Chap VII: Sustainable Water Management and Smart Water Cities

In the past water management treated water as a disposable commodity, use, treat, discharge. Nowadays sustainable water management treats it as **a circular, and finite resource** to enhance water efficiency, reduce waste, and manage resources like rainwater sustainably even in urban area by integrating technology, such as AI (Artificial Intelligence) and IoT (Internet of thing) sensors. These initiatives improve urban resilience against climate change by optimizing infrastructure through real-time data, reducing leaks, and facilitating water recycling.

7.1 Core Principles of water management sustainability:

Water Security: Ensuring reliable access to safe water for all users (people, industry, agriculture) even during droughts.

Resource Efficiency: it is the right optimization of water and energy by reducing water loss (leakage), improving reuse, and minimizing energy use in pumping/treatment.

Ecosystem Protection: Maintaining environmental flows for rivers, wetlands, and aquifers after any change the stream flow (up or down), not just focusing on human needs.

Circular Economy: Treating used water as a resource for cooling in industry, and nutrients (phosphorus/fertilizers).

Climate Adaptation: Managing floods (too much water) and droughts (too little) simultaneously. Resilience in drought periods is highly recommended.

7.2 Key Components of Sustainable and Smart Water Management:

IoT Sensors & Data Analytics: Use the data collected on real-time from water networks monitoring to manage water quality, quantity, pressure, and leakage detection. This technology allow to reduce cost of useless repair and maintenance intervention and proactive maintenance. Example is the acoustic sensors or pressure loggers find leaks within hours, not weeks.

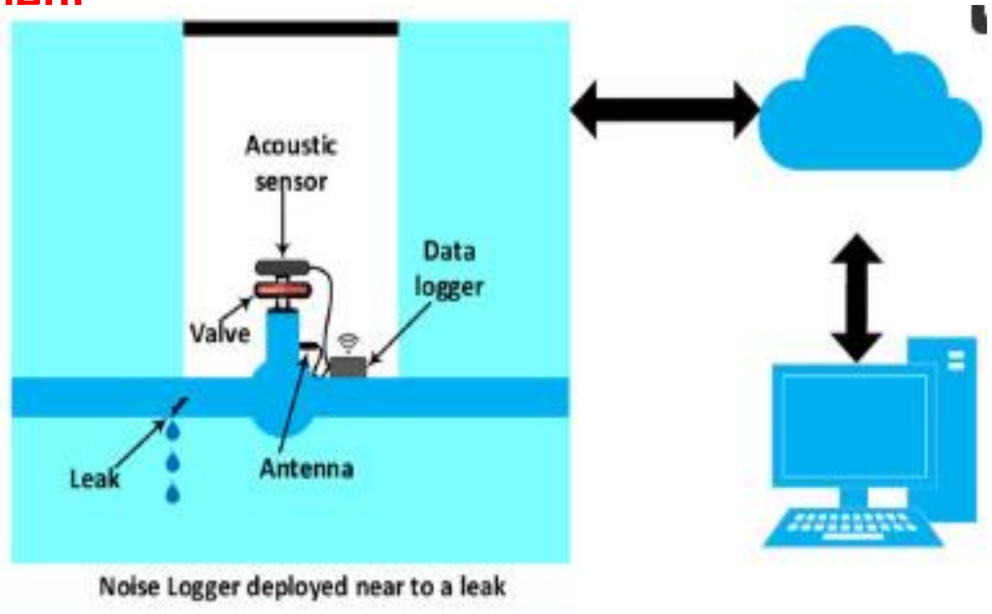

Figure 7.1: Data Collection system. Source Samer El Zahab

Smart Metering: Enables consumers and utilities to track water usage, identify leaks, promote conservation and prioritize water distribution.

Sustainable Drainage Systems (SuDS): Includes green infrastructure like permeable pavements, rain gardens, and green roofs to manage stormwater runoff, reduce flooding, decrease water pollution, and improve groundwater recharge.

Water Recycling & Reuse: Advanced, decentralized treatment systems for treating wastewater; the **greywater** (from sinks/showers) or **blackwater** (sewage) for non-potable uses like irrigation and industrial processes.

7.3 Smart water cities:

A Smart Water City uses a digital layer (IoT sensors, AI, real-time data) on top of physical water infrastructure to make it adaptive, predictive, and autonomous. The creation of water-smart cities is a complex process. However, **the benefits clearly outweigh the costs**, as they make it possible to offer an excellent service to the population and build a more resilient and sustainable future.

The core technologies to implement this innovative strategy of water resources management in cities is summarized in the following table (which continue on next page).

Tabler 7.1 Core technologies for smart water cities

Technology	Application in water
IoT Sensors	Real-time monitoring of pressure, flow, water quality (pH, turbidity, chlorine), and aquifer levels.
Smart Meters	Customer-level usage data, leak alerts, time-of-use pricing.

Technology	Application in water
AI & Machine Learning	Predicting pipe bursts (failure probability), optimizing pump schedules, forecasting flood extent.
SCADA + Automation	Remote control of valves, pumps, and treatment plant processes.
Digital Twins	A virtual replica of the entire water/sewer network to run "what-if" scenarios (e.g., 100-year storm).

So, as you can see to make a city smart you must have a real time monitoring system to detect leakage, predictive waste water management and automated water quality early warning system. To ensure the success this type of water management you should have a fully engaged citizen; because he can alert if any system did not work properly (flooding+ leakage) by using phone or writing email….etc. smart cities management can use smartphone applications that helps citizen to inform immediately about any anomaly or used it to pay his invoices (Smart meters). Digital twins and SCADA are the best tools that is involved in predicting a lot of events with different scenarios by using ML (Machine learning) and AI.

As a rule of thumb smart water cities transform data into information, which is available for decision-making purpose.

7.4 Challenges and limitations:

Cost & Legacy Infrastructure: Most cities have pipes over 50-100 years old. Retrofitting sensors to these old networks and digital twins is complicated and expensive.

Skills Gap: Cities need data scientists/ Machine learner and hydraulic **modelers**, but most water utilities are staffed by civil/environmental engineers.

Equity & Privacy: Smart meters can lead to surveillance (knowing when you shower or flush) this a real breach of privacy. Low-income neighborhoods may lack of sensors, which perpetuating service gaps and compromise the whole system.

Data Silos & Cybersecurity: Water departments, sewer departments, and energy departments often don't share data. And a hacked smart water system could be catastrophic (e.g., altering chemical dosing) especially during wars.

7.5 Examples of leading smart water cities :

Table 7.2: leading smart water cities

Cities	Innovation
Singapore (Public 's Smart Water Networks)	Nationwide real-time monitoring; uses AI to predict water demand and detect anomalies in its highly recycled NEWater system.
Copenhagen, Denmark	A "Cloud Burst Management Plan" using sensors, green streets, and digital twins to route floodwater away from basements during extreme rain.
Amsterdam, Netherland	Smart canal boats that monitor water quality as they navigate; IoT sensors on historic canal walls to track structural stress from water levels.
São Paulo, Brazil	After severe drought, deployed acoustic sensors and pressure management to slash non-revenue water (leaks/theft) from 40% to 25%.
Barcelona, Spain	Smart irrigation in parks uses soil moisture sensors and weather forecasts to reduce watering by 25-30%.

Smart water cities provide the *nerve system* (sensors, data, AI) to achieve the sustainability goals it is time and money consumer, it needs a high skill specialized personnel, aging infrastructure and a suitable policies and laws.

7.6 Smart water cities in developing countries : Cities in developing countries are developing infrastructure for rainwater harvesting and greywater recycling to manage shortages of water. Best example is the Indian project to implement large-scale rooftop rainwater collection/harvesting to manage urban water crises.

7.6.1 Algiers as a smart water city:

The process is already being laid through national digitalization efforts. It is not to simply copy global models like Singapore or Copenhagen. Instead, the city has a unique opportunity to pioneer a **"Resilience-First"** smart water model that directly confronts its most pressing local challenges which are:

- Intermittent supply or no supply at all during summer;
- Aging infrastructure;
- Groundwater depletion;
- Need to rehabilitate polluted urban waterways.

Currently we are at the first phase to build the digital foundation. So, before deploying advanced AI, the city needs to digitize its existing assets. This foundational layer is critical for reducing waste and improving service.

Paperless Billing & Customer Service: L'Algérienne des Eaux (ADE) has signed agreements to introduce electronic billing via the "MyBADR" application, by the same SEEAL provide another application named “Wakalati”. While simple, this digital shift improves revenue collection and provides a platform for future water usage data.

Telemetry & Remote Management: Algiers city has already begun implementing a centralized remote management system for its drinking water network . Operators can monitor pumps, valves, and reservoirs in real-time, moving from reactive repairs to proactive maintenance.

Mobile Water Quality Labs: Boumerdes has already deployed mobile labs for rapid, on-site water testing . Replicating this experience for Algiers allows for faster responses to contamination events and builds public trust in water safety.

AI-Powered Groundwater Management: Algiers has already involved in a project using **AI, GIS, and geophysics** to combat groundwater depletion, pollutant dispersion and providing crucial data for sustainable abstraction limits.

Basically, the alternative for Algiers is not to wait for a perfect, centralized "smart grid" like Singapore's. Instead use what was already digitilized to reduce cost and get the most quick and efficient decision**.**

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