techniques for sustainable planning and management of WTD systems;
• Understand the theory of transient flows, and plan the measures to prevent/control water hammer;
• Distinguish between various sources of water quality problems in distribution networks; understand the basic mechanisms of biological stability and suggest the list of preventive and reactive measures
• Setting the context of generating data from various sources through the cycle of water management
• Analysing historical data, understand the changes happening through the years and develop adaptive solutions for future
• Develop the ability to provide meaningful information and generate the possibility to take informed decisions based on big data generation in water sector.
• Scoping of operationalising neural networks in water management
• Develop a smart integrated infrastructure through the tools for data analysis</td></tr>
<tr><td rowspan="3">Assessments</td><td>12%</td><td>Assignment</td></tr>
<tr><td>60%</td><td>Written Examination (Closed Book)</td></tr>
<tr><td>28%</td><td>Assignment</td></tr>
<tr><td>Topics</td><td colspan="2">Topic 1: Advanced Water Distribution Modelling and Data analytics
Principles of genetic algorithm; pressure-driven demand calculations; network calibration; failure analysis and calculation of demand losses; economic aspects of capital investments and network operation.
Optimization of networks and scoping of introducing neural networks for water management, asset management

Topic 2: Advanced O&M Practices in Water Distribution
Monitoring of network condition and operation; data collection and management; organisation of maintenance, emergency water supply, asset management plans, water company organisation.

Topic 3: GIS in Water Distribution
The aim of this course is to provide both a solid theoretical understanding and a comprehensive practical introduction of how to use geographic information systems and remote sensing technologies for the analysis and solution of water distribution related problems. The course focuses on the analysis of digital spatial data, preparation</td></tr>
</table>

	for numerical modelling, presentation of modelling results and support to the decision-making process. The topics covered in the course include the following: introduction to geographic information systems and remote sensing technologies, active and passive remote sensing, data structures, map projections and coordinate systems, processing of digital geographic information, creation of digital elevation models, visualisation, mapping of water related features, delineation of pressure zone areas, digitisation, soil and land use mapping, map algebra, export of GIS layers into a modelling package, incorporation of modelling results in GIS. Topic 4: Introduction to Water Hammer Basic equations and applications; computer modelling: model building, simulations of simple cases (full pump trip, emergency shut down; protection devices: practical methods of surge suppression, direct action, diversionary tactics, choice of protection strategy. Topic 5: Water Quality in Distribution Networks Bacterial growth in drinking water, influence of water treatment and distribution on biological stability of drinking water, optimal water composition, principles of water quality modelling of distribution networks, modelling of chlorine residuals.	
Education Material	Manual	CPHEEO Govt of India
	Books	Urban Water Distribution, Nemanja Trifunovic
Scientific Software	ARCGIS Bentley Water Hammer	

Topic Table and Workload Distribution

Sr. No.	WTM09 Data Analytics and Advanced Water Transport and Distribution	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Advanced Water Distribution Modelling and Data analytics	--	12	12	
2	Advanced O&M Practices in Water Distribution	--	--	8	
3	GIS in Water Distribution	--	--	3	
4	Introduction to Water Hammer	--	2	2	
5	Water Quality in Distribution Networks	--	4	2	
	TOTAL	--	18	27	3

<table>
<tr><td>WTM09</td><td colspan="2">Data Analytics and Decentralised Water Supply and Sanitation</td></tr>
<tr><td>Learning Objectives</td><td colspan="2">• Know different technologies/methods for small-scale water abstraction and water treatment that can be used at household or small community level
• Understand the basics of sustainable sanitation technologies including nutrient reuse in agriculture, solid waste management and faecal sludge management and their implementation in small towns, peri-urban and urban poor areas of developing countries
• Prepare concept design for small-scale water supply treatment and technology
• Facilitate planning, financing, implementation and operation and maintenance of decentralised water supply and sanitation infrastructures based on stakeholder participation and community management
• Setting the context of generating data from various sources through the cycle of water management
• Analysing historical data, understand the changes happening through the years and develop adaptive solutions for future
• Develop the ability to provide meaningful information and generate the possibility to take informed decisions based on big data generation in water sector.
• Scoping of operationalising neural networks in water management
• Develop a smart integrated infrastructure through the tools for data analysis</td></tr>
<tr><td rowspan="3">Assessments</td><td>30%</td><td>Assignment</td></tr>
<tr><td>10%</td><td>Presentation</td></tr>
<tr><td>60%</td><td>Written Examination (Closed Book)</td></tr>
<tr><td>Topics</td><td colspan="2">Topic 1: Introduction
Introduction to the module; Water Supply and Sanitation situations in small towns, peri-urban areas and urban poor areas. Rationale for decentralized water supply system

Topic 2: Decentralized Water Supply and Treatment Systems
Water Supply Systems (water sources, source selection, service levels, suitability of types of water supply systems under different conditions); Rainwater Harvesting (introduction, collection systems, advantages and limitations, design considerations). Small-scale Water Treatment Methods (design water treatment systems for small community or household, Filtration, slow sand filters, small-scale disinfection)

Topic 3: Decentralized Sanitation Systems
Sanitation Systems (introduction to sanitation systems, characteristics of urine, faeces and greywater; overview of technologies for sanitation technologies; conventional on-site sanitation; storage and transport logistics); Sanitation Planning and Strategic Tools (institutional, social and policy aspects). Faecal Sludge Management (treatment goals and standards, treatment options, Faecal sludge management (planning, financial, economic, agronomic, institutional and legal aspects), transmission of excreta-related infections and risk management). Solid waste management in developing countries (technical and practical aspects of collection, transport, segregation, disposal and reuse)

Topic 4: Data Analytics for Decentralized Water Supply and Sanitation
Generate data points based on decentralised patterns for system implementation</td></tr>
</table>

	Data generation based on – diversity, constraints, legislation, interdependence, water as a limited resource, climate change, emergence of new technologies and chemicals, risk characterisation and mitigation as well as velocity, volume, diversity, legacy data Topic 5: Management Aspects of DWSS Participatory Planning and Evaluation (demand responsive approach); Institutional Arrangements (community-based management; small-scale independent providers), Operation and Maintenance Aspects (operation and maintenance plan, financing and cost recovery) Topic 6: Presentation of the Participants All participants make a presentation of 10 minutes in the field of decentralized water supply and sanitation in order to share experiences or problems they are facing now and learn from each other's experience.	
Education Material	Manual	CPHEEO, Govt. of India
	Book	Decentralised Water Supply and Sanitation by SK Sharma
	Book	Faecal Sludge Management by D. Brdjanovic, M. Ronteltap, L. Strande
Scientific Software		

Topic Table and Workload Distribution

Sr. No.	WTM09 Data Analytics and Decentralised Water Supply and Sanitation	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Introduction to decentralized water supply and sanitation	--	2	1	
2	Decentralized Water Supply and Treatment Systems	--	6	3	
3	Decentralized Sanitation Systems	--	6	4	
4	Data Analytics for Decentralized Water Supply and Sanitation	--	4	8	
5	Management Aspects of DWSS	--	3	2	
6	Presentation of the Participants	--		6	
	TOTAL		21	24	3

<table>
<tr><td>WTM09</td><td colspan="2">Data Analytics and Water Sensitive Cities</td></tr>
<tr><td>Learning Objectives</td><td colspan="2">

Describe the historical transition of cities from the viewpoint of water management. List salient features of that transition (both positive and negative). (ILO1: History)
Argue that the three main components of the urban water cycle (UWC) management are interdependent.
Describe the interactions with other important aspects of UWC like groundwater, urban atmosphere, etc., and how they affect each. (ILO2: Integration)
Identify interactions between water system components, while following 'thematic' topics (e.g. urban hydrology, water transport and distribution). Describe how to exploit such interactions to enhance liveability, sustainability and resilience of cities.
Argue that considering multiple aspects of the water systems could provide opportunities to add extra value and create substantial additional benefits related to water management projects. Estimate such benefits using toolkits. (ILO4: Multiple Values)
Illustrate the importance of 'mainstreaming' water sensitive elements to general urban development process.
Describe concrete examples (real-world and hypothetical) of such mainstreaming. (ILO5: Mainstreaming)
Analyse the stakeholder involvement in the management of water in city. Argue that for effective embedding of water-sensitive features to urban development, stakeholders should also include traditionally 'non-water' domains. (ILO6: Stakeholders)
Reflect on the relationship of WSC principals and practice to existing cities and their sub-components (e.g. neighbourhoods). Propose (conceptual) next steps in moving towards a more water-sensitive state for a given concrete case-study. (ILO7: Vision)
Setting the context of generating data from various sources through the cycle of water management
Analysing historical data, understand the changes happening through the years and develop adaptive solutions for future
Develop the ability to provide meaningful information and generate the possibility to take informed decisions based on big data generation in water sector.
Scoping of operationalising neural networks in water management
Develop a smart integrated infrastructure through the tools for data analysis

</td></tr>
<tr><td rowspan="3">Assessments</td><td>50%</td><td>Assignment</td></tr>
<tr><td>25%</td><td>Oral Examination</td></tr>
<tr><td>25%</td><td>Presentation</td></tr>
<tr><td>Topics</td><td colspan="2">Topic T1: Introduction to water sensitive cities
This module's structure is quite different from the 'traditional model' of teaching modules here at IHE. The Learning objectives are realized via a series of 'Cast Studies' (between 10 and 14) each taking a half a day or full day. Each case study has a hands-on, workshop type part as well.
This section which precedes those case studies describe:</td></tr>
</table>

	1. What is a water sensitive city? Why it is important? How cities can strive to arrive at more water sensitive states? 2. The components of the urban water cycle (Water supply, Surface/storm water system, Wastewater system + groundwater), each as a brief introduction and how they interact with each other and the broader urban processes that are outside the domain of water. Topic T2: Case studies (change every year) List of case studies. Each case study has 1. Lecture/discussion part 2. Workshop - hands-on part. Since the number and content of the case studies change every year this section represents the 'collection' of the case studies. Topic T3: Data Analytics Data generation and analysis based on – diversity, constraints, legislation, interdependence, water as a limited resource, climate change, emergence of new technologies and chemicals, risk characterisation and mitigation as well as velocity, volume, diversity, legacy data Develop smart integrated infrastructure through the tools for data analysis Topic T4: Field trip In most years, the module has a one-day field trip. Topic T5: Final presentations Here students present their own impressions about the concept of WSC, its implementation, challenges, suitability, etc. They do peer-assessment.	
Education Material	This module is innovative and interactive. The coursework is highly interactive and workshop type activities are conducted. Hence no traditional books are there	
	Books	Every year a set of scientific papers, reports and book chapters will be provided in addition to the slides used in the class.
Scientific Software		

Topic Table and Workload Distribution

Sr. No.	WTM09 Data Analytics and Water Sensitive Cities	Teaching Scheme Hours Distribution			Credits (15 hours = 1 Credit)
		L	T	P	
1	Introduction to water sensitive cities	--	2		
2	Case studies (change every year)	--	12	14	
3	Data Analytics	--	4	6	
4	Field trip	--	--	4	
5	Final presentations	--	--	3	
	TOTAL		18	27	3

IMP Note: By week 21 the student shall have decided their topic of choice to work on for the rest of the year and continue the internship at the host company who has set the topic-challenge

WTM10: Summer Course topic to be decided later as per student's choice

WTM11: Applied Project Work.

In relation to the topic of the student's choice with the host company, some preparatory challenges will be solved in this module, which will enhance the abilities of the students to successfully participate and finish the internship

WTM12: Internship at the host company