

**ACADEMIC AFFAIRS OFFICE  
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

No. Acd./ 378 /IAPC-116

Dated: February 11, 2022

**Head, Department of Water Resources Development and Management**

The IAPC, in its 116<sup>th</sup> meeting held on 02.02.2022 vide Item No. 116.2.3 (2), considered and approved the proposal of Department of Water Resources Development and Management to introduce following PECs:

1. WRN-597: Machine Learning Models in Water Resources Planning and Management
2. WRN-598: Smart Irrigation Systems

The approved syllabus of the above courses is attached as **Appendix-A**.



**Assistant Registrar (Curriculum)**

**Copy to (through e mail):-**

1. All faculty
2. Head of all Departments/ Centres/ School
3. Dean, Academic Affairs
4. Associate Dean of Academic Affairs (Curriculum)
5. Channel i/ AIS (Acad. portal)/ Academic webpage of iitr.ac.in

## INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT/CENTRE:** Department of Water Resources Development and Management

1. **Subject Code:** WRN-597                      **Course Title:** Machine Learning Models in Water Resources Planning and Management
2. **Contact Hours:**                      **L:** 3                      **T:** 1                      **P:** 0
3. **Examination Duration (Hrs.):**                      **Theory:** 3                      **Practical:** 0
4. **Relative Weightage:**    **CWS:** 20-35                      **PRS:** 0                      **MTE:** 20-30                      **ETE:** 40-50                      **PRE:** 0
5. **Credits:** 4                      6. **Semester:** Both                      7. **Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To develop and apply machine learning (ML) approaches to improve overall understanding and enhance their application in water resources planning and management.

### 10. Details of the Course

S.No.	Contents	Contact hours
1.	<b>Introduction to water resource system data and models:</b> Concepts of Systems, models, Classification of simulation models, water resources simulation models, Principles of simulation, Nature and role of simulation, Collection, storage, distribution and processing of large volume of geo-spatial data, statistical analyses	4
2.	<b>Overview of ML approaches:</b> Neural networks, Support Vector Machines, Genetic Programming	4
3.	<b>Optimization techniques in water resources models</b> – linear programming, dynamic programming, Evolutionary algorithms (EA): Basic units of EA, EA operations, Variants of different evolutionary algorithm EA in Watershed modelling: Watershed characteristics; Physics aware artificial intelligence hydrologic model, hybrid models- conceptualization, selection of inputs- mutual information, calibration of parameters, cross validation, and model testing	8
4.	<b>Data driven modelling in water resource systems:</b> <ul style="list-style-type: none"> <li>• <b>Urban runoff models:</b> Introduction to urban hydrology; Rainfall disaggregation, Bias correction of climate data, optimizing urban drainage design variables, prediction/forecasting of runoff</li> <li>• <b>Reservoir simulation models:</b> Reservoir operation policy; Developing models for determination of reservoir storage capacity, reservoir operation – deriving operational rule curves</li> <li>• <b>Groundwater modelling:</b> Introduction to Groundwater hydrology, statistical analyses of groundwater data, prediction and forecasting of groundwater levels</li> </ul>	12
5.	<b>Time series analysis using ML:</b> Data pre-processing tools – wavelets; Time series modelling of water resource system concerning to prediction/forecasting of floods and droughts	4

6.	<b>Sensitivity and Uncertainty analysis:</b> One-at-a-time, derivative and variance based, SOBOL, Monte Carlo simulation, Perturbation method, Bootstrap methods, First Order Uncertainty Analysis (FOUA)	6
7.	<b>Term projects with real case examples:</b> Applications of ML in surface and groundwater simulation models	4
<b>Total</b>		<b>42</b>

### 11. Suggested Books:

<b>S.No.</b>	<b>Name of Authors/Book/Publisher</b>	<b>Year of Publication / Reprint</b>
1.	Sandeep Samantaray, Abinash Sahoo, Dillip K. Ghose, "Watershed Management and Applications of AI" CRC Press, Taylor and Francis	2021
2.	Averill Law, "Simulation modelling and analysis", McGraw Hill Education; 4 <sup>th</sup> Edition	2017
3.	Tayfur, G," Soft Computing in Water Resources Engineering", WIT Press, United Kingdom	2012
4.	Loucks, D.P. and Eelco van Beek, "Water Resources Systems Planning and Management - an introduction to methods, models and applications, Studies and Reports in Hydrology" UNESCO Pub.	2005

## INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

**NAME OF DEPARTMENT/CENTRE:** Department of Water Resources Development and Management

1. **Subject Code:** WRN-598 **Course Title:** Smart Irrigation Systems
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** Provide an overview of the concepts, technologies, and implementation strategies of smart irrigation systems.

### 10. Details of the Course

S.No.	Contents	Contact hours
1.	<b>Introduction to Smart Irrigation Systems:</b> Overview of irrigation and soil-water-plant relationships; Irrigation water requirements and system capacity; Precision irrigation concepts and application; Benefits of precision irrigation; Scope and challenges of the smart irrigation system; Spatial and geographical concepts of precision irrigation.	6
2.	<b>Tools of Precision Irrigation:</b> Geographical Position System (GPS); Geographic Information System (GIS); Variable-Rate Irrigation (VRI) Technology; Remote Sensing (aerial and satellite imagery, above ground non-contact sensors); Unmanned Aerial Systems; Soil, crop, and weather sensors.	8
3.	<b>Variable-Rate Irrigation (VRI) Technology:</b> Considerations in adopting VRI technology; Types of VRI technology; Components of VRI technology; VRI zone and speed; Agronomic benefits and limitations.	6
4.	<b>Elements of Precision Irrigation:</b> Data collection; Data processing; Data Analysis and applications, Solar-based smart irrigation.	6
5.	<b>Applications of IoT and Big Data in Precision Irrigation:</b> Introduction and basics of IoT and big data; Big data source layers; Challenges in application/adoption of IoT/big data in precision irrigation; Big data management on the farm; Applications of IoT/big data to enhance irrigation water management decisions; Case studies.	8
6.	<b>Decision support tools in Precision Irrigation:</b> Introduction and basics of cropping system modeling; Input data requirement and model set up; Agromet Advisory Service in smart irrigation; Development of decision support tools for irrigation water management; Irrigation management with climate-smart irrigation system.	8
<b>Total</b>		<b>42</b>

## 11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	FAO. Climate-smart agriculture case studies 2021 – Projects from around the world. Food and Agriculture organization, Rome.	2021
2.	Pattnaik, P.K., Kumar, R., Pal, S. “Internet of Things and Analytics for Agriculture” Volume 2. Springer.	2020
3.	Pilawjian, G.A., Balech, P.T., Saad, G.E, “Automated Irrigation System” LAP Lambert Academic Publishing, Republic of Moldova, p 80	2018
4.	Zhang, Q. “Precision Agriculture Technology for Crop Farming” CRC Press Taylor & Francis, Boca Raton, FL	2016
5.	Ćulibrk D. (Ed.) “Sensing Technologies for Precision Irrigation”. Springer-Verlag New York.	2014
6.	Heege, H. J. (Ed.). “Precision in Crop Farming: Site-Specific Concepts and Sensing Methods: Applications and Results”. Springer Science & Business Media.	2013
7.	FAO 2013, Climate Smart Agriculture Sourcebook, Food, and Agriculture Organization of the United Nations, ISBN	2013