IARE
INSTITUTE OF
AERONAUTICAL ENGINEERING

# HIGH IMPACT PRACTICES (HIPS)
# HYDRO INFORMATICS
# INFORMATION PACKET
## 2025 - 2026

INSTITUTE OF AERONAUTICAL ENGINEERING
25 YEARS 2000 2025

I appreciate IARE students who are showing interest in the Hydro-Informatics Project Program at the Institute of Aeronautical Engineering.

A cornerstone project (CoP) is typically introduced during the early or middle stages of an academic program at the Institute of Aeronautical Engineering. It focuses on helping students build foundational skills and understand how to apply basic concepts to real-world scenarios. These projects are usually smaller in scope, moderately complex, and designed to strengthen practical understanding of core subjects.

These projects encourage students to connect theoretical learning to data-centric applications, such as developing the data learning model, performing simple data analysis, or creating prototype engineering solutions. Emphasis is placed on learning by doing, helping students build confidence in applying methods like data preprocessing, statistical analysis, basic modelling, and reporting results. By working on these projects, students begin to understand how engineering and data science principles apply in real-world scenarios. Ultimately, cornerstone projects act as the foundation of experiential learning at IARE, transitioning students from passive learners to active problem-solvers, equipped with both technical skills and professional behaviours necessary for the challenges of advanced engineering education.

**Cornerstone Project (CoP) teams are:**

- Collaborative Project – This is an excellent opportunity for students who are committed to working towards social developments and emerging needs.
- Project Activity – The project coordinator listed current working areas for offering cornerstone projects with a team size of at least two students. The coordinator allotted mentors based on the work area and facilitated exclusive project laboratories for selected cornerstone project (CoP)students. This cornerstone project (CoP) bridges the gap between academic learning and real-world social applications. It helps enhance the professional development
- Short-term - Each undergraduate student may participate in a project for an assigned period.

The primary goal of cornerstone projects is to provide a level of moderate complexity, expertise, and diversity of thought in social data-centric areas that will allow them to gain hands-on experience with the cornerstone projects.

- Simulate real-world project work environments - Familiarize students with the structure, expectations, and deliverables typical of data-driven and software development projects.
- Encourage interdisciplinary thinking - Promote the application of data science methods to diverse domains such as healthcare, finance, education, environment, and smart cities.
- Promote ethical and responsible data use - Instil awareness of data ethics, privacy, security, and responsible AI practices during project planning and execution.
- Support data-driven decision making - Enable students to create data solutions that drive actionable insights, support evidence-based decisions, and add value to stakeholders.
- Foster hands-on project experience - Engage students in comprehensive, real-world data science project work that integrates the full data lifecycle from collection to insight generation and emerging technologies like AutoML, NLP, and LLMs.
- Build strong project portfolios - To enable students to create social and industry-ready project portfolios that demonstrate technical depth, innovation, and impact on careers.
- Bridge academic learning and practical application - Apply theoretical knowledge to practical challenges involving data analysis, machine learning, and visualization using real datasets.

The **Hydro-Informatics** project team members work as part of a research-driven group of students, research scholars, and faculty members to tackle innovative design and research challenges in domains such as water resource management, climate-resilient infrastructure, and sustainable watershed development.

By integrating **Hydro-Informatics**—which combines water science with advanced computing tools such as Artificial Intelligence (AI), Machine Learning (ML), Computational Fluid Dynamics (CFD) and Geographical Information Systems (GIS) and Remote Sensing enhances capabilities in flood forecasting, groundwater modelling, irrigation efficiency, and urban water distribution. This interdisciplinary approach empowers the next generation of engineers to make data-driven, sustainable, and adaptive decisions for addressing critical water-related challenges in a changing climate.

**The goals of Hydro-Informatics projects are,**

1. **Enhance Water Resource Management**
   Utilize data-driven tools to improve planning, allocation, and utilization of surface and groundwater resources.
2. **Improve Flood and Drought Forecasting**
   Develop predictive models using AI/ML and hydrological data to provide early warnings and reduce disaster impacts.
3. **Support Sustainable Urban Water Systems**
   Design intelligent systems for real-time monitoring and control of water supply, wastewater, and stormwater networks in smart cities.
4. **Integrate Remote Sensing and GIS**
   Apply spatial technologies to assess watershed conditions, land use changes, and hydrological behaviour across different terrains.
5. **Promote Climate Resilience**
   Model and simulate climate change impacts on hydrological cycles to support adaptive water infrastructure planning.
6. **Optimize Irrigation and Agricultural Water Use**
   Implement smart irrigation techniques and evapotranspiration models for efficient water use in agriculture.
7. **Enable Real-Time Decision Support Systems**
   Build interactive platforms that assist stakeholders in decision-making using live hydrological and meteorological data.
8. **Advance Groundwater Modelling and Management**
   Simulate aquifer systems, recharge rates, and contamination pathways to inform sustainable groundwater extraction policies.
9. **Ensure Water Quality Monitoring and Control**
   Integrate sensors and AI to monitor pollution levels, track sources, and design mitigation strategies.
10. **Facilitate Participatory and Transparent Water Governance**
    Use open data platforms and visualization tools to engage communities and policymakers in water management.

Cornerstone Projects (CoPs) focuses on the challenges presented by the Sustainable Development Goals (SDGs)

| **Sustainability Development Goals (SDGs) for the Dept. of CSE (DS), IARE** | |
|---|---|
| SDG #6 | Ensure availability and sustainable management of water and sanitation for all |
| SDG #9 | Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation |
| SDG #11 | Make cities and human settlements inclusive, safe, resilient and sustainable |
| SDG #13 | Take urgent action to combat climate change and its impacts |
| SDG #15 | Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss |

**Themes of Cornerstone Projects (CoPs) for the CE:**

The following project domains are recommended for cornerstone projects (CoPs), and the students should frame the problem statements from any one of the following themes:

1. Big Data Analytics for Smart Urban Water Management **(SDG #6, SDG #9, SDG #11)**
2. AI-Assisted Sustainable Watershed Planning and Management **(SDG #6, SDG #15)**
3. Explainable AI for Water Quality and Hydrological Risk Analysis **(SDG #6, SDG #9)**
4. AI-Driven Water Quality Prediction for Public Health Protection **(SDG #6)**
5. Cloud-Based Hydro-Informatics Platforms for Watershed Development Planning **(SDG #6, SDG #9, SDG #15)**
6. AI-Based Smart Hydrological Forecasting and Early Warning Systems **(SDG #6, SDG #11, SDG #13)**
7. Deep Learning Models for River Flow and Sediment Load Prediction **(SDG #6, SDG #13, SDG #15)**
8. AI-Enabled Groundwater Potential Zonation Using Remote Sensing and GIS **(SDG #6, SDG #9, SDG #15)**
9. AI-Based Leakage Detection in Urban Water Distribution Networks **(SDG #6, SDG #9, SDG #11)**
10. Reinforcement Learning for Adaptive Reservoir Operation and Water Allocation **(SDG #6)**

In order to participate in cornerstone projects, you must formally apply and be accepted by the project coordinator. To proceed, please mail to the project coordinator, Dr. N Sri Ramya (n.sriramya@iare.ac.in), Assistant Professor of CE. This will bring up all available open positions tagged as cornerstone projects. Please note that participation by the cornerstone project (CoP)team requires registration for the accompanying project work from any of the specified domains. More information will be provided to all selected cornerstone project (CoP)applicants who have been offered a position.

If you have any questions about a particular team, please contact the faculty mentor. We encourage you to contemplate this fascinating new opportunity. We look forward to receiving your application submission!

# Big Data Analytics for Smart Urban Water Management

Dr. Nanna Sri Ramya, Assistant Professor, Civil Engineering _ Faculty Mentor

## GOALS

Big Data Analytics for Smart Urban Water Management is an evolving research domain within Hydro-Informatics that leverages the power of large-scale, real-time data collection and advanced analytics to improve the planning, operation, and management of urban water supply, drainage, and wastewater systems. Traditionally, urban water utilities have faced challenges such as aging infrastructure, non-revenue water losses, unpredictable demand patterns, and increasing risks due to urban flooding and climate variability. Decision-making in such complex, data-intensive systems often suffer from delays, inefficiencies, and a lack of actionable insights.

This research domain introduces big data frameworks integrated with artificial intelligence, cloud computing, and Internet of Things (IoT)-based telemetry to handle vast and heterogeneous data streams generated by urban water networks. These systems aim to automate the analysis of water distribution data, sensor logs, consumer usage patterns, and meteorological inputs to support predictive maintenance, leakage detection, real-time demand forecasting, and operational optimization.

The primary goal is to develop intelligent, data-driven platforms that enable municipal authorities and water managers to make informed, proactive decisions for efficient water delivery, reduce operational costs, minimize energy consumption, and enhance system reliability. This domain contributes directly to Sustainable Development Goals like SDG 6 (Clean Water and Sanitation), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 11 (Sustainable Cities and Communities) by enabling resilient, sustainable, and inclusive water services in urban regions.

## METHODS & TECHNOLOGIES

The enabling technologies for this domain include distributed big data processing systems, AI-powered analytics, cloud-based data storage, and real-time telemetry networks. Platforms such as Apache Hadoop, Apache Spark, and Google Cloud Big Query are widely used for scalable data ingestion and parallel processing of large hydrological and infrastructure datasets. IoT-enabled smart meters, pressure sensors, and flow monitoring devices provide continuous, high-frequency data on system performance and water quality parameters.

Artificial intelligence and machine learning models—including time series forecasting algorithms, anomaly detection systems, and clustering techniques—are applied for real-time demand prediction, leakage detection, and consumer behaviour analysis. Geospatial AI tools are integrated with remote sensing data and GIS-based water infrastructure models to visualize spatial distribution of water usage, detect urban heat islands, and monitor surface water levels.

Dashboards and cloud-based decision support systems consolidate insights from big data analytics, offering interactive visualizations for control room operators and utility managers. Tools like Microsoft Azure IoT Hub, AWS Greengrass, and Google Earth Engine support seamless integration of AI models with real-time telemetry data for dynamic operational decision-making in smart cities.

## MAJORS & AREAS OF INTEREST

This interdisciplinary research domain is especially relevant for students, researchers, and professionals in Civil Engineering, Environmental Engineering, Computer Science, and Data Science. It also intersects with Smart Cities, Urban Planning, and Internet of Things (IoT) applications in infrastructure monitoring. Students in Hydraulic Engineering and Urban Drainage Management will find this area valuable as it addresses contemporary urban water challenges using modern AI and big data tools.

Key areas of research and practical application include AI-driven water demand forecasting, leakage detection and loss management, energy optimization in water pumping stations, real-time stormwater drainage system monitoring, and consumer engagement through smart water metering solutions. Other areas include predictive analytics for pipe burst risk assessment, asset management, and integrated urban water modelling.

By embedding big data analytics and AI technologies into water utility operations, this domain directly contributes to achieving SDG 6 by ensuring safe, affordable, and continuous water access, SDG 9 by promoting innovation-driven infrastructure solutions, and SDG 11 by building resilient, smart urban environments capable of adapting to growing population demands and climate uncertainties.

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## AI-Assisted Sustainable Watershed Planning and Management

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### GOALS

AI-Assisted Sustainable Watershed Planning and Management is an advanced research domain that integrates artificial intelligence, remote sensing, GIS, and hydrological modelling to enhance the planning, prioritization, and management of watersheds. Traditional watershed development relies on manual interpretation of topographic maps, field data, and basic hydrological simulations, which are often time-consuming and limited in spatial and temporal resolution. The growing impacts of land-use changes, deforestation, and climate variability have increased the need for data-driven, adaptive watershed management practices.

This domain focuses on utilizing AI algorithms to automate land capability classification, soil erosion modelling, and watershed prioritization processes. The goal is to develop intelligent decision-support frameworks that optimize water conservation structures, recommend site-specific soil-water conservation measures, and enhance groundwater recharge potential. AI models help identify critical sub-watersheds based on multiple parameters like slope, drainage density, soil texture, and rainfall intensity.

By integrating AI into watershed planning, this research supports sustainable water resource utilization, ecological preservation, and land management in rural and semi-urban regions. It contributes directly to SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), and SDG 15 (Life on Land) by ensuring sustainable land and water conservation interventions at the watershed level.

### METHODS & TECHNOLOGIES

The primary methods employed include supervised and unsupervised machine learning algorithms for terrain classification, land use/land cover (LULC) change detection, and watershed delineation using satellite imagery and DEM data. AI models such as Random Forest, Support Vector Machines, and K-means clustering are used for terrain feature extraction and land capability classification.

Geospatial AI tools like Google Earth Engine and ArcGIS Pro integrated with AI-driven soil erosion prediction models such as RUSLE (Revised Universal Soil Loss Equation) assist in identifying soil erosion hotspots. Decision-tree-based multi-criteria analysis and fuzzy logic approaches are employed for watershed prioritization based on hydrological, environmental, and socio-economic indicators.

AI-based optimization techniques, such as Genetic Algorithms and Particle Swarm Optimization, are utilized for optimal placement of water harvesting structures, check dams, and percolation tanks to maximize water retention and soil conservation benefits.

### MAJORS & AREAS OF INTEREST

This research domain is highly relevant to students and researchers in Civil Engineering, Environmental Engineering, Water Resources Engineering, Remote Sensing, and GIS. It also overlaps with Data Science, AI, and Environmental Informatics due to the integration of AI models with geospatial and hydrological data. Professionals involved in rural development, land management, and climate resilience projects will find this domain valuable for practical implementation.

Key areas of research include AI-based watershed delineation, erosion modeling, land capability classification, sustainable site selection for water harvesting, and real-time monitoring of soil moisture and water quality. AI-powered decision support systems for integrated watershed management planning, flood risk mapping, and climate-resilient infrastructure development are also significant areas of interest.

This domain contributes to sustainable rural development, climate-smart agriculture, and conservation of natural resources through AI-driven insights, directly supporting SDG 6, SDG 12, and SDG 15.

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## Explainable AI for Water Quality and Hydrological Risk Analysis

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### GOALS

Explainable AI for Water Quality and Hydrological Risk Analysis is an emerging research area that combines AI-powered prediction models with interpretability techniques to enhance transparency, accountability, and reliability in Hydro-Informatics systems. Traditional hydrological models and water quality monitoring systems often produce complex outputs that are difficult for decision-makers and non-technical stakeholders to interpret. With the growing adoption of AI models in flood forecasting, pollution detection, and hydrological hazard prediction, ensuring explainability and traceability of AI-generated results has become a crucial priority.

This research domain aims to develop explainable AI frameworks that not only predict water quality anomalies, flood risks, and drought events but also justify the reasoning behind those predictions. By providing clear insights into the factors influencing AI model outcomes, these systems build trust among water managers, policymakers, and the public. They also help identify hidden risk factors, data inconsistencies, and operational vulnerabilities within water management systems.

The goal is to create AI-based risk analysis platforms capable of real-time decision support, while maintaining high levels of interpretability and transparency. This domain contributes directly to SDG 6 (Clean Water and Sanitation), SDG 9 (Industry, Innovation and Infrastructure), and SDG 16 (Peace, Justice and Strong Institutions) by promoting fair, responsible, and transparent water governance practices.

### METHODS & TECHNOLOGIES

The core technologies used in this domain include Explainable AI frameworks such as SHAP (SHapley Additive Explanations), LIME (Local Interpretable Model-Agnostic Explanations), and counterfactual reasoning models to interpret AI predictions in water resource applications. These tools allow stakeholders to understand the contribution of each input parameter (e.g., rainfall, soil moisture, pollutant concentration) to a specific prediction, such as a flood alert or water contamination detection.

Machine learning models like Random Forests, Gradient Boosting, and deep learning architectures such as CNN-LSTM are integrated with XAI modules to detect hydrological risks and water quality anomalies. Geospatial AI techniques combined with saliency maps and visual explanation tools are applied for spatially visualizing risk zones, contamination hotspots, and model confidence levels.

Cloud-based hydro-Informatics platforms and AI-driven dashboards are enhanced with real-time explainability analytics to ensure dynamic, interpretable water quality assessments and risk forecasts accessible to non-technical users, city planners, and environmental agencies.

## MAJORS & AREAS OF INTEREST

This research domain is particularly relevant to students and professionals in Civil Engineering, Water Resources Engineering, Environmental Engineering, AI and Data Science, and Remote Sensing & GIS. It also connects with fields like Environmental Policy, Public Health Informatics, and Climate Risk Management.

Key areas of interest include explainable AI for flood forecasting, water quality anomaly detection, drought prediction, and AI model auditing in hydrological applications. Researchers are exploring AI model fairness, uncertainty quantification, and real-time explainability dashboards for hydrological risk management.

The domain supports sustainable and transparent water management practices, enhancing public trust and regulatory compliance in critical water infrastructure operations, directly addressing SDG 6, SDG 9, and SDG 16.

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## AI-Driven Water Quality Prediction for Public Health Protection

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## GOALS

AI-Driven Water Quality Prediction for Public Health Protection is an impactful research domain focused on harnessing artificial intelligence and machine learning techniques to predict and manage potential water quality risks that directly affect human and ecosystem health. Traditionally, water quality monitoring has been reactive, relying on periodic sampling and laboratory testing, often resulting in delayed responses to contamination incidents and public health hazards. The increasing threat of waterborne diseases, industrial pollution, and nutrient overloading in freshwater bodies demands real-time, predictive systems capable of early detection and intervention.

This domain aims to develop AI-based predictive models that analyze water quality parameters such as pH, dissolved oxygen, turbidity, biological oxygen demand (BOD), and heavy metal concentrations using telemetry sensors and remote sensing data. These models help forecast pollution events, detect anomalies, and assess public health risks in drinking water supplies, rivers, reservoirs, and urban water bodies. The ultimate goal is to safeguard community health, prevent disease outbreaks, and support the proactive management of water resources.

It contributes significantly to SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), and SDG 14 (Life Below Water) by ensuring the safety of water resources for human use and preserving aquatic ecosystems through data-driven, anticipatory water quality management systems.

## METHODS & TECHNOLOGIES

This domain utilizes supervised machine learning algorithms such as Decision Trees, Random Forests, Support Vector Machines, and Deep Neural Networks to predict water quality indicators based on historical and real-time data streams. Time series models like ARIMA and LSTM are employed for forecasting pollution trends and identifying periods of heightened public health risk.

AI-based anomaly detection algorithms, including Isolation Forests and Autoencoders, are integrated with water sensor networks for real-time detection of outliers and contamination events. Geospatial AI models process remote sensing data to assess eutrophication risks, algal bloom occurrences, and sediment pollution in water bodies.

Cloud computing platforms and IoT-based water quality monitoring systems enable continuous data acquisition, storage, and AI-driven analysis, facilitating early warning alerts and decision support for water supply agencies and public health departments.

## MAJORS & AREAS OF INTEREST

This research area is highly relevant for students, researchers, and professionals in Civil Engineering, Environmental Engineering, Water Resources Management, Public Health

Engineering, and Data Science. It also holds value for those in Environmental Informatics, Urban Governance, and Public Health Informatics due to its interdisciplinary nature.

Key areas of interest include AI-based contamination prediction models, real-time water quality monitoring systems, disease outbreak risk assessment, and the integration of AI-driven decision support systems with municipal water supply operations. Research into public health surveillance models using AI to correlate water quality anomalies with disease incidence trends is also gaining momentum.

The domain directly addresses community health protection and sustainable water management by embedding AI-driven, preventive measures into public infrastructure systems, thereby supporting SDG 3, SDG 6, and SDG 14.

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## Cloud-Based Hydro-Informatics Platforms for Watershed Development Planning

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## GOALS

Cloud-Based Hydro-Informatics Platforms for Watershed Development Planning is a progressive research domain that focuses on integrating cloud computing, AI, remote sensing, and geospatial analysis tools into a unified, scalable, and collaborative decision-support framework for watershed management. Traditionally, watershed development planning has been hampered by fragmented data, limited computational resources, and lack of real-time integration between field data, hydrological models, and management authorities. This limits timely decision-making and hinders the sustainable development of critical land and water resources in rural and semi-urban areas.

This domain aims to develop intelligent, cloud-hosted Hydro-Informatics systems that provide centralized access to real-time watershed data, AI-enhanced modeling tools, and decision-support dashboards for multi-stakeholder use. These platforms facilitate collaborative watershed development planning, incorporating land-use classification, hydrological simulation, soil erosion analysis, and water harvesting structure optimization.

By leveraging cloud infrastructure, these systems ensure scalability, remote accessibility, and continuous data synchronization from telemetry sensors, mobile apps, and satellite feeds. The ultimate goal is to empower decision-makers with actionable insights for sustainable watershed management, soil and water conservation, and rural development projects. This domain directly supports SDG 6 (Clean Water and Sanitation), SDG 9 (Industry, Innovation and Infrastructure), and SDG 15 (Life on Land) by promoting resilient, technology-enabled watershed development frameworks.

## METHODS & TECHNOLOGIES

The enabling technologies in this domain include cloud-based data management systems such as Google Cloud, Microsoft Azure, and AWS for hosting watershed datasets, AI models, and decision-support dashboards. AI algorithms, including supervised and unsupervised learning, are employed for terrain classification, erosion risk prediction, and hydrological anomaly detection.

Geospatial AI tools integrated with remote sensing imagery and Digital Elevation Models (DEMs) facilitate automated watershed delineation, stream network extraction, and sub-watershed prioritization. AI-powered optimization algorithms like Genetic Algorithms and Particle Swarm Optimization are used for the strategic placement of soil and water conservation structures within the watershed.

Cloud-hosted Hydro-Informatics dashboards consolidate real-time data streams, AI-generated insights, and hydrological simulation outputs into user-friendly visualizations for water resource managers, agricultural extension officers, and local governance bodies. Mobile-integrated data collection systems and IoT-based sensor networks feed continuous data into the cloud platform for adaptive, real-time planning.

## MAJORS & AREAS OF INTEREST

This research domain is highly relevant for students, researchers, and professionals in Civil Engineering, Environmental Engineering, Water Resources Management, Remote Sensing & GIS, and Data Science. It also intersects with Cloud Computing, Smart Agriculture, and Sustainable Infrastructure Planning, making it a highly interdisciplinary field.

Key areas of interest include AI-enhanced watershed prioritization, cloud-based data integration for watershed analytics, predictive modelling of hydrological behaviour, and AI-driven land capability classification. Additionally, real-time soil moisture and rainfall monitoring using IoT-integrated telemetry systems, cloud-hosted geospatial analytics for soil erosion assessment, and collaborative decision-support interfaces for rural water resource management are significant research areas.

This domain directly strengthens rural sustainability, climate adaptation, and integrated water management strategies through AI-powered, cloud-based solutions, addressing SDG 6, SDG 9, and SDG 15.

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## AI-Based Smart Hydrological Forecasting and Decision Support Systems

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### GOALS

AI-Based Smart Hydrological Forecasting and Decision Support Systems is an emerging interdisciplinary research domain within Hydro-Informatics that focuses on integrating artificial intelligence and machine learning techniques into water resources management and hydrological prediction systems. Traditionally, hydrological forecasting and water resource decision-making have relied heavily on manual data interpretation, statistical models, and physical hydrological simulations. These approaches, though effective, are often time-consuming, data-limited, and sensitive to uncertainties in climatic and land-use changes.

This domain leverages AI to automate and enhance the collection, analysis, prediction, and visualization of hydrological data for applications such as flood forecasting, drought monitoring, reservoir operation, and watershed prioritization. The primary goal is to build intelligent systems capable of generating reliable, real-time forecasts and decision recommendations based on multi-source data — including remote sensing, telemetry, and historical records.

These AI-enhanced systems aim to improve early warning capabilities, minimize water-related disaster risks, and optimize resource allocation in water-scarce and climate-vulnerable regions. AI-driven Hydro-Informatics frameworks also contribute to sustainable urban water management by supporting smart water distribution, demand prediction, and anomaly detection. This domain directly supports SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action) by enabling climate-resilient, data-driven water management and disaster mitigation strategies.

### METHODS & TECHNOLOGIES

The core enabling technologies for this domain include advanced machine learning models and AI-powered big data analytics platforms capable of handling large spatiotemporal hydrological datasets.

Key techniques include:

- **Time Series Forecasting Models**: LSTM, ARIMA, Prophet, and hybrid CNN-LSTM models for rainfall-runoff and streamflow forecasting.
- **AI-Based Flood Prediction Systems**: Real-time flood forecasting models using telemetry and remote sensing data, combined with AI-based anomaly detection algorithms.
- **Geospatial AI (GeoAI)**: AI-enhanced remote sensing, GIS analytics, and land-use change detection for watershed prioritization and flood risk mapping.
- **Hydro-Informatics Decision Support Systems (DSS)**: AI-integrated DSS platforms that combine hydrological models with predictive analytics for operational decision-making in reservoirs, irrigation, and water distribution networks.

- **Cloud Computing and IoT-based Data Acquisition**: Integration of AI models with cloud-based platforms for real-time telemetry data handling from IoT sensors and meteorological stations.

These systems employ AI libraries and tools such as TensorFlow, Keras, Scikit-learn, and cloud services like AWS IoT and Google Earth Engine, along with Hydro-Informatics tools like HEC-RAS, MIKE SHE, and SWAT integrated into AI workflows.

## MAJORS & AREAS OF INTEREST

This research domain is highly relevant for students and professionals in Hydraulic Engineering, Civil Engineering, Remote Sensing & GIS, Environmental Engineering, and Computer Science (for AI integration). It also intersects with Climate Informatics, Data Science, and Smart Infrastructure Planning.

Key areas of research and practical application include:

- AI-based rainfall-runoff forecasting and hydrological disaster early warning systems.
- AI-enhanced water demand prediction and distribution optimization.
- Real-time AI-based anomaly detection in urban water networks.
- AI-assisted hydrological risk analysis and climate resilience planning.
- Sustainable watershed prioritization and AI-powered erosion control planning.
- Integration of AI-based decision support systems for smart cities and rural water management schemes.

The domain promotes climate-smart water governance and contributes to Sustainable Development Goals like SDG 6, SDG 11, and SDG 13 by embedding AI innovation into core water resource management strategies.

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## Deep Learning Models for River Flow and Sediment Load Prediction

Dr. Nanna Sri Ramya, Assistant Professor, Civil Engineering _ Faculty Mentor

## GOALS

This project focuses on leveraging deep learning models to predict river discharge and sediment load dynamics in riverine systems. River sedimentation and flow variability are critical parameters for sustainable watershed and river basin management. Traditional hydrological models often struggle to capture nonlinear dependencies and spatio-temporal variability in sediment transport processes, particularly under climate variability and land-use changes.

Deep learning frameworks, such as Long Short-Term Memory (LSTM) networks and Convolutional Neural Networks (CNNs), offer a promising alternative by learning complex patterns from historical hydrological, meteorological, and remote sensing data. The primary goal is to build an intelligent, data-driven prediction system that improves decision-making in flood risk assessment, reservoir operation, sedimentation control, and habitat conservation. The project aligns with SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action), and SDG 15 (Life on Land) by enhancing river health, promoting ecosystem resilience, and improving water resource sustainability.

## METHODS & TECHNOLOGIES

Key methods include time-series analysis using LSTM or GRU networks trained on rainfall, temperature, streamflow, and sediment concentration datasets. Hybrid models combining CNNs with sequence models are used for capturing both spatial and temporal correlations. Data preprocessing involves noise filtering, normalization, and imputation of missing values. Satellite-derived data (e.g., from MODIS, Landsat, or Sentinel) and gauging station measurements are integrated to train robust predictive models. Model training and validation are performed using frameworks like TensorFlow or PyTorch. Performance evaluation metrics such as RMSE, NSE, and $R^2$ are used to assess model reliability. GIS-based visualization tools help display spatiotemporal sediment load predictions for watershed managers.

## MAJORS & AREAS OF INTEREST

This research area is suitable for students and professionals in Civil Engineering, Water Resources Engineering, Geoinformatics, and Environmental Data Science. It is highly relevant for those interested in river basin modelling, soil erosion studies, reservoir sedimentation, and predictive hydrology. Applications include sediment budgeting, design of sediment traps, integrated catchment management, and decision support for reservoir siltation control. The project contributes to building climate-resilient infrastructure and preserving aquatic habitats through advanced AI techniques.

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## AI-Enabled Groundwater Potential Zonation Using Remote Sensing and GIS

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### GOALS

This project aims to use AI algorithms in conjunction with remote sensing and GIS data to delineate zones with high groundwater potential. Identifying such zones is critical in semi-arid and water-scarce regions where groundwater is the primary source of water for agriculture, domestic use, and industry.

Traditional groundwater assessment techniques are often time-consuming and require extensive field surveys. AI-enabled methods provide a faster, more scalable approach by analysing spatial features such as lithology, slope, rainfall, drainage density, and land use. The goal is to create accurate, data-driven groundwater potential maps that support groundwater exploration, aquifer recharge planning, and sustainable water resource management. The project aligns with SDG 6 (Clean Water), SDG 9 (Industry & Innovation), and SDG 15 (Life on Land).

### METHODS & TECHNOLOGIES

The project uses GIS-based spatial data layers derived from satellite images (Landsat, IRS, DEMs) and ground-truth datasets. Feature extraction is followed by application of AI classifiers like Support Vector Machines (SVM), Random Forests (RF), or Gradient Boosting to determine the relative importance of hydrogeological parameters.

Multi-criteria decision-making tools like Analytical Hierarchy Process (AHP) may be integrated for knowledge-based weighting. The final output is a groundwater potential map ranked into high, moderate, and low zones, validated with borewell data and field observations. Technologies used include ArcGIS/QGIS, Google Earth Engine, Python (scikit-learn), and Google Colab for cloud-based processing.

### MAJORS & AREAS OF INTEREST

The integration of Artificial Intelligence (AI) with Remote Sensing (RS) and Geographic Information System (GIS) technologies has revolutionized groundwater potential zonation, particularly in water-scarce regions. This interdisciplinary topic spans Civil Engineering, Environmental Engineering, Geology, and Geoinformatics, offering advanced tools for water resource planning, watershed management, and hydrogeological analysis.

AI-driven models can process complex spatial datasets—such as lithology, land use, slope, rainfall, drainage, and geomorphology—to identify and map zones with high groundwater potential. These maps support critical applications including site selection for wells and boreholes, groundwater recharge planning, drought resilience mapping, and hydrogeological risk assessment. The use of machine learning algorithms like Random Forests, SVMs, or deep neural networks enhances the accuracy and adaptability of these predictions, enabling data-driven, location-specific decisions that were previously difficult with traditional methods.

This approach is particularly beneficial for engineers, planners, geologists, and environmental scientists working toward sustainable water infrastructure. Civil engineers can use groundwater potential maps to optimize water supply schemes and well placements, while environmental engineers can assess aquifer sustainability and identify areas vulnerable to over-extraction or contamination. Geologists contribute key subsurface data, and geoinformatics specialists enable real-time spatial analysis and model integration.

The AI-based framework not only reduces time and cost associated with manual surveys but also allows dynamic updates as new data become available. For students and researchers, this topic fosters interdisciplinary skills in spatial modelling, AI applications, and sustainable resource planning—making it highly relevant in addressing global challenges like water scarcity, climate variability, and urban water demand.

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# AI-Based Leakage Detection in Urban Water Distribution Networks

Mr. R Suresh Kumar, Assistant Professor, Civil Engineering _ Faculty Mentor

## GOALS

This project targets the growing issue of non-revenue water losses in aging urban water supply networks. Leakage not only results in economic loss but also undermines urban sustainability and equitable water distribution. Traditional manual leak detection is slow, costly, and lacks predictive capability.AI-based leakage detection systems integrate real-time sensor data, hydraulic modelling, and machine learning algorithms to automatically identify and localize anomalies in pressure and flow patterns across the network. The goal is to develop a scalable, real-time leakage monitoring framework that reduces operational costs, conserves water and enhances service reliability—contributing to SDG 6 (Clean Water), SDG 9 (Infrastructure Innovation), and SDG 11 (Sustainable Cities).

## METHODS & TECHNOLOGIES

The integration of smart water meters, acoustic sensors, and flow/pressure sensors across urban pipeline networks has transformed water distribution systems into intelligent, data-driven infrastructures. These IoT-enabled devices continuously monitor parameters such as flow rate, pressure, and acoustic signatures, generating real-time data streams that serve as the foundation for anomaly detection and predictive maintenance.

Advanced AI techniques—such as autoencoders for unsupervised pattern recognition, K-means clustering for behavioural grouping, and isolation forests for outlier detection—are applied to identify deviations indicative of leaks, bursts, or unauthorized consumption. To ensure reliability, these AI-generated insights are validated using hydraulic simulation tools like EPANET and WaterGEMS, which simulate various demand scenarios and pressure zones across the water network. This hybrid AI-hydraulic modelling approach not only enhances detection accuracy but also enables pre-emptive decision-making in urban water management.

## MAJORS & AREAS OF INTEREST

Deployment of such systems is facilitated by cloud-based platforms like AWS IoT Core and Azure Machine Learning, which support scalable data ingestion, real-time analytics, and continuous model retraining. These platforms also enable the creation of interactive dashboards that provide actionable alerts and health reports for pipeline networks—allowing utility operators to pinpoint failures and prioritize maintenance, thereby reducing time-to-repair and water losses. The system generates tangible outputs such as leak probability maps, pipeline health scores, and real-time notifications for field engineers.

This topic is highly relevant to students and professionals in Civil Engineering (Urban Water Supply), IoT in Infrastructure, Environmental Systems, and AI for Smart Cities, particularly those interested in water auditing, infrastructure resilience, smart metering, and sensor-based automation. By combining AI, IoT, and hydraulic modelling, this framework offers a pathway toward intelligent and sustainable urban water infrastructure.

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## Reinforcement Learning for Adaptive Reservoir Operation and Water Allocation

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### GOALS

This project applies reinforcement learning (RL), a branch of AI, to optimize reservoir operation strategies under uncertain inflow, demand, and climate scenarios. Traditional rule-curve-based operation methods are often static and fail to adapt to changing priorities such as irrigation, hydropower, flood control, and ecological flows. RL frameworks allow for adaptive, self-learning control policies that improve water allocation efficiency, reduce energy costs, and enhance multi-purpose reservoir performance. The goal is to design smart reservoir controllers that learn optimal release schedules over time, balancing competing objectives while ensuring sustainability. The project supports SDG 6 (Water), SDG 7 (Clean Energy), and SDG 12 (Responsible Consumption).

### METHODS & TECHNOLOGIES

Markov Decision Processes (MDPs), Deep Q-Learning, and Proximal Policy Optimization (PPO) are used to train agents on historical inflow, storage, and release data. The RL agent interacts with a simulation environment representing reservoir dynamics and reward structures (e.g., water demand satisfaction, power generation, flood mitigation). Tools include Python (TensorFlow, OpenAI Gym), MATLAB/Simulink, and reservoir modelling packages like HEC-Res. Climate forecasts and remote sensing inputs may be integrated for anticipatory decision-making. Sensitivity analysis and Pareto optimization methods ensure robustness under uncertainty.

### MAJORS & AREAS OF INTEREST

Relevant for students in Civil Engineering, Hydrology, Water Resources Systems, and AI for Engineering Optimization. Particularly valuable for research in multi-objective reservoir operations, decision support systems, and sustainable hydropower. Key applications include reservoir rule curve updating, inter-basin water transfer planning, and transboundary water conflict minimization.

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