TECHNICAL ARTICLE PREPRINT Water Management · Digital Technology

AI and Water: The Invisible Engineer Behind Every Drop

Artificial intelligence is reshaping how the world produces, distributes and reuses water — insights from Israel and India

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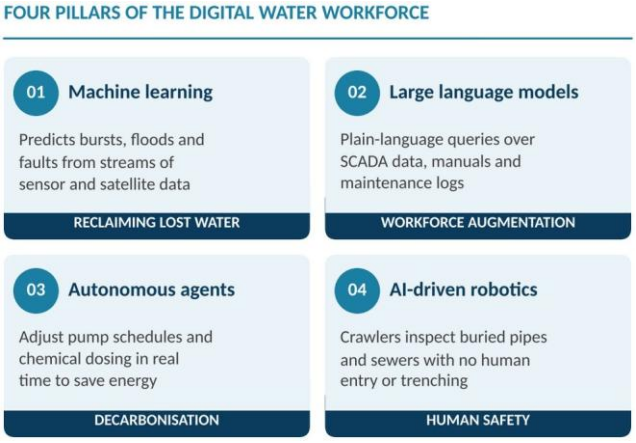
OVERVIEW

AI is the undisputed disruptive technology of our time. It speaks all languages simultaneously, creates astonishing videos and solves century-old mathematical problems. It carries no spanner and digs no trench, but it may end up **saving more water than any dam** by telling us, faster and more precisely than ever before, exactly where water is being wasted, when floods are coming, and how to use every drop more wisely. It also, as any new technology does, brings challenges and risks that the sector must take seriously.

Keywords: artificial intelligence; non-revenue water; leak detection; digital twins; flood forecasting; cybersecurity; wastewater reuse; India; Israel

1 What Exactly Is AI in Water?

In simple terms, AI has evolved from basic data processing, using readings from sensors to detect problems and, in advanced applications, **predict** them before they happen, into a **multidisciplinary digital workforce**. Today's AI encompasses (a) **machine learning** models that process multiple streams of big data and continuously refine fault prediction capability, used, for example, for pipe bursts prevention or flood preparation; (b) **Large Language Models (LLMs)** that allow operators to instantly query complex SCADA systems and engineering manuals using natural conversation; (c) **autonomous AI agents** that independently adjust pump schedules and chemical dosing in real time to optimise energy use; and (d) **AI-driven robotics** that physically navigate and inspect subterranean networks and more. Think of it as the ultimate team of experts — engineers, analysts, and inspectors combined, working around the clock. This tireless "ecosystem" is now rolling out across the world.



AI penetration into the water sector can be seen at all levels, from global macro solutions in flood forecasting to micro level optimisation of dosing systems. Following are selected examples of such solutions:

MACRO-LEVEL: GLOBAL FORECASTING AND SIMULATION

- **Predictive Climate and Flood Forecasting (Google Flood Hub):** Google piloted its AI-powered flood forecasting in India in 2018 and expanded it to Bangladesh in 2020. The system uses machine learning on global weather and river data to forecast riverine floods **up to 7 days in advance** and urban flash floods up to 24 hours in advance covering **2 billion people in over 150 countries**, including over 200 million people in India.
- **Digital Twins for Utility Simulation (Singapore PUB):** Singapore's Public Utilities Board (PUB) heavily relies on its Smart Water Grid and Hydroinformatics platform — a functional digital twin — to simulate and test scenarios without risking physical infrastructure. It uses Machine Learning (ML) to continuously calibrate that model and keep it identical to the operational system.
- **Rural Supply Chain Predictive Maintenance (JJM, India):** At the national level, the Jal Jeevan Mission's mandate spans India's more than **600,000 villages**. Translating this massive scale into regional action, individual states such as Maharashtra have executed immense IoT hardware rollouts, building live dashboards that track flow and water quality across thousands of their own villages simultaneously. While current dashboards focus on descriptive monitoring, this

continuous telemetry provides the foundational data layer required for predictive algorithms for rural needs. Transitioning this passive data into a machine-learning foundation to forecast localised supply deficits, optimise intermittent pump scheduling, and predict asset failures before service disruptions occur is the recognised strategic roadmap for India's rural water sector.

MID-LEVEL: NETWORK AND UTILITY OPERATIONS

- **Water Event Detection & Management (TaKaDu):** TaKaDu uses AI and analytics to convert telemetry real time data into knowledge about network incidents of any type, empowering the operators to manage and prioritise their actions.
- **Acoustic Leak detection (AQS, formerly Aquarius Spectrum):** AQS uses AI and machine learning to analyse raw audio from hydrophones and accelerometers, isolating leak frequencies from urban noise to identify and locate developing leaks.
- **LLM-Based Engineering Co-Pilots (Technion, Israel):** Researchers at the Technion – Israel Institute of Technology are pioneering applied frameworks for Large Language Model-based Multi-Agents (LLM-MAs) in water engineering. These systems integrate with utility data, allowing operators to use natural language queries to instantly synthesise insights from complex SCADA readouts, regulatory compliance manuals, and historical maintenance logs — effectively acting as an interactive digital consultant during emergencies.
- **Orbital Subterranean Leak Detection (ASTERRA):** ASTERRA (formerly Utilis) actively applies machine learning algorithms to radar imaging data from satellites (Synthetic Aperture Radar – SAR) to filter dielectric signatures and pinpoint invisible underground water leaks.

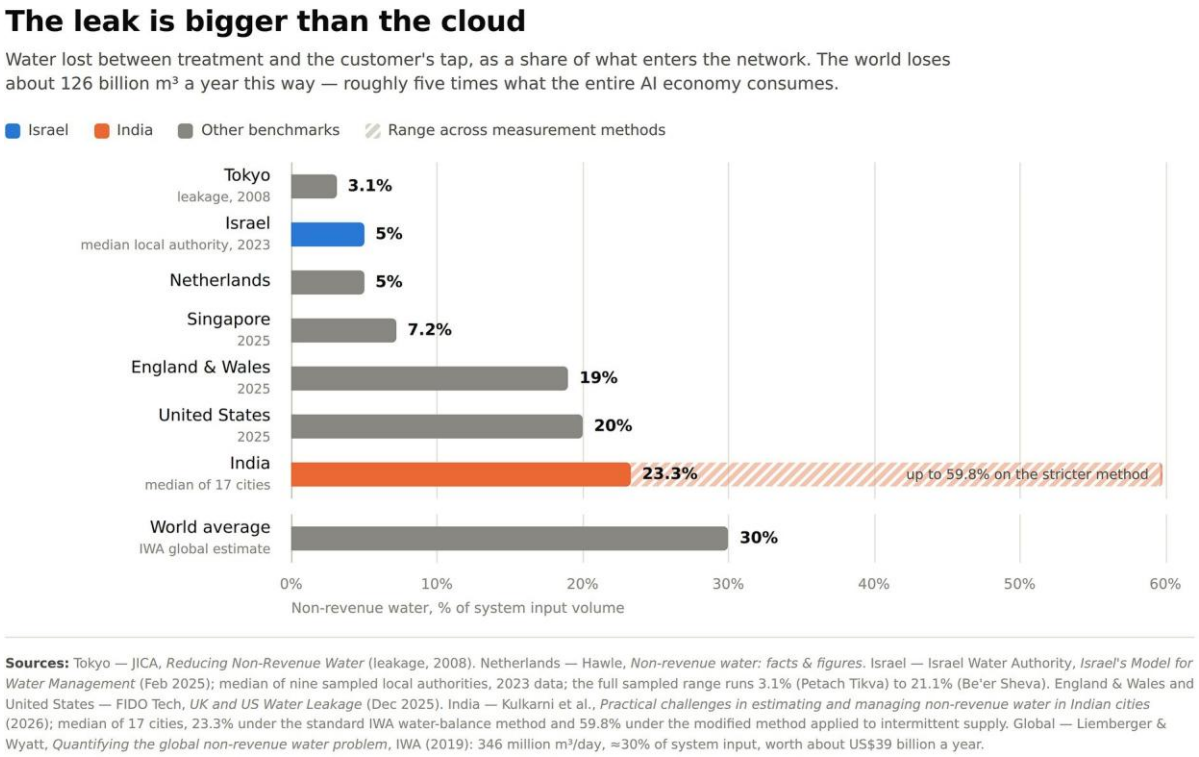


Figure 1. Non-revenue water — water lost between the source and the customer — as a share of system input volume for selected countries and the world average. India's bar shows the median of 17 cities; the hatched range reflects the stricter method applied to intermittent supply.

MICRO-LEVEL: GROUND ACTION AND END-USER IMPACT

- **AI-Guided Precision Agriculture (Israel):** Israeli companies (such as SupPlant, CropX, and Netafim) combine foundational drip irrigation with AI algorithms that process real-time soil moisture, plant stress, and weather forecasts to maximise yield and minimise water waste.
- **AI-Driven Robotic Network Inspection (India):** In Bengaluru, the Bengaluru Water Supply and Sewerage Board (BWSSB) has actively deployed robotic technologies combined with AI-driven data analysis to inspect underground pipelines and detect leaks and illegal connections. Solinas Integrity, an IIT Madras-incubated startup, developed Endobot, a robotic crawler that physically navigates subterranean water lines. Its proprietary Swasth AI cloud software processes laser profiling and HD camera data to automatically categorise defects, detect leaks, identify illegal connections and map

network degradation without requiring hazardous human entry or manual trenching.

- **Household Behavioral Automation (Agua / Dr. Rohit Nara, Bengaluru):** Nara Technologies, founded by Dr. Rohit Nara, deployed the "Agua" AI-enabled smart water system in Bengaluru. 2025 reports confirm the success of automated water source switching, residential leak detection, and successful **water consumption reduction by 35%** and **monthly bills by over 55%**.

Implementing AI shifts utility operations away from chasing water network failures and breaks toward preventive maintenance, surgical repairs, strategic asset management, and climate resilience. In 2025 the global water sector spent about **$9.3 billion on AI** for water management. However, translating these technological capabilities from top tier utility and early adopter deployments into common practice reveals a complex operational divide.

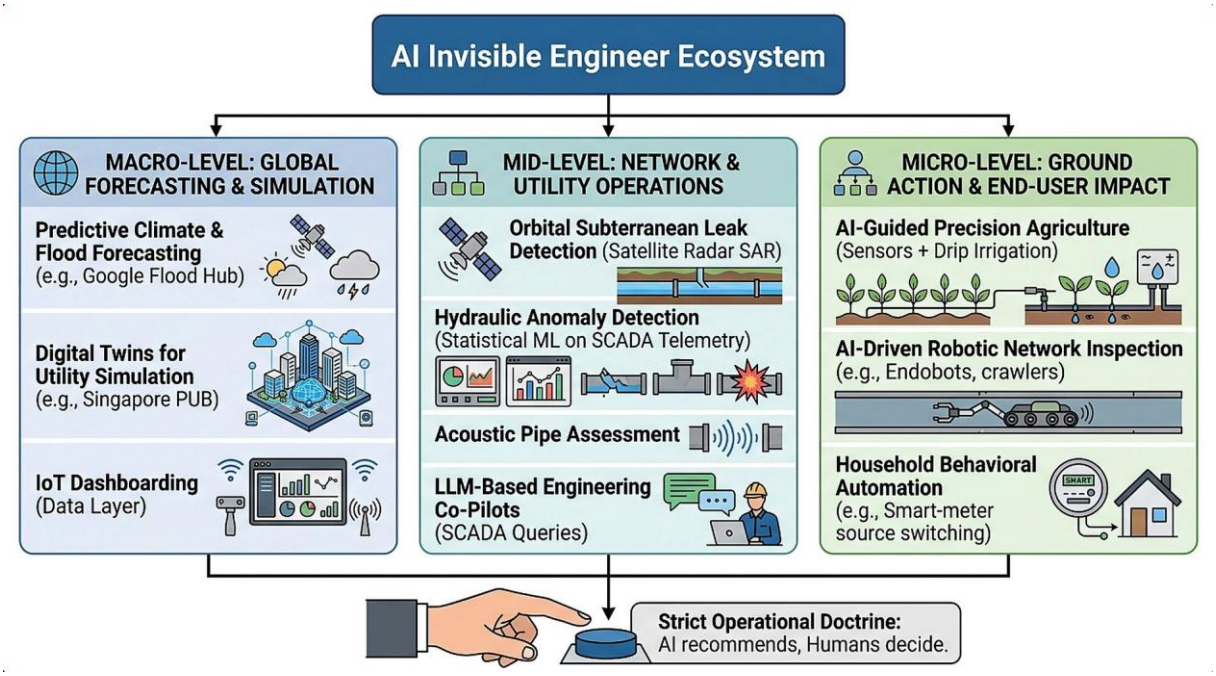


Figure 2. The AI "invisible engineer" ecosystem in water: macro-level forecasting and simulation, mid-level network and utility operations, and micro-level ground action — all governed by the operational doctrine *AI recommends, human decides*.

2 How Widespread Is AI in the Water Sector, Really?

Despite the high-profile breakthroughs across satellite imaging from space, subterranean robots, and digital twins, the penetration of AI remains **sharply divided between pioneering flagships and standard municipal operations**. Recent independent benchmarks confirm that while the water sector is adopting these tools, it is doing so with significant caution.

The American Water Works Association's (AWWA) 2026 *State of the Water Industry Report* found that while utilities are increasingly exploring artificial intelligence, they remain deeply cautious due to cybersecurity risks, funding gaps, and the overwhelming burden of aging physical infrastructure. Deloitte's September 2026 *Future of Infrastructure Survey* further validated this bottleneck, noting that while utilities increasingly rely on AI and operational technologies, broader adoption is severely hampered by institutional friction. Among global infrastructure leaders surveyed, **39% cited complex policies and regulations**, and **31% cited strict budgetary constraints** as the primary hurdles to digital delivery.

THE ADOPTION GAP

39% of infrastructure leaders cite complex policies and regulations as the main hurdle

31% cite strict budgetary constraints

4,000+ Indian urban local bodies — most still on manual oversight and reactive repairs

Sources: Deloitte Future of Infrastructure Survey (2026); authors' analysis.

In India, adoption mirrors this global divide, characterised by targeted flagship initiatives rather than broad systemic deployment. While Bengaluru's BWSSB implements integrated AI monitoring under the Cauvery Stage V expansion, and cities like Bhopal operate multi-sensor SCADA networks under AMRUT 2.0, these remain showcase projects. Across India's more than **4,000 urban local bodies (ULBs)** and state execution agencies such as the Maharashtra Jeevan Pradhikaran (MJP), most networks still rely on manual oversight, localised pump operations, intermittent scheduling and reactive repairs. The modern digital workforce is proving

its technical value, but **closing the gap between advanced pilots and full utility coverage remains the sector's most significant hurdle for the coming decade.**

Table 1. Examples of AI-driven water management deployment

Location	AI-driven water management
Israel	Integrated acoustic, hydraulic, and satellite event-detection networks (TaKaDu, AQS, ASTERRA) covering 2,000+ km of pipe; AI-optimised desalination at Sorek 2
United States	56% anticipate positive impact from generative AI technologies within a year; 49% lack established policies that govern AI use
India — Bengaluru	BWSSB is building an AI-powered control centre under the Cauvery Stage V project for city-wide supply, leak and quality tracking
India — Bhopal	SCADA-based control system with hundreds of sensors; AI features expanding under AMRUT 2.0 / Smart Cities Mission
Singapore	National water agency PUB runs a digital twin of the entire water network for planning and control

2026 (see References).

3 The Promise and the Price

The operational advantages of deploying this digital workforce directly mirror its four technological pillars. By transitioning from manual guesswork to AI-driven precision, utilities are fundamentally altering their economic and environmental baselines, e.g.:

- **Machine Learning (Reclaiming Lost Water):** Global non-revenue water stands at **~126 bn m³/yr**, about 30% of system input — an annual economic drain nearing **$39 billion**. Predictive analytics and satellite radar transform this loss into manageable action, catching hidden bursts before they surface.
- **Autonomous Agents (Decarbonisation):** Algorithmic process control slashes energy consumption in heavy operations like seawater reverse osmosis and agricultural irrigation, operating at a level of real-time optimisation a human cannot physically match.
- **AI-Driven Robotics (Human Safety):** Subterranean robotic crawlers eliminate the need for human technicians to enter hazardous, confined sewer environments.
- **Large Language Models (Workforce Augmentation):** As experienced engineers retire, LLMs act as interactive co-pilots, instantly synthesising complex SCADA diagnostics and compliance manuals to guide junior operators during emergencies.

AT A GLANCE

~126 bn m³/yr
global non-revenue water — about 30% of system input, worth ~US$39 bn a year

US$9.3 bn
spent by the global water sector on AI for water management in 2025

2 billion
people covered by AI flood forecasts in 150+ countries

4.2–6.6 bn m³
projected AI-related water demand in 2027

~90% vs 11%
Israel's treated-wastewater reuse vs the global average

Furthermore, algorithmic reliance creates severe operational vulnerabilities. Predictive models are only as reliable as their sensors; uncalibrated IoT inputs or "sensor drift" can mislead machine-learning models, prompting incorrect chemical dosing or false burst alarms. To prevent catastrophic failures, leading utilities are adopting a strict operational doctrine: **AI recommends, human decides**. Finally, the high cost of these systems threatens to widen the equity gap between affluent urban utilities and underfunded rural networks.

Yet, this computational power introduces severe systemic risks that demand strict executive governance. Most striking is the **water-for-compute paradox**. The very technology deployed to conserve water quietly consumes vast volumes of it inside hyperscale data centres. The global "AI Economy" according to the World Bank blog (Jan 2026) cites **4.2–6.6 bn m³ of AI-related water demand in 2027**, a figure projected to more than double by 2050.

> ***"We are using billions of litres of water simply to cool the servers that tell us how to save water."***

An even greater, immediate vulnerability looms over this digital transformation: **cybersecurity**. Water utilities rely on programmable logic controllers (PLCs) that physically open valves and dose chemicals. These legacy systems are already prime targets for cyberattacks, with or without AI, often left exposed by underfunded municipalities using default passwords. Recent coordinated intrusions by state-linked actors on water systems across the United States demonstrate the severity of this baseline physical threat. Layering AI onto these networks amplifies the stakes. By connecting historically isolated infrastructure to cloud-based AI platforms, utilities inevitably widen their attack surface. While a well-built AI can detect a chemical dosing anomaly or an odd login in seconds, a poorly secured integration hands attackers a smarter set of controls and allows manipulated sensors to blind the AI with false data. As utilities digitise, **security must be built into the foundation from day one, rather than bolted on afterward.**

Table 2. AI in water supply and treatment: benefits vs risks at a glance

Area	Benefit	Risk
Leak & water loss	Pinpoints leaks fast, cutting water losses that run close to 30% globally	Manipulated or faulty sensor data can mask real leaks or trigger false alarms
Flood & disaster warning	Up to 7 days' advance warning, now reaching 2 billion people worldwide	Can fail in truly extreme, unprecedented events; risk of over-reliance
Treatment & chemical dosing	Optimises dosing contributes to a reduced carbon footprint of up to 30% in Sorek 2 desalination plant	Hacked dosing controls can push chemicals to unsafe levels
Utility operations	24/7 monitoring; frees staff for higher-value repair and planning work	Widens the cyberattack surface via connected PLCs and SCADA systems
Households & billing	Cuts household water use and bills — up to 55% in one Bengaluru pilot	Smart-meter data raises real privacy questions for families
Cost & equity	Long-run savings for utilities once systems are running	High upfront cost and skills gap risk favouring rich cities over poor towns
Environmental footprint	Better long-term resource planning and lower emissions	AI's own data centres can consume billions of cubic metres of water globally

4 The Road Ahead — Lessons from Israel and the World

Israel turned water scarcity into a national strength over five decades, and the model offers highly practical lessons.

A multi-tiered, AI-driven leak detection operates alongside large-scale desalination and a wastewater reuse program that returns **nearly 90% of treated water to agriculture**, against a global average of just **11%**.

Drip irrigation, an Israeli invention refined over sixty years and increasingly guided today by AI-based soil and weather sensors, helped multiply the value of the country's farm produce **sixteen-fold** even as water grew scarcer.

Internationally, the direction of travel is similar: "digital twins" let planners in Singapore, the Netherlands, and elsewhere test decisions virtually before touching a single physical pipe.

The strategic lesson for India and other developing regions is **not to wait for perfect, highly expensive systems, nor to connect existing systems carelessly**. Low-cost sensors paired with AI, as already piloted in Bengaluru and rural Maharashtra, demonstrate that immense gains are possible even on modest budgets. These technologies succeed when paired with trained people, trusted data, and basic cybersecurity discipline, such as changing default passwords and isolating control systems from the open internet.

PRACTICAL LESSONS FOR UTILITIES

- ✓ **Start lean** — low-cost sensors paired with AI deliver gains on modest budgets
- ✓ **Trusted data** — calibrate sensors to prevent drift misleading the models
- ✓ **Keep humans in the loop** — AI recommends, human decides
- ✓ **Secure from day one** — change default passwords; isolate control systems from the open internet
- ✓ **Invest in people** — trained operators turn AI insight into action

AI will not replace the plumber, the field engineer, or the policymaker. What it offers is superior visibility and early warning: a way to catch a leak before it becomes a crater, a flood before it becomes a tragedy, and a wasted drop before it drains the economy. As India executes massive initiatives to bring water to every home, and Israel continues refining a model born of necessity, the shared conclusion is clear.

CONCLUSION

AI is a comprehensive tool for water resilience, capable of achieving its true potential when guided by human experts who manage its risks as rigorously as they leverage its rewards. ■

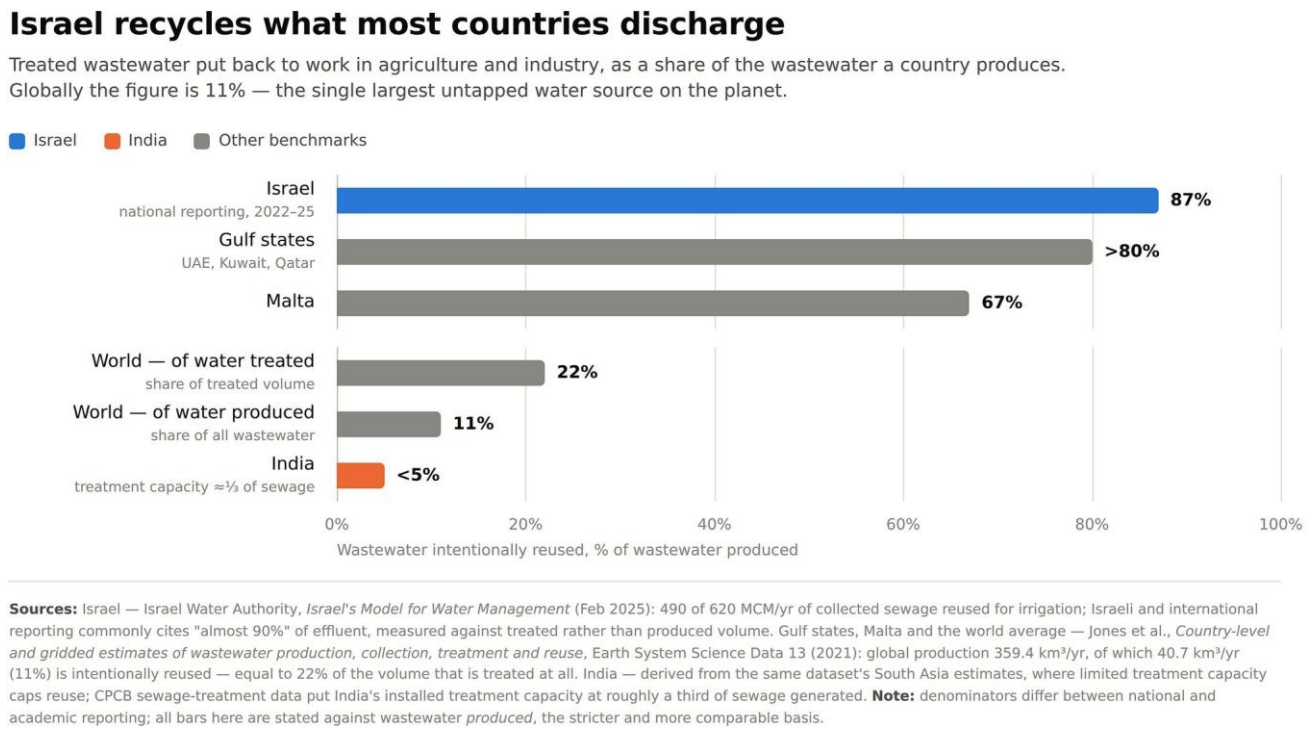


Figure 3. Treated wastewater intentionally reused in agriculture and industry, as a share of wastewater produced. Israel leads the world; the global figure is 11%, the single largest untapped water source on the planet.

Key Takeaways

01
AI works at every scale
From flood forecasts covering 2 billion people to robots in pipes and smart household meters.

02
Adoption is uneven
Flagship pilots lead the way, while most utilities still rely on manual oversight and reactive repairs.

03
The price must be managed
The water-for-compute paradox and a wider cyberattack surface demand strict governance.

04
Humans stay in charge
AI recommends, human decides — with trained people, trusted data and security built in from day one.

Glossary of Terms

Non-revenue water (NRW)	Water produced but lost before it reaches customers, through leaks, theft or metering errors.	**LLM**	Large Language Model: AI that understands and generates natural language.
SCADA	Supervisory Control and Data Acquisition: the system that remotely monitors and controls pumps, valves and sensors.	**SAR**	Synthetic Aperture Radar: satellite radar imaging used to detect moisture from underground leaks.
PLC	Programmable Logic Controller: an industrial computer that physically operates valves, pumps and dosing equipment.	**IoT**	Internet of Things: networked sensors and meters that stream field data in real time.
Digital twin	A live virtual model of a physical network, continuously calibrated with operational data.	**ULB**	Urban Local Body: the municipal authority responsible for local water services in India.

About the Authors



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Mr Raanan Adin specializes in innovation management, empowering companies and organizations to achieve better results, and in water strategy across the private and public sectors. As **CEO of Adin Horizons**, a consulting company headquartered in Israel, and **former Chairman of the Israel Water Association**, he brings over 35 years of global executive experience in corporate innovation management and industry-research collaboration. Adin is a qualified ISO 56001 Internal Auditor and co-inventor of seven patents, serving as executive mentor and international competitions judge. Adin graduated with distinction from the elite Talpiot Academic Program at the Hebrew University of Jerusalem.



Romiel Samuel

Mr Romiel Samuel has been active in the Real Estate and Infrastructure sector for the past 30 years. He has been instrumental in envisioning iconic water projects in India, partnering with MEKOROT Development and Enterprises Ltd, the National Water Company of the State of Israel, to design the **Water Supply Grid for the Marathwada Region of Maharashtra** — the largest non-defense project of the Government of Israel in India.

Romiel jointly founded **Indus Water Institute** with BSE Institute Ltd and has set up an incubator and accelerator specifically for India's water and wastewater sectors doing Research, Education, Incubation and Acceleration.

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