Expert Roundtable on

Urban Water Management Challenges and AI Solutions

17th August 2022

(A confluence session of industry leaders, technologists, innovators, and researchers to understand the use cases, problems, challenges, and particularly AI-based solution possibilities pertaining to Urban Water Management)

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Compiled by Sanchita Joshi (Consultant) and Prakarsh Mishra (Senior Manager) from the AGNIi Mission of the Office of the Principal Scientific Adviser at Invest India

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1 Context

As per UN estimates[1] India's urban population is expected to add another 416 million people to its urban areas by 2050. This rapid pace of urbanization along with climate change can pose additional challenges with respect to demand proliferation, stress on natural resources, and management, operation, and expansion of critical infrastructure. This calls for immediate and better utilization of legacy as well as emerging technology solutions to meet India's urban challenges effectively and efficiently. The objective of the same would be to propel economic growth and improve the quality of citizens' lives through deployment of integrated and sustainable technology solutions which are locally relevant in order to render smart outcomes. In this context, the Government of India has also emphasised on development of low-cost and user-friendly technologies for resolving varied urban challenges. Against this backdrop of emerging national priorities, the AGNIi Mission along with IIIT Hyderabad organized an Expert Roundtable series titled 'Technology and Innovation for Sustainable and Resilient Cities'. It brought together a gamut of stakeholders to deliberate on how best emerging technologies and innovations, especially with respect to artificial intelligence (AI) can be leveraged by Indian cities to resolve their current urban challenges and ensure sustainable development.

The focus of the discussion was on the following segments:

1. Existing key urban water management challenges and identifying priority areas specific to Indian cities for technology intervention
2. Best practices in urban water management through AI technology adoption and scaling
3. Expertise to be developed at the city level for technology adoption.

In this context, the current position paper summarises the key deliberations and the way forward.

2 Key deliberations

Discussion was initiated to understand the key challenges that are being faced in urban water management.

2.1 Climate change – affects water consumption and quality

According to experts, climate changes like variability of temperature and precipitation dynamically change the water flow and water levels which pose major challenges in the context of urban water management. Sensors can be installed to assess the water flow pattern and quality, along with climatic data sets, and manage urban water flows in a better and more efficient manner.

Climate informatics is informed by AI-driven technology that can refine weather forecasting and provide better understanding of climate change risks. Deep learning networks allow for energy efficient means to run AI algorithms, allowing for better understanding of climate risks, trends and predictions. AI, via advanced data modelling tools, can thus provide the means to predict accurately the changing weather conditions. Using real-time data analysis, AI leverages multi-sourced data to accurately predict extreme weather conditions in advance. By analysing climate trends and examining the areas at high-risk, AI can help develop a more adaptive response system

[1] https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html

to disasters. AI algorithms can assist in creating more opportunities for disaster response to provide predictive data, warnings and emergency information.

2.2 High urbanization rates – Increase in water pollution in big cities

Population is expected to significantly increase in the coming years. At present, due to unplanned urbanisation, a significant percentage of the water is being discharged without treatment into freshwater sources. There is a need to identify localities with unsafe water disposal and informal settlements.

2.3 Water replenishment- Need of the hour

Water management is primarily concerned with prevention of water wastage. Manual monitoring of identification of leaks and water loss is becoming increasingly difficult as the same can be due to a variety of reasons. In this context, automated systems and satellite imagery can enable identification of areas where water loss is happening in an efficient manner.

Additionally, non-revenue water, treated wastewater, rain-water harvesting, and preservation and rejuvenation of water bodies are also areas that need immediate focus to prevent future depletion of water sources. Furthermore, technologies such as blockchain and AI can be used to develop a credit system for carbon and water to help achieve the goal of carbon neutrality and water security.

The concept of geospatial technology integrates remote sensing and Geographic Information System (GIS) in a novel manner and has proven to be an efficient tool in groundwater studies. Remote sensing and GIS can be used very effectively in generating various thematic maps (like slope, geology, geomorphology, land use, etc.) for water replenishment and other purposes. The GIS mapping system along with predictive analytics can also be useful to know about the forthcomings in terms of droughts and floods.

2.4 Dataset availability – A tougher challenge

There is a need for policy makers to focus on generating sufficient data sets for different water quality parameters, discharge measurement datasets and flow measurement, etc. For e.g., the generation of these datasets during high flow and low flow, can help to estimate turbidity, temperature, oxygen levels for different inflow conditions and high and low water flow areas can be predicted to take preventive actions accordingly.

There is a need for datasets associated with wastewater, rainwater, clean water and treated water in order to tackle problems like urban flooding. In most cases, these data sets are collected by different government agencies and data acquisition itself presents a challenge.

2.5 Water quality measurement – Lot to consider

At present, only Total Dissolve Solids (TDS) and pH of water is measured, which according to experts, alone is not sufficient. There are more than 20 parameters[2] associated with water quality. Cost effective indigenous sensors need to be identified.

[2] https://cpcb.nic.in/wqm/Guidelines_Water_Quality_Monitoring_2017.pdf

2.6 Implementation challenges – Slowing progress

In the context of procurement, as per experts, designing technical tenders presents a challenge where emerging technologies are concerned. The justification of cost escalation in the proposals poses a constraint because of fast changing technologies. Procurement tenders can focus on end requirements in addition to the technology used in building it. In particular, in delivering public benefit at the price most competitive for taxpayers, emerging technologies have certain complexities which traditional procurement systems (designed for other contexts and requirements) are not adapted for. For example, when considering AI solutions for urban water management, if any hardware component is involved, there is a need to manufacture these components at large scale. If a solution provider does not have enough operational manufacturing capability, even though they are providing the most effective software solutions, they may fail to meet the requirements of traditional procurement systems. Therefore, there is a need to revisit these traditional ways for providing a way forward to these technologies.

Meanwhile, the intention of decision makers to approve the project based on feasibility of the given requirements also presents an important factor that needs consideration. However, pilots or proof of concepts can be conducted to account for this.

Last but not the least, there are maintenance challenges. There is a requirement of quasi technical manpower and automation at the ground level, for both maintenance and implementation.

2.7 Sensors related challenges – Priority

Sensors are an important aspect of modern engineering and can improve our day-to-day life with their applications in almost every field. Sensors collect data in the form of signals by detecting changes in the environment and then respond accordingly. Light, temperature, movements, and pressure etc. are among the range of sources that are used to collect data. In this context, the participants identified the following challenges related to the role of sensors in water management:

- Identification of protective locations for sensor placement.
- At present, water quality as well as quantity are measured manually which incurs errors of sampling. There is a requirement for innovation when it comes to samplings and automation for data authenticity. A proposed alternative is mass deployment of sensor devices. However, as the availability of sensors in India is low, they are being imported at high prices and minimum technical support. For example, physical sensors for water quality measurement like chlorine, nitrate, are not manufactured in India and when procured from outside they can be expensive, for example, experts highlighted that at times sensors can cost around 5 lakh rupees a piece.
- Calibration data need and procedure of calibration for different spatial and temporal conditions can be devised and be updated on a regular basis for cost effective sensors.
- There are no sensors available for measurement of water hardness, total ammoniacal nitrogen, total phosphorous, total carbon and biological sensors for prediction of e-coli etc. Only TDS which is a derivative for water hardness can be used to a certain extent.

- Non-availability of indigenously designed sensors, to work in a scenario where the water supply is intermittent in India. Whereas the imported sensors are suited for situations characterised by continuous water supply. To address the local contextual challenges, the design of these sensors needs to be indigenized as well.
- Short life span of sensors - approximately 2-5 years.
- Non-availability of technology that identifies the source of contamination.

3 Way forward

3.1 Focus on sensor research – Need of indigenous low-cost sensors

As a country, India needs to bring focus on sensor research and large-scale sensor manufacturing to reduce dependency on high-cost foreign imports and enable wider deployment to tackle the myriad urban water management challenges. The IoT sensors are required to be interconnected and work in sync to capture and send relevant data to the control system. Interconnectedness and data stream help in capturing the relevant data and overcoming ambiguity. The timeframe should be properly planned in accordance with the location and the flow of water – which helps in capturing data periodically. Some examples of sensors are pH Sensor, Conductivity Sensor, Residual Chlorine Sensor, Turbidity Sensor. When multiple sensors capture multiple parameters of water, data cleaning plays a vital role in the process to extract critical information.

There is also a need to identify alternatives to sensors by way of developing solutions that utilise AI vision to train images, to produce a good cost-effective database. For instance, development of bioluminescence sensors (bacteria which change colours with respect to contamination - used in Israel[3]) with nil operational costs can be explored. This would allow locally manufactured sensors to be deployed in various locations

3.2 Improved infrastructure – Building future capacity

To maximise the delivery of AI efforts, good, fast and reliable networks are a must. Deep learning algorithms are very much dependent on communications; this also suggests the need for strong networks. Additionally, AI requires a high-bandwidth, low-latency network. Hence, infrastructure development becomes a must to support high speed computing to build AI solutions to generate required data sets.

3.3 Network maintenance – Ensuring reliability

Maintenance plays a major role post deployment of sensors at various locations to monitor water related parameters. Automated processes and mechanisms need to be put in place to ensure that sensors are constantly checked for proper functioning and data availability.

3.4 Citizen awareness and accountability – Adopting a bottom's up approach

Citizens living in a particular locality are better aware of the exact nature of the problem being faced in the area. Data from citizens (micro level) is required to drive meaningful action and change. Initiatives like the Water Bank can be started, wherein citizens are provided credits for water conservation. Blockchain technology can be used for this purpose. For instance, an industry

[3] https://www.nytimes.com/2021/06/21/science/landmines-glowing-bacteria.html

can create an account in the Water Bank, if it is following zero discharge norms, undertaking 100 percent recycling, not engaging in groundwater extraction, following all the best practices. In this manner, the approach to urban water management can be made more citizen driven.

Furthermore, incentives and penalties can be utilised to make citizens aware and responsible for water consumption and sewage disposal. At times, incentivization plays a major role in plan implementation. Branding houses based on their water savings and waste generation and subsequent incentivization and penalty can make the solution more impactful. Social media is a powerful tool, which can be utilised for both promoting citizen awareness and incentivization policies. Existing apps can be made to reach more people to update about immediate issues regarding water infrastructure in their localities.

3.5 Promoting best practices

Many countries and even few Indian states provide good examples of urban water management. Administrative units can try to emulate/replicate those models. For example, harvesting in Thailand, where a Prototype of Tumblers is being adopted at society level; in Singapore's Changi[4] airport, water requirement of garden space is met with wastewater as treated water is high in nitrogen and phosphorus and is good for plant growth. These and other models can be replicated in India as well to help reduce water wastage.

3.6 Skill development of ground personnel

Ground level staff like plumbers can be made aware of available technology solutions as they can help to promote the same on the ground level. Certification courses, build-up centres for their training can be expanded. Since these personnel work at the ground level, they can play an instrumental role to effectively tackle urban water management problems.

3.7 AI / ML for conditional infrastructure assessment

AI/ML video analytics can be utilised for assessing the life expectancy of water pipelines. Condition assessment of pipelines is difficult in certain areas due to geographical conditions (such as desert areas). Video analytics can be deployed to assess the life expectancy of these assets and the optimum duration of replacement. Also, it can help to reconstruct datasets where data is missing and the same can be validated using satellite data.

4 Action points

AGNIi Mission and IIIT Hyderabad will continue to work together on following action items:

- Understanding the pain points, use cases and operational scenarios on application of Indian emerging technology to enhance water management across geographies through surveys, discussions etc.
- Collaborate on scouting indigenous technologies for the use cases identified
- Conduct workshops/technology showcases on algorithm-based systems, sensor research and datasets to demonstrate the solutions to relevant stakeholders

[4] https://www.water-technology.net/projects/changi-reclamation/

- Collaborate on developing emerging technology use cases for relevant government ministries

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For any information contact sanchita.joshi@investindia.org.in and prakarsh.mishra@investindia.org.in