Hydropolitics Association-Türkiye

AI in Türkiye's Irrigation and WASH Sectors

A TECHNO-POLITICAL PERSPECTIVE

Compiled by

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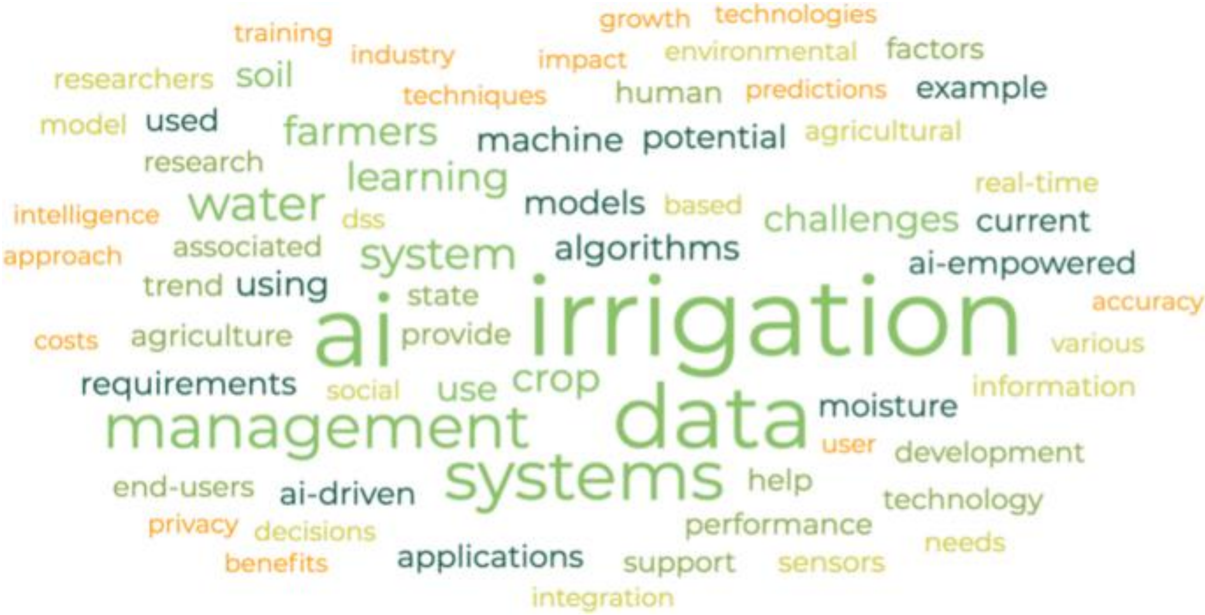
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AI in Türkiye’s Irrigation and WASH Sectors – A Techno-Political Perspective

Executive Summary

Türkiye’s Water Challenge: Türkiye is approaching water scarcity by mid-century due to population growth and climate change. By 2050 the population may reach 105 million, reducing annual water availability per capita to around 1,066 m³ – near the “water poverty” threshold. This underscores an urgent need for smarter water governance. Artificial Intelligence (AI) offers transformative tools to improve water efficiency, quality, and resilience. Globally, AI-driven systems are setting new benchmarks in precision and responsiveness for water management, and Türkiye is beginning to leverage these innovations in irrigation and WASH (water, sanitation and hygiene).

Current Adoption: Türkiye’s irrigation sector has seen initial deployments of AI and digital technologies. Pilot projects demonstrate significant gains: for example, an AI-supported smart irrigation system in Adana’s Imamoğlu district achieved *up to 65–70% water savings* and *90% reductions* in energy use and labor. Academic trials likewise confirm AI can optimize water use – one university study in Rize found AI-controlled irrigation minimized water loss, adapting to soil moisture and weather in real time. In urban water and sanitation, digitalization is at an earlier stage. Major cities are exploring smart water networks, and researchers have shown how machine learning improves wastewater treatment efficiency and effluent quality prediction. These developments remain nascent but illustrate AI’s potential across Türkiye’s water value chain.

Techno-Political Dynamics: The Turkish government plays a pivotal role in advancing AI in water governance. National plans call for modernizing water infrastructure and embracing digital tools. The 12th Development Plan (2024–2028) explicitly mandates expanding ICT use in irrigation management, while a new Water Efficiency Strategy (2023–2033) sets targets to cut municipal water losses from 33.5% today to 10% by 2040 and to raise irrigation efficiency from ~49% now to 65% by 2050. Achieving these goals will require widespread adoption of smart meters, sensors, automation and AI analytics. Government agencies – from the State Hydraulic Works (DSİ) to municipal water utilities – are beginning to invest in such technologies, supported by policy incentives and public awareness campaigns (e.g. the 2023 nationwide Water Efficiency Mobilization). Private sector and civil society actors are also emerging: local tech firms and startups are developing AI solutions for leak detection and precision irrigation, while NGOs and research institutions partner on pilot projects (including international EU-funded initiatives) to demonstrate AI’s value. International donors like the World Bank and European Union provide financial and technical support for modernizing Türkiye’s water systems, aligning with global best practices.

International Context: Compared to peer nations, Türkiye stands at an inflection point. Countries with similar or higher GDP have made AI and “digital water” a cornerstone of water strategy. In Europe, for instance, utilities are investing billions – Spain has committed $3.3 billion to digitize its water cycle and Italy $2.1 billion to reduce leaks – driving the European digital water market to double to a projected $27.2 billion by 2033. These investments include AI for real-time network monitoring and optimization. Israel, a regional

leader in water tech, already uses AI-based systems (like WINT and Kando) to detect leaks and monitor wastewater, contributing to 85% reuse of its treated wastewater for irrigation. South Korea's national water corporation (K-water) similarly deploys AI for smart treatment plants and network management as part of its climate-tech agenda. Türkiye's strategic position – as an upper-middle income country with high water stress – makes it imperative to emulate and tailor these successes. While Türkiye has begun its journey (e.g. the Imamoğlu smart irrigation project being a notable success), scaling up AI adoption nationwide and keeping pace with global advances will require concerted policy action.

Vision 2050: Looking ahead, AI can be a linchpin in Türkiye's water security by 2050. In irrigation, AI-driven platforms could dynamically allocate water based on crop needs, weather forecasts, and basin-level data, maximizing yield per drop of water. In WASH services, intelligent water networks could self-detect leaks, optimize pressure and quality, and ensure equitable distribution even under drought conditions. AI-enabled early warning systems could safeguard against floods and pollution – indeed, an international project is piloting AI sensors in Thrace's Ergene River to trace contaminant spills to their source within minutes. Realizing this vision will require Türkiye to integrate AI across all levels of water governance, from field-level IoT sensors to national data platforms, supported by skilled human operators and sound policies.

Policy Recommendations: To harness AI effectively in water governance, Turkish policymakers should: **(1)** Invest in digital infrastructure (sensors, remote monitoring, connectivity) across irrigation schemes and utility networks, ensuring robust data for AI systems; **(2)** Build technical capacity in government and water agencies through training and partnerships, so staff can deploy and manage AI tools; **(3)** Foster innovation via public–private collaboration and pilot programs, scaling up successful AI solutions like the Imamoğlu model to other regions; **(4)** Strengthen the regulatory framework – finalize the draft AI law and the long-pending Water Law – to provide clear guidance on data sharing, privacy, and ethical AI use in critical sectors; **(5)** Promote open data and interoperability so that various stakeholders (universities, startups, utilities) can contribute AI applications within a unified national water information system; **(6)** Leverage international support and best practices, aligning with EU standards and accessing climate finance or development aid for "digital water" initiatives; and **(7)** Engage the public and farmers through awareness campaigns and incentives (such as smart irrigation subsidies and water-use efficiency grants) to encourage grassroots adoption of AI-driven practices. Taken together, these steps can ensure Türkiye not only meets its 2050 water needs but also becomes a regional exemplar in the smart management of precious water resources.

Chapter 1: Introduction: Water Security and the Promise of AI

Water stress in Türkiye: Aerial view of a reservoir in Ankara province at just 16.7% capacity in early 2023, reflecting severe drought impacts. By 2050, per capita water availability in Türkiye is projected to decline near the scarcity threshold, underscoring the need for efficient water management.

Türkiye's water resources are under growing pressure from demographic expansion, economic development, and climate change. Although Türkiye is not traditionally "water-rich," it has until recently managed with about 1,350 m^3 per person per year of renewable water. But projections show that by 2050 this figure will fall close to 1,000 m^3 – the internationally recognized threshold of water scarcity. This looming scenario has serious implications for food security, public health, and economic prosperity. Already, 76% of Türkiye's freshwater is consumed by agriculture, much of it through inefficient irrigation systems. Aging networks, open canals, and fragmented farm plots have kept irrigation efficiency around 45% on average. Meanwhile, cities face water stress, with some reservoirs (as above) reaching precariously low levels in dry seasons. Traditional approaches alone (e.g. building new dams or drilling more wells) are not sustainable solutions to these challenges in the long term.

AI as a Game-Changer: Artificial Intelligence holds transformative potential to address these water challenges by enabling *smart water management*. Unlike manual or purely mechanical methods, AI can analyze vast streams of data (from weather to soil moisture to consumption patterns) and make optimized decisions or predictions at high speed. In the water sector worldwide, AI is being applied to *predict* droughts and floods, *optimize* irrigation scheduling, *detect* leaks in pipelines, *monitor* water quality, and even *anticipate* infrastructure failures. By moving beyond automation to true machine intelligence, AI systems can respond to changing conditions with precision and speed that outpace human capabilities. For instance, advanced AI algorithms can integrate satellite imagery, sensor readings, and historical records to assess water risks in real time – something that used to overwhelm human analysts. These technologies align perfectly with the need for dynamic, adaptive water management under climate variability. In short, AI offers tools to do "more with less": more crop per drop of water, more safety with fewer resources, more foresight with less uncertainty.

Scope of this Report: This report provides a comprehensive analysis of how AI is currently used, and could further be applied, in Türkiye's irrigation and WASH sectors, with a perspective toward 2050. It examines technological applications *in context* – meaning the *techno-political dynamics* that influence adoption in Türkiye. The role of government strategy and policy is emphasized, given that water infrastructure and regulation in Türkiye are largely state-driven. However, the report also considers contributions by the private sector (such as tech companies and agribusiness), civil society (NGOs, research institutions), and international actors (donors and partnerships). To place Türkiye's progress in context, comparisons are drawn with other countries of similar or greater economic size that have incorporated AI into water management. Finally, actionable policy recommendations are presented to guide Turkish decision-makers in leveraging AI for sustainable water governance, ensuring that by 2050 Türkiye's water sector is resilient, efficient, and equitable.


MAIN FRAME
CPU
CONTROL PANEL
Plant science


Big Data

Chapter 2: AI in Türkiye's Irrigation Sector: Current Uses and Future Potential

2A. Traditional Irrigation Challenges in Türkiye

Agriculture is the backbone of Türkiye's water use, accounting for roughly three-quarters of national consumption. Irrigation has expanded rapidly over decades – about 6.7 million hectares are irrigated now, out of ~8.5 million ha economically irrigable land. Most irrigation projects historically relied on gravity-fed canals and farmer-managed scheduling. This traditional system has led to inefficiencies and water waste due to factors such as: aging open-channel networks (many over 40 years old, prone to leakage and evaporation), inadequate maintenance, and fragmented farm plots that complicate water delivery. As a result, only an estimated 45% of water diverted for agriculture actually reaches crops effectively. With increasing drought incidents and competition for water, improving irrigation efficiency is imperative. Over the past two decades, Türkiye has made efforts to modernize: switching to pressurized pipe networks, promoting drip and sprinkler irrigation with government grants, and consolidating land parcels to enable better infrastructure. These measures have shown that modern techniques can save about 50% of water compared to old methods. However, modernization has been uneven across regions. Looking ahead, simply upgrading hardware may not suffice – *intelligence* in management is needed to optimize water use under varying conditions and to squeeze more productivity from limited water. This is where AI can play a critical role.

2B. Emerging AI Applications in Irrigation

Türkiye's first forays into AI-assisted irrigation have already demonstrated remarkable benefits. **Research Pilots:** Universities and research institutes have led pilot projects to apply AI in controlled settings. In one study at Recep Tayyip Erdoğan University (Rize), researchers implemented an **AI-supported autonomous irrigation system** in an experimental greenhouse, cultivating a native plant species. The AI system continuously monitored soil moisture and climate factors, automatically adjusting watering in real time. The results were striking: the AI-managed plots achieved healthy plant growth with *minimal water loss*, whereas manually irrigated plots experienced issues like over-watering and soil salinization. The study cited global findings that AI systems can improve water use efficiency by on the order of 30–40% over conventional manual irrigation. By leveraging sensor data and machine learning, the AI was able to "learn" the optimal irrigation pattern for the plants, delivering water precisely when and where needed and immediately pausing when conditions (like rain or sufficient soil moisture) made irrigation unnecessary. Such fine-tuned control is nearly impossible to achieve at scale with human labor alone.

Real-World Implementation – The Imamoğlu Smart Irrigation Scheme: Perhaps the most significant example of AI in Turkish irrigation to date is the Imamoğlu Agricultural Irrigation Automation Project in Adana province. Initiated in the 2020s, this project modernized one of Türkiye's largest irrigation networks (fed by Yedigöze Dam) by introducing a *centralized, AI-driven control system*. A Geographic Information System (GIS)-based interface integrates data from hundreds of field sensors (soil moisture probes, weather stations, pressure and flow meters) into an Electronic Water Management System (ESYS). Using deep learning algorithms, the system analyzes this real-time data to make informed decisions on water allocation and scheduling across the network. Farmers participate via an online portal where they input their crop plans and receive optimized irrigation schedules, a significant change from the past when water was requested and delivered manually on a fixed rotation. The outcomes have been groundbreaking: water consumption in the pilot area dropped dramatically. **Key metrics reported include** a *65–70% increase in water savings* and about *90% reductions in energy usage and labor costs* due to automated pumping and remote operation. Essentially, the same water now irrigates far more land with less human intervention. Additionally, the AI system improved equity and reliability of water distribution – every farmer gets the right amount at the right time, monitored centrally. This improves crop yields and reduces conflicts over water. The Imamoğlu project is widely seen as a model for the future of irrigation in Türkiye, showing that AI can effectively "revolutionize water management and allocation" in agriculture. Plans are underway to extend similar automation to other schemes, especially in water-scarce basins.

Precision Agriculture and AI: Beyond large schemes, AI is also being embedded in on-farm precision agriculture tools in Türkiye. Smart irrigation controllers, often powered by AI algorithms, are increasingly available to farmers. These systems, sometimes combined with smartphone apps, use weather forecasts and remote sensing data to advise farmers exactly when to irrigate and how much. While adoption is still limited to progressive farmers or those in development projects, the potential is significant: such AI-based advisory services can prevent over-irrigation (saving water and energy) and under-irrigation (protecting yields). They also integrate with other AI-driven farm practices, like pest detection or fertilizer optimization, forming part of an overall "smart farming" ecosystem. For example, local agri-tech startups – often supported by TÜBİTAK (the Scientific and Technological Research Council of Türkiye) – are piloting AI systems that read satellite images of fields to gauge crop stress and soil moisture, helping target irrigation only where needed. In the long term, widespread adoption of these technologies could substantially reduce agricultural water demand even as climate change makes rainfall more erratic.

2C. Future Opportunities: Towards AI-Optimized Irrigation by 2050

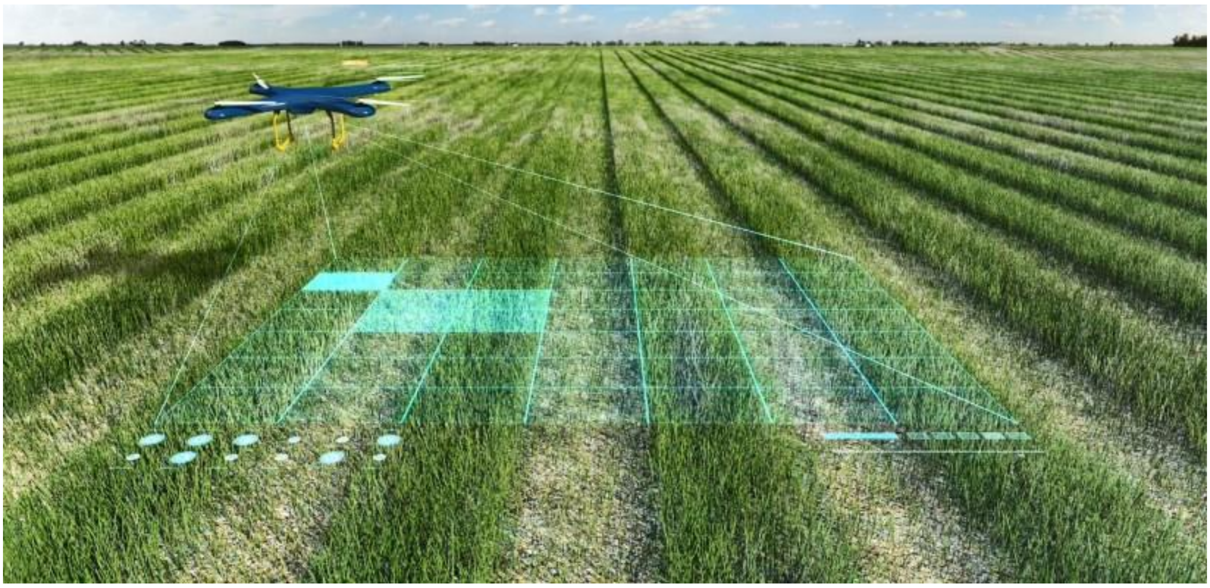
Looking ahead to 2050, Türkiye's vision for irrigation is one where **every drop counts** – and AI will be central to achieving this. By 2050, all irrigable lands (expected to expand to ~9.5 million hectares) should ideally be managed with smart techniques. Key opportunities include:

- **Fully Integrated Smart Irrigation Networks:** Building on projects like Imamoğlu, Türkiye can develop basin-wide irrigation management systems. Imagine entire river basins (e.g. Konya Plain or the GAP region) managed via interconnected AI platforms that balance water supply and demand in real time. These systems would continuously monitor river flows, reservoir levels, soil moisture across fields, and weather forecasts, automatically adjusting water deliveries. During a drought year, the AI could equitably ration water and prioritize high-value or less water-intensive crops, using predictive analytics to minimize economic loss while preventing ecological damage. By 2050, such "smart grids" for water could become as routine as smart electrical grids.
- **Drought Prediction and Adaptive Planning:** AI excels at pattern recognition, which can greatly aid in predicting droughts and planning responses. Advanced climate models coupled with machine learning can improve seasonal rainfall forecasts and detect early signs of drought. Türkiye could implement AI-driven early warning systems that tell irrigation authorities and farmers well in advance about potential water

shortages, allowing proactive measures (like adjusting planting dates or areas, securing alternative water sources, or implementing deficit irrigation strategies). Adaptive planning might also include AI-suggested cropping pattern changes in drought years – e.g. shifting from water-intensive crops (rice, cotton) to more drought-tolerant ones, guided by data on weather and market conditions.

- **Efficient Groundwater Use:** In some regions, especially central Anatolia, irrigation relies on groundwater which is being rapidly depleted. AI can help manage this hidden resource by analyzing aquifer data and usage patterns to suggest sustainable pumping regimes. Smart pumps equipped with AI controllers could dynamically adjust extraction to avoid aquifer overdraw, and even coordinate among farmers in a community so that wells take turns pumping, preventing interference and decline of the water table. By 2050, if Türkiye enacts strong groundwater governance (including the use of AI for monitoring), it could stabilize or even recover critical aquifers.
- **Robotics and Automation:** Another frontier is the use of robotics in irrigation – for example, solar-powered AI robots that traverse fields monitoring crop health and irrigating with precision drippers exactly at the plant root zone. Such technologies exist in experimental forms globally. By 2050, these could become viable in Türkiye's high-tech farming enterprises, further reducing water waste and labor needs. Drones with AI image analysis could also frequently survey fields to detect moisture deficits or leaks in irrigation lines, alerting farmers instantly.
- **Data-Driven Water Allocation Policies:** AI can also inform the *policy* side of irrigation management. By simulating countless scenarios of water allocation, AI models (like reinforcement learning agents) could help policymakers identify optimal water sharing rules among sectors (agriculture, urban, industry) or among provinces, under varying hydrological conditions. For instance, an AI might reveal how much efficiency gain in agriculture is needed to free enough water for growing urban demand by 2050, enabling evidence-based policy targets. As Türkiye enacts its long-awaited Water Law, embedding such AI-informed insights could lead to more adaptive and fair water allocation frameworks.

Challenges to Address: Realizing these opportunities isn't automatic. Key challenges include ensuring quality data (many irrigation systems currently lack sufficient sensors or telemetry), investing in the technology at scale, and training users. Importantly, there is a social dimension: many farmers are older and accustomed to traditional practices; building trust in AI systems and incentivizing adoption (through extension services or subsidies for smart equipment) will be crucial. Moreover, AI recommendations must align with agronomic realities – hence ongoing agricultural R&D to localize AI models to Turkish crops and conditions is needed. Finally, cybersecurity and system reliability must be managed – as irrigation becomes digitally controlled, protections against failures or cyber-attacks (which could potentially disrupt water delivery) are essential. With appropriate strategies to overcome these challenges, AI-optimized irrigation by 2050 can be a cornerstone of Türkiye's water and food security



Chapter 3: AI in WASH (Water, Sanitation, Hygiene): Modernizing Urban Water and Sanitation Systems

While agriculture is the dominant water user in Türkiye, the WASH sector – which encompasses drinking water supply, wastewater management, and hygiene services – is equally critical for sustainable development. Turkish cities and towns have made great strides in expanding access to safe water and sanitation in past decades. The focus now is on **improving efficiency, reliability, and quality** of these services, especially under stressors like urban population growth and aging infrastructure. AI offers multiple pathways to transform urban water and sanitation systems:

3A. Smart Water Distribution Networks

Urban water utilities in Türkiye (typically city-based "Water and Sewerage Administrations") face challenges including water loss (non-revenue water through leaks), intermittent supply in some areas, and operational inefficiencies. Current estimates put average distribution losses above 30% nationally – meaning nearly a third of treated water is lost before reaching consumers. The government's strategy aims to slash this to 25% by 2033 and 10% by 2040, levels that will require aggressive action. AI can be a powerful ally in this effort:

- **Leak Detection and Prevention:** Traditionally, leak detection in pipelines has been labor-intensive, using acoustic listening devices or waiting for visible signs. AI revolutionizes this by enabling continuous, *proactive* monitoring. For example, utilities can deploy networks of pressure and flow sensors and then use AI algorithms to analyze the data patterns. Machine learning models can learn to recognize the subtle signature of a leak – a slight drop in pressure or an acoustic vibration – and pinpoint its location, often before the leak becomes large. In the UK, such AI-based systems have helped companies like Thames Water improve leak detection speed and reduce losses. Although Turkish utilities have begun installing smart meters and sensors, AI analytics remain an emerging field. A forward-looking initiative would be for major cities like Istanbul, Ankara, and Izmir to integrate AI leak detection software into their SCADA (Supervisory Control and Data Acquisition) systems. This could vastly accelerate repairs and cut water waste. Additionally, AI can optimize network pressure management – adjusting pump operations to maintain just enough pressure to serve customers but not so high as to exacerbate leaks. **International example:** Israel's WINT system (already applied in some buildings globally) uses AI to detect leaks at the building level and can automatically shut off water to prevent damage. Scaling similar concepts in municipal networks could similarly yield large savings.
- **Demand Forecasting and Supply Optimization:** AI can help utilities balance water supply and demand more efficiently. By analyzing historical consumption data, weather patterns, and even special events, AI models can forecast daily or hourly water demand with high accuracy. Utilities can then optimize pumping schedules and reservoir releases to meet this demand at least cost (in energy) and with minimal stress on the system. This is particularly valuable for energy-intensive aspects like pumping water from deep sources or over long distances – AI optimizations can schedule pumping during off-peak electricity hours or when renewable energy is available, cutting costs and emissions. Some Turkish cities are already experimenting with such "smart grid" approaches for water, often in partnership with tech companies or universities. By 2050,

real-time AI-driven control rooms could become standard, where operators oversee AI recommendations for valve adjustments, pump speeds, and cross-regional water transfers to ensure every neighborhood gets adequate water with minimal waste.

- **Quality Monitoring:** Ensuring drinking water quality is paramount for public health. Traditional water quality monitoring involves periodic sampling and lab tests. AI offers the ability to have continuous monitoring through smart sensors (for parameters like chlorine residual, turbidity, etc.) and to detect anomalies. Machine learning models can be trained on normal water quality data so that they quickly flag abnormal readings that might indicate contamination or treatment failures. Early detection means quicker response – e.g. isolating part of the network or boosting treatment dosing. Moreover, AI can optimize treatment chemical dosing by predicting water quality changes (for instance, anticipating when a reservoir will experience a drop in chlorine due to a surge in demand or organic load, and adjusting accordingly). Some Turkish utilities have begun installing online sensors in treatment plants and critical points in the distribution network; adding AI analytics could elevate these to an integrated "smart water safety" system.
- **Customer Service and Equity:** On the consumer end, AI can help manage demand through smart metering and pricing. Istanbul has rolled out smart water meters in recent years; with AI, the data from these meters can identify usage patterns and even detect abnormal use (which could indicate leaks in home plumbing or unauthorized use). Utilities can then alert customers or send repair crews as needed. AI chatbots and apps might also improve customer engagement, helping people understand and manage their water usage (thus promoting conservation behavior to reach the goal of 100 liters per person per day by 2050 from the current 146 liters). Ensuring equitable access is another aspect – AI could identify underserved areas or times of service interruptions and guide investments to address those gaps proactively.

3B. Wastewater Treatment and Water Reuse

Managing wastewater is a critical component of the WASH sector, with direct impacts on environmental health and the sustainability of water resources. Türkiye has expanded wastewater treatment capacity significantly, and now attention is turning to improving efficiency and enabling water reuse (treated wastewater is increasingly seen as a resource, especially in arid regions). AI can contribute in the following ways:

- **Optimizing Treatment Plant Operations:** Wastewater treatment is a complex biochemical process that can benefit greatly from AI's predictive and control capabilities. Fluctuations in incoming sewage quality (e.g. spikes in organic load or toxins) can upset treatment processes. AI models, such as those developed in recent Turkish research, can predict key effluent parameters like Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), or nutrient levels based on sensor data from earlier in the treatment process. For instance, a 2025 Scientific Reports study by Turkish engineers demonstrated that machine learning models (Gradient Boosting, XGBoost, etc.) could predict effluent quality with high accuracy, far out-performing traditional control methods. By identifying patterns (like the importance of certain indicators such as volatile suspended solids in predicting outcomes), AI helps operators adjust aeration rates, chemical dosing, or other controls preemptively to ensure the plant remains within regulatory discharge limits. This leads to **improved compliance and resource efficiency** – less energy wasted on over-aeration, and more consistent water quality. Moreover, AI can enable semi-autonomous plants: operators move from constant manual tweaks to supervising AI-driven controls, intervening only when needed. The EU-funded DARROW project is an example from Europe: it is training AI to run a wastewater plant more efficiently, aiming for 20% energy reduction and 50% less sludge generation, while boosting nutrient recovery. Turkish plants could follow a similar path, retrofitting AI control systems to existing infrastructure.

- **Fault Detection and Maintenance:** AI can analyze data from treatment plant sensors and equipment (pumps, blowers, filters) to detect early signs of malfunctions or maintenance needs. For example, if a pump's energy draw starts deviating from its normal pattern, an AI anomaly detection system might flag it as a sign of clogging or wear. Early detection allows maintenance crews to fix issues before they escalate into failures that could cause overflows or environmental hazards. This predictive maintenance, widely used in industries, can significantly reduce downtime and emergency repair costs in water utilities.
- **Water Reuse and Quality Assurance:** Türkiye aims to increase the reuse of treated wastewater (for agriculture, industry, or groundwater recharge) as a key strategy to alleviate water scarcity. AI can help ensure that reclaimed water is safe and reliable. One approach is AI-enhanced monitoring: for instance, if treated wastewater is being piped to irrigate fields, AI could continuously monitor a range of quality parameters and automatically divert the flow if any parameter goes out of safe range, preventing contaminated water from reaching crops. Additionally, AI could optimize the reuse process by blending treated wastewater with freshwater in optimal ratios depending on availability and quality, ensuring farmers get a consistent supply. Israel's experience is telling: about 85% of its wastewater is reused for irrigation, enabled by strict monitoring and advanced tech. AI could allow Türkiye to emulate such high reuse rates safely by providing the necessary precision and responsiveness in quality control.
- **AI for Sewer Networks:** Beyond treatment plants, managing sewer networks (collection systems) is another area for AI. Urban drainage systems are prone to overflows during heavy rains or blockages that cause localized flooding and pollution. AI can integrate weather forecasts with real-time sensor data from sewers to predict overflow risks, enabling operators to take actions like temporary storage or controlled diversions. Additionally, AI-powered "smart manholes" with sensors might detect illicit discharges or unusual sewage composition that could harm treatment processes, tracing them to source (similar to pollution tracking in rivers). Such capabilities tie into the concept of creating "smart wastewater systems" that are as dynamic and self-adjusting as smart water supply systems.
- **Public Health and Hygiene:** In the broader WASH context, AI can contribute to public health monitoring. An interesting emerging field is **wastewater epidemiology** – analyzing sewage for indicators of community health (such as virus DNA, antibiotic levels, etc.). AI could amplify this by quickly interpreting complex biochemical data and flagging trends (for example, an outbreak of a virus). During the COVID-19 pandemic, many countries including Türkiye monitored sewage for virus signals; AI could make such systems faster and more sensitive. By 2050, routine AI analysis of wastewater might help cities monitor the health and even diet of populations, feeding into proactive public health interventions (though this raises privacy considerations that policy would need to address).

3C. Case Spotlight: AI for Water Pollution Monitoring

AI for environmental water monitoring: Map from the SWAIN project showing the Ergene River basin in Thrace (European Türkiye) with sensor stations (red dots) and industrial (red) and agricultural (yellow) areas. An international team is deploying AI-driven sensors here to detect and trace river pollution in real time, aiming to protect water quality for downstream users.

An exemplary initiative at the intersection of water management and AI is the **SWAIN project** (Smart Water Analytics and Intelligent Monitoring), which includes Turkish and European partners. Launched in the wake of a major pollution incident, SWAIN's goal is an *AI-based early warning system* for river pollution. The Ergene River in Thrace, one of Türkiye's most polluted rivers due to heavy industry and intensive agriculture, serves as a test bed. The approach combines a network of IoT sensors along the river (measuring parameters like chemical contaminants, conductivity, etc.) with a machine learning model (specifically a graph neural network) that understands the river's branching network structure. This AI system continuously compares incoming data against learned patterns to **detect any anomaly** indicative of a pollutant spill. Crucially, it doesn't stop at detection: the AI can *backtrack* through the river network model to identify the likely source of pollution within minutes. In practical terms, if a factory upstream discharges a toxic substance, the system will catch the change at the nearest sensor and immediately infer where it came from, allowing authorities to respond (e.g. shutting off the source or closing downstream water intakes) before the pollution spreads widely. By validating this in Ergene and also in a river in Finland for contrast, the project aims to create a blueprint for AI-powered water quality protection. For Türkiye, such technology is extremely pertinent: many rivers suffer periodic pollution (e.g. from mining or industrial accidents), and currently these often go unnoticed until fish die or people fall ill. With AI early warning, the damage to ecosystems and public health can be significantly reduced.

The SWAIN project reflects how **civil society and academia**, backed by international funding, are contributing to Türkiye's AI capacity in water management. A professor originally from Türkiye (now in Vienna) leads it, illustrating the value of diaspora and international collaboration. It also hints at the *techno-political* aspects: to be fully effective, such systems require regulatory support (e.g. empowering agencies to act on AI alerts) and data sharing across borders (pollution doesn't stop at borders, and Türkiye's EU neighbors are stakeholders in Thrace's water quality). As Türkiye develops its national AI and water strategies, integrating the outcomes of projects like this could yield a stronger, regionally harmonized approach to water quality management.

3D. Vision 2050 for Urban Water: Safe, Sustainable, Smart

By 2050, we envision Türkiye's cities and industries enjoying water and sanitation services that are vastly more efficient and resilient, thanks in large part to AI. In this future:

- **"Digital Twins" of Water Systems** are commonplace. A digital twin is a real-time digital replica of physical infrastructure. Major Turkish cities may maintain digital twins of their entire water and wastewater networks, constantly updated with sensor inputs. AI algorithms run on these twins to simulate scenarios – from pipe burst incidents to demand surges during heat waves – and either autonomously adjust operations or provide decision support to human operators. This means problems are anticipated and addressed before customers even notice them.
- **Consumer-Centric Services:** Water supply in 2050 is continuous and quality-guaranteed. AI helps achieve this by fine-tuning treatment and distribution, but also by

empowering consumers. Smart home systems could work with utility AI: for example, if the city's AI predicts a peak demand period, it might signal smart appliances in homes to temporally reduce usage (akin to demand response in electricity). Conversely, households with rainwater harvesting and recycling systems (possibly mandated by green building codes) could supply excess back to the network, with AI ensuring safe integration.

- **Climate Resilience:** AI will be a linchpin in tackling climate-induced extremes. In floods, AI-driven stormwater systems might dynamically re-route flows, open retention basins, or deploy inflatable plugs in sewers to prevent urban flooding. In droughts, AI will optimize every aspect of water use, from stochastically blending different source waters (surface, groundwater, recycled) to prioritizing essential uses. Desalination plants (if built on Türkiye's coasts by 2050) will likely be AI-optimized for energy use and integrated with grid management.
- **Wastewater as Resource:** By 2050, the line between water and wastewater blurs – nearly all wastewater is treated to high standards and reused in some manner. AI ensures these systems run smoothly and safely, with advanced treatments like membrane filtration or advanced oxidation controlled by AI for peak performance at minimal cost. Sludge from treatment plants is processed in AI-optimized anaerobic digesters to recover biogas energy and nutrients, contributing to a circular economy. All these complex facilities require smart control, which AI provides.

In summary, AI technologies have started to penetrate Türkiye's WASH sector in pilot forms and research, and the coming decades present an opportunity to mainstream them. The result can be a quantum leap in service delivery – *24/7 water supply, near-zero losses, superior quality,* and *environmentally sustainable operations* – even as external pressures mount. Achieving this will depend not just on technology, but on governance, investment, and capacity, as discussed next.

Chapter 4: Techno-Political Dynamics: Governance, Stakeholders, and Strategies

4A.AI could be a game changer for farmers around the world

For farmers, every planting decision carries risks, and many of those risks are increasing with climate change. One of the most consequential is weather, which can damage crop yields and livelihoods. A delayed monsoon, for example, can force a rice farmer in South Asia to replant or switch crops altogether, losing both time and income(10).

Access to reliable, timely weather forecasts can help farmers prepare for the weeks ahead, find the best time to plant or determine how much fertilizer will be needed, resulting in better crop yields and lower costs. Yet, in many low- and middle-income countries, accurate weather forecasts remain out of reach, limited by the high technology costs and infrastructure demands of traditional forecasting models. A new wave of AI-powered weather forecasting models has the potential to change that.

By using artificial intelligence, these models can deliver accurate, localized predictions at a fraction of the computational cost of conventional physics-based models. This makes it possible for national meteorological agencies in developing countries to provide farmers with the timely, localized information about changing rainfall patterns that the farmers need. The challenge is getting this technology where it's needed(10).

4B.Technopolitics in Transboundary Water Management

The concepts of hydropolitics and technopolitics are closely intertwined, especially when it comes to issues such as water resources management, transboundary waters, climate change, and infrastructure technologies. Today, infrastructures such as large dams, irrigation facilities, water transmission pipelines, hydroelectric power plants, and advanced water treatment systems are not only instruments of technical but also political power. Therefore, hydropolitical analyses have increasingly begun to incorporate technopolitical approaches. The concepts of Hydrotechnopolitics and Hydrotechnopolitics will now become increasingly prominent on the agenda.

Both hydropolitics and technopolitics are based on an interdisciplinary approach. Water issues are now intertwined not only with natural resource management but also with high-tech investments and geopolitical strategies. Therefore, hydropolitical analysis would be incomplete without technopolitical elements.

Water is not only a vital resource but also a strategic element in terms of national security, economic development, and international relations. In this context, "hydropolitics" examines the political, economic, and geostrategic dimensions of water, while "technopolitics" analyzes the role of technology in these processes and its connection to power relations. In summary, while hydropolitics defines the "politics of water," technopolitics determines the technological forces and infrastructure used in the implementation of water policies. These two fields constitute a framework of strategic thought that must be analyzed together, especially in the

21st century. This study reveals the connection between hydropolitics and technopolitics, examining how technological infrastructures function not only as instruments of engineering but also as instruments of political power in water management.

In the 21st century, the strategic value of water has further increased with factors such as global water crises, climate change, increasing population, and transboundary water management. These developments have necessitated the evaluation of water management policies not only in terms of technical but also political, economic, and security dimensions. Therefore, an interdisciplinary approach is necessary in the analysis of water policies. For example, Türkiye's Southeastern Anatolia Project is based on both a hydropolitical and technopolitical strategy within Türkiye's Euphrates-Tigris policies. The water supply project for the Turkish Republic of Northern Cyprus from Türkiye was also implemented as a result of a combined approach of hydropolitical and technopolitical strategies. Water management institutions today, with their technological and engineering infrastructures, are technopolitical and strategic actors.

Hydropolitics: The Power Struggle for Water

Hydropolitics deals specifically with the disputes and collaborations that arise in the management of transboundary waters. States that claim rights to transboundary rivers, lakes, and groundwater resources develop political strategies for the use of these vital resources. Examples such as Türkiye's policies on the Euphrates and Tigris rivers, the Ethiopia-Egypt tensions in the Nile Basin, the dispute between India and Pakistan over the Indus River, or the water sharing around the Aral Sea in Central Asia are at the heart of hydropolitical debates.

Technopolitics: The Political Role of Technology

Technopolitics argues that technology is not merely instrumental but also directly linked to power relations. A country's water technologies—dams, irrigation systems, hydroelectric power plants, water treatment plants—are integral to both economic development and regional power projection. The capacity to produce, implement, and export this technology directly enhances a country's political influence.

The Relationship Between Hydropolitics and Technopolitics

While dams, irrigation projects, and long-distance water transfer projects may appear as technical solutions, they are actually tools of political power and foreign policy. GAP is not only an integrated regional development initiative but also a technopolitical tool that strengthens Türkiye’s policies for peace and stability in the region..

In today's world, where the impact of climate change is increasing and nearly half of the world's population lives in transboundary water basins, technologies such as smart water management systems, in addition to possessing water resources, increase countries' water supply security and provide strategic advantage over neighboring countries. This, in turn, allows them to build geopolitical power through water technologies.

Information and Data Sovereignty in Transboundary Watersheds

Transboundary river basins cover approximately 50% of the world's land surface. Approximately 45% of the world's population lives in these basins. Some countries (e.g., Hungary, the Netherlands, Egypt, and Iraq) receive more than 90% of their freshwater resources from rivers originating outside their political borders. Climate change, rapid population growth, pollution, and historical challenges place significant pressure on transboundary water management. The 153 countries located in transboundary watersheds, in particular, must manage their waters in the most efficient way possible. For these countries, the ability to collect data on water resources through technologies such as remote sensing, water sensors, and satellite monitoring systems is also a key factor in their power. This data sovereignty is decisive in shaping water policies.

Türkiye: An Actor at the Intersection of Hydropolitics and Technopolitics

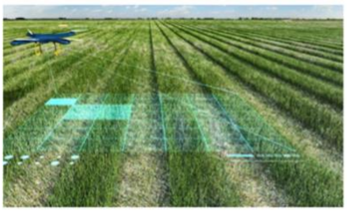
Türkiye is a significant hydropolitical actor, particularly because it is located at the source of the Tigris and Euphrates Rivers, which flow into the Middle East. It also possesses a strong technopolitical infrastructure with its dam technologies, hydroelectric capacity, and irrigation systems. Türkiye's strategic integration of these two dimensions provides a significant advantage in regional water politics.

While hydropolitics analyzes the strategic importance of water and the policies within this framework, technopolitics assesses the political impact of the technological infrastructures used in the implementation of these strategies. Today, these two approaches have become complementary concepts in the context of water management and water security. In summary, hydropolitics determines the "politics of water," while technopolitics determines the "technological forces and infrastructure used in the implementation of water policies." These two areas constitute a strategic framework of thought that must be analyzed together, especially in the 21st century.

4C.Irrigation Policy and Technopolitics

The success of irrigation policies depends not only on the physical management of water but also on technological capacity and how this capacity is integrated into political processes.



Technopolitics is an approach that analyzes the impact of technology on socio-political processes. While the concept of hydropolitics emphasizes the political aspect of water, the technopolitical approach highlights the decisive role of technological infrastructure in these processes. For example:

Dam and irrigation infrastructures, digital water monitoring and remote sensing systems, and smart irrigation and automation technologies can shift the balance of power over water distribution, usage priorities, and the sharing of transboundary waters.

Water is a strategic resource for agriculture and food security. Global climate change, drought risks, and increasing population pressures have made the effectiveness of irrigation policies more crucial than ever. In this context, technopolitics (the impact of technology on policymaking and power relations) plays a critical role in irrigation management strategies.

Irrigation policy encompasses legal, institutional, and technical regulations designed to ensure the efficient, equitable, and sustainable use of water resources.

Its primary objectives are:

• Increasing agricultural productivity

• Ensuring food security

• Promoting the sustainable use of water resources

• Increasing the economic well-being of farmers

Where do irrigation policies and technopolicies intersect?

There is a two-way interaction between irrigation policies and technopolicies. Satellite-based water monitoring systems and artificial intelligence-supported water allocation models are used for irrigation projects. Political decisions can be made more effective with advanced water efficiency technologies.

Furthermore, in the context of using technology as a political power tool, large irrigation projects can become strategic leverage in international relations. Actors with digital data infrastructure can influence water management decision-making.

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Furthermore, in the context of using technology as a political power tool, large irrigation projects can become strategic leverage in international relations. Actors possessing digital data infrastructure can influence decision-making mechanisms in water management.

Projects of Technopolitical Importance and Future Trends

Large-scale irrigation projects, such as the GAP in Türkiye, carry a technopolitical dimension as both a tool for economic development and a tool for regional power. The strategic use of irrigation technologies in transboundary water management creates a technopolitical dynamic between India and Pakistan within the framework of the Indus Waters Treaty. Smart irrigation and digital data monitoring infrastructure under the EU's Common Agricultural Policy support the efficient use of water.

With increasing digitalization in the future, IoT (Internet of Things)-based irrigation management will be increasingly utilized. Furthermore, artificial intelligence-supported water management will increase, and the implementation of irrigation policies integrated with data analytics and climate forecasts will become widespread. Technopolitical competition in irrigation management and water use will intensify in transboundary water basins. Data and technological superiority will become strategic power factors in transboundary waters.

The success of irrigation policies depends not only on the physical management of water but also on technological capacity and how this capacity is integrated into political processes. The technopolitical approach offers a strategic perspective on future water management and constitutes an indispensable field of application for sustainable agricultural development.

4D.Technological potential alone does not guarantee adoption.

The trajectory of AI in Türkiye's irrigation and WASH sectors will be determined by a complex interplay of actors – primarily government agencies, but also private firms, civil society, and international partners. This section examines those dynamics, focusing on how policy and politics can enable or constrain the effective use of AI for water governance.

4E. Government Leadership and Policy Frameworks

The Turkish government has historically been the central player in water management. Key institutions include the **Ministry of Agriculture and Forestry** (which oversees irrigation through DSİ and agricultural water use through its directorates) and the **Ministry of Environment, Urbanization and Climate Change** (which deals with water supply, wastewater regulation, and environmental water issues). In recent years, government strategy documents have increasingly recognized the importance of digital transformation and AI:

- **National AI Strategy (2021–2025):** Türkiye released its first National Artificial Intelligence Strategy in 2021, aligning with its 11th Development Plan. While this strategy mostly addresses cross-cutting themes (like workforce development, AI ethics, R&D, and sectoral priorities in areas such as health, finance, mobility), it signals high-level political will to foster AI across the economy. Water management is not explicitly highlighted as a sector in that initial strategy, which focused more on industries like manufacturing and public services. However, the existence of the strategy means mechanisms (like funding programs and innovation hubs) are being put in place that water-related agencies could leverage. Notably, the strategy calls for public sector adoption of AI and collaboration with academia and industry – a model that water agencies could follow. It also commits to developing legal regulations for AI, a process now underway (as of 2025, Türkiye has multiple AI guidelines and a draft AI law in the legislative pipeline).
- **Water Policy and Legislation:** On the water governance front, Türkiye is moving toward more integrated management. The draft Water Law (long in preparation) aims to unify fragmented water management duties and implement basin-scale planning. Once passed, this law can create a better environment for national-level data integration – for example, by mandating all water-related agencies to share data into a central system. The law could also formalize roles for emerging technologies (e.g. recognizing electronic metering or remote sensing data as official for water accounting). Additionally, coordination bodies like the **Water Management Coordination Board** and basin committees are being strengthened. If these bodies are empowered, they could champion the use of AI tools in decision-making (for instance, basin committees

using AI-based forecasts for drought management). Türkiye's Water Efficiency Strategy and Action Plan (2023–2033) is another crucial policy, as discussed earlier: it explicitly lists measures like geographic information systems, remote sensing, automation, and modern irrigation techniques as tools to be implemented. Though it doesn't mention "AI" by name, these digital foundations are prerequisites for AI – essentially building the data and hardware infrastructure on which AI applications run. The strategy's ambitious targets (e.g. cutting losses and raising efficiency) likely cannot be met without deploying advanced analytics and AI. Thus, we can expect the Ministry of Agriculture and Forestry, along with DSİ, to increasingly incorporate AI projects to fulfill the action plan.

- **Smart City and Digital Government Initiatives:** Beyond water-specific policies, Türkiye's broader digital government push also influences the WASH sector. The government's "National Smart Cities Strategy" (2019–2022) encouraged municipalities to adopt IoT and data analytics for services including water management. Cities like Konya, Ankara, and Istanbul have piloted smart city concepts – for example, Konya has a control center that monitors city utilities, and Istanbul has an open data portal releasing some water statistics. The challenge has been scaling pilot projects into city-wide implementations. With the momentum of e-government and smart city programs, municipalities have greater access to funding and expertise for digital upgrades. We see this in procurement notices where water utilities seek "smart water network" solutions or AMI (advanced metering infrastructure). The techno-political dynamic here is that local governments (often aligned or at least in dialogue with the central government) are key implementers. Political commitment at the city mayor level can spur rapid adoption – as seen when mayors champion traffic or energy smart systems. A similar championing for water could accelerate AI uptake. Conversely, changes in political leadership can redirect priorities, a risk for continuity of long-term tech projects.
- **Capacity and Bureaucracy:** A potential bottleneck is the capacity within government agencies. Developing and managing AI systems requires specialized skills (data science, IT, etc.) that public sector teams may currently lack. There is awareness of this; the Development Plans mention enriching human capital for digital transformation. Already, ministries are recruiting more IT personnel and partnering with universities. For example, the Presidency's Digital Transformation Office often provides guidance or training to ministries on big data and AI. Ensuring that water ministries and municipal water departments benefit from such capacity-building is essential. A positive sign is that DSİ and some large utilities have R&D departments that collaborate with academic researchers – fertile ground for AI pilot projects. The bureaucracy must also adapt to the faster timelines of tech deployment; procurement laws and project cycles might need streamlining to allow iterative development of AI tools (traditional multi-year public works projects are not well-suited to software innovation, which thrives on agile and incremental approaches). Reforms or special programs might be needed to give water agencies more flexibility to experiment with AI solutions without lengthy bidding processes for every change.

4F. Private Sector and Entrepreneurship

The private sector is an indispensable partner in technology adoption, as it develops and supplies many of the tools. In water and AI, several private sector dimensions are at play in Türkiye:

- **Technology Companies and Startups:** Both domestic and international companies are providing solutions. Multinational firms like Siemens, Xylem, and ABB (all active in the Turkish water market) are increasingly incorporating AI into their water management product lines – such as AI-enhanced SCADA systems or leak detection software. These companies often pilot new technologies in collaboration with utilities. On the domestic front, Türkiye's vibrant tech startup scene has a niche of "water-tech" innovators. For instance, startups have emerged offering IoT sensor networks for agriculture, AI-based crop monitoring apps, or industrial water optimization software. One example is a Turkish firm that developed an AI-driven irrigation platform connecting farmers with real-time data (as hinted by an Instagram announcement of a domestic "Atlantis Smart Irrigation" system, though details are scarce). Another is software companies entering the market of utility analytics. However, water is a somewhat conservative sector to break into; many startups struggle to get pilot opportunities. The government and donors can help by funding pilot deployments with guaranteed offtake if successful.
- **Agricultural Industry Players:** Large agribusiness companies and irrigation equipment manufacturers in Türkiye are important for scaling AI in irrigation. Companies that sell drip irrigation systems, for example, are now adding "smart irrigation controllers" to their product lines, sometimes via licensing foreign tech or developing in-house R&D. There's also a role for farm cooperatives and commodity producers – if they see value (higher yields or water savings), they can drive adoption among members. Some big farming enterprises (especially in export-oriented sectors like fruits, nuts, or textiles) are already investing in precision agriculture, including AI, to ensure supply chain resilience.
- **Utilities and Public–Private Partnerships:** In urban water, while utilities are publicly owned, many outsource certain operations or projects to private firms (e.g. Non-Revenue Water reduction projects, treatment plant concessions, etc.). Companies that contract with utilities can be incentivized to bring in AI solutions to meet performance targets. For example, if a city hires a firm to reduce water losses, that firm might deploy an AI leak detection solution to succeed and earn its performance fees. Similarly, if private operators run wastewater plants under contract, they have incentive to use AI to cut energy costs and meet effluent standards economically. The key is structuring contracts that encourage innovation rather than stick to traditional methods. We are seeing early movement – tenders in Türkiye have begun specifying "smart system" requirements. Over time, this can create a market pull for AI solutions.
- **Data and IT Sector:** AI in water also depends on digital infrastructure – cloud computing, data management platforms, connectivity. Türkiye's ICT sector is quite developed and can provide these under the government's guidance. With data centers in Türkiye and government cloud initiatives, water data can be securely stored and processed within the country, addressing data sovereignty concerns. Moreover, telecom companies rolling out NB-IoT and 5G networks will bolster the IoT backbone needed for connecting thousands of water sensors. Collaboration between water authorities and telecom/IT firms (like Turk Telekom or Turkcell's IoT divisions) has already started in smart city contexts; strengthening this synergy will ensure water projects aren't held back by connectivity issues.

One potential issue on the horizon is the **ethical and equitable use of AI**. Private companies bring proprietary algorithms which might be "black boxes". It will be important for public authorities to have transparency – knowing how an AI is making decisions that could affect water allocation or access is crucial for public trust. Imagine an AI system deciding water rationing in a drought – citizens will want to be assured it's fair and based on sound data. This raises the need for **AI ethics guidelines** in government procurement (ensuring algorithms are explainable and unbiased). Türkiye's forthcoming AI regulations and the existing ethical principles likely will cover this, and they must be applied in the water sector context.

4G. Civil Society and Public Engagement

Civil society (NGOs, academia, community groups) plays a multifaceted role. On one hand, NGOs can act as watchdogs or advocates to ensure technology is used to serve the public interest (for example, advocating that smart water systems should also ensure affordability and not just profitability). On the other hand, they can be enablers of innovation by piloting solutions at the grassroots or facilitating stakeholder dialogues.

- **NGOs and Advocacy Groups:** Environmental NGOs in Türkiye, such as TEMA Foundation or WWF-Türkiye, have traditionally focused on conservation and awareness (e.g. saving wetlands, reducing pollution). In recent years, some have also embraced technology as a tool for conservation. For instance, WWF-Türkiye partnered with a company on water savings in production, and other groups have promoted efficient irrigation to protect river flows. These organizations could champion AI by highlighting success stories or pressing government to adopt state-of-the-art management to combat climate change impacts. Additionally, NGOs might use AI themselves to enhance transparency – for example, using remote sensing and AI to monitor illegal water withdrawals or reservoir levels independently and raise alerts (one can envision a citizen-driven platform that tracks water health metrics, which would keep public pressure on authorities to manage resources well).
- **Academia and Research Institutions:** Turkish universities produce many of the country's AI and water experts. As seen with the Rize and Imamoğlu case studies, academics are at the forefront of experimenting with AI in water contexts. The government has various funding programs (TÜBİTAK projects, university grants) that have been fueling research like drought forecasting models, precision irrigation, etc. The key is translating research into practice. Strengthening collaboration mechanisms – such as living labs where universities and utilities co-develop solutions – would help. Türkiye might look at models like the Netherlands, where institutes like Deltares work closely with government on water AI, or Singapore's PUB which has an R&D fund for water tech. Encouraging local research helps tailor AI to Türkiye's specific climatic and social conditions, and builds domestic expertise, which is strategically important.
- **Public Awareness and Acceptance:** For AI-driven changes to truly take hold, the public must be informed and, ideally, supportive. There can be apprehension about new technology (will smart meters overcharge me? Will automation take jobs? etc.). Continuous public communication is needed, emphasizing the benefits (e.g. fewer water cuts, lower long-term costs, safer water). Türkiye's Water Efficiency Mobilization led by the First Lady indicates recognition that public buy-in is crucial. That campaign primarily targets behavior (saving water), but it also introduced the concept of modern methods. As more AI comes in, similar communication strategies should explain in simple terms how, say, an AI leak detector in your neighborhood means less water wasted and possibly lower bills. Education in schools about water and tech could inspire the next generation of water engineers and cultivate trust in these systems.

It’s also worth noting a **political economy** aspect: implementing AI and digitalization can shift power and job landscapes. For example, if irrigation scheduling becomes AI-driven, the traditional local “water distribution chiefs” or irrigation associations might fear loss of influence. Or if utilities go high-tech, some labor roles may change (field technicians might need retraining for IT maintenance roles). Anticipating and managing these shifts is part of the techno-political dynamic – ensuring stakeholders are included rather than alienated. The government might need to provide re-skilling programs, and involve local communities in the design of AI systems (for instance, farmers participating in customizing the AI’s irrigation rules to respect traditional knowledge or local conditions). Successful tech deployment often requires blending new algorithms with on-the-ground insights from experienced personnel.

4H. International Donors and Partnerships

International cooperation has historically supported Türkiye’s water development, and it continues to be a source of innovation and funding especially on cutting-edge issues like AI. Key avenues include:

- **Financial Institutions:** The World Bank, European Bank for Reconstruction and Development (EBRD), and others have funded major Turkish water projects (e.g. the World Bank’s Irrigation Modernization Project). Increasingly, these financiers incorporate digital components into project design. For instance, a World Bank project might finance not just canals but also a modern SCADA and farmers’ information system. Donor requirements can push the adoption of AI: they may insist on components like real-time monitoring for performance tracking. Türkiye can proactively engage these institutions to secure funding specifically earmarked for digital upgrades. The Water Efficiency Action Plan’s goals align well with the priorities of global climate funds and green financing – proposals that include AI for water saving could attract support as climate adaptation projects.
- **European Union Programs:** As a candidate country and neighbor, Türkiye has access to EU programs like Horizon Europe (for research) and instrument for Pre-Accession (for infrastructure). The EU, through its Green Deal and digital agenda, is heavily promoting digital water management among member states. Türkiye’s participation in European research consortia (e.g. SWAIN, and others indicated by joint projects) gives it access to knowledge networks and cutting-edge pilot demonstrations. Maintaining and expanding these collaborations (for example, joining EU’s Water and AI initiatives or twinning Turkish basins with EU basins for digital management projects) could accelerate learning and reduce costs through shared development.
- **Multilateral Organizations:** Agencies like the UN (UNDP, FAO, UNESCO) are active in Türkiye on water issues. UNESCO’s recent publication on AI for water management, which even includes a Turkish co-author, shows that Türkiye’s case is visible internationally. These organizations often convene workshops, provide policy advice, or small grants for innovation. The FAO, for instance, is deeply interested in water-use efficiency for food security. They might help scale smart irrigation at the farmer level by integrating AI tools into extension programs. UNICEF and WHO focus on WASH – in contexts like refugee camps in Türkiye or disadvantaged rural areas, they could pilot AI monitoring to ensure safe water supply even where resources are thin (imagine solar-powered AI water pumps in remote villages ensuring constant flow and auto-reporting issues).
- **Peer Learning:** Besides formal projects, Türkiye can learn from and contribute to global best practices networks. Being part of the International Water Association’s

digital water forum or the World Water Council discussions on innovation can keep Turkish policymakers abreast of what's working elsewhere. Countries like Spain, Australia, the US, or Singapore have experiences with digital water governance worth studying. Conversely, Türkiye's unique experiences (like managing transboundary Tigris-Euphrates with data or its vast GAP irrigation project) can be enriched by AI and then offered as knowledge to others, boosting Türkiye's profile as a leader in water management by 2050.

In conclusion, the techno-political landscape is quite favorable: there is high-level acknowledgement in Türkiye that digitalization and AI are the future, and water is starting to be included in that narrative. The success of AI in water, however, will depend on consistent and coordinated efforts: aligning national AI strategies with water strategies, securing funding, building capacity, engaging stakeholders to mitigate resistance, and upholding ethical considerations. The next section provides concrete policy recommendations synthesizing these insights.

Chapter 5: International Comparisons: How Does Türkiye Measure Up?

To put Türkiye's progress and ambitions in perspective, it is useful to compare with international peers. We consider countries with comparable or higher GDP and significant water challenges, and how they use AI in water management, drawing lessons for Türkiye's path to 2050.

- **Israel – "Start-Up Nation" in Water:** Though smaller in economy (GDP ~$500B, but high-tech oriented), Israel is often highlighted due to its arid climate and pioneering role in water technology. Israel has turned extreme scarcity into an opportunity, achieving high efficiency via drip irrigation (itself an Israeli invention) and reusing the majority of its wastewater. Today, Israel augments these successes with AI. As noted, Israeli companies have produced cutting-edge solutions: *WINT* uses AI to eliminate water waste in buildings by detecting leaks and anomalies (adopted in places like the Empire State Building); *Kando* deploys AI and IoT to continuously monitor wastewater networks, tracing pollution to its source to prevent damage to treatment and crops. These innovations, coupled with policies (Israel prices water to reflect its scarcity and invested heavily in tech R&D), have given Israel a reputation as a global water leader. **Lesson for Türkiye:** Embrace innovation as a necessity. Türkiye's climate is not as dry nationwide, but certain regions (Konya basin, Southeastern Anatolia) are facing Israeli-level water stress. By fostering a vibrant water-tech sector domestically and adopting solutions like precision irrigation, Türkiye can similarly turn scarcity into an innovation driver. Government support was crucial in Israel (e.g. grants, an innovation authority, etc.), which Türkiye can mirror via TÜBİTAK and tech incubators focusing on water.
- **Spain and Italy – Digital Water in Europe:** Spain and Italy have economies a bit larger than Türkiye's and share a Mediterranean climate with drought-prone areas. Both countries, under EU influence, are heavily investing in digital water management. Spain, for instance, committed over $3.3 billion to digitalize its water cycle in recent years. This includes nationwide smart metering rollouts, AI-based irrigation scheduling in its southern farms, and advanced drought monitoring systems. Italy is investing $2.1 billion specifically to reduce leakages in aging city networks, using methods like AI acoustic sensors and predictive maintenance. They also have national platforms that compile water data to enable AI analysis at scale. These investments are in part funded by the EU Recovery and Resilience Facility (post-COVID), tying economic recovery with green/digital transition. **Lesson for Türkiye:** Even without EU funds, Türkiye can align its investments to kill two birds with one stone – economic stimulus and water sustainability. Adopting a similar approach (auditing networks, targeting investments where AI shows the most cost-effective improvements) can help justify the expense by clear returns (water saved, costs avoided). Also, Türkiye should prepare for future integration with EU norms – the EU's upcoming regulations on AI and strict water directives mean any exporter or candidate will need to meet high standards of water monitoring and data quality. Early adoption of AI can make Turkish utilities and industries compliant and competitive.
- **United States – Pockets of Innovation:** The US, with a GDP far larger, has diverse water challenges (water scarcity in the west, aging infrastructure in the east). There isn't a unified national push like in the EU, but individual states and cities innovate.

California, grappling with drought, uses AI for things like optimizing reservoir releases and water trading platforms. The city of Los Angeles uses an AI-driven system for predictive leakage management on its sprawling water pipes, reportedly preventing hundreds of mains breaks. In the realm of water quality, US researchers have used AI for tracking algal blooms in lakes and predicting contaminant spread. Also noteworthy is the use of AI by large companies (like Microsoft's project that used sound-based AI to find leaky pipes in rural areas). **Lesson for Türkiye:** Collaboration with global tech firms and adoption of proven solutions from anywhere in the world is beneficial. Many AI tools are software-based and transferable; Türkiye can adapt solutions from US cities that fit its context (e.g. if a Midwestern city's river pollution AI works, apply it to a Turkish river). Moreover, Türkiye can avoid pitfalls by observing others – for example, ensuring AI tools are inclusive and consider social factors, something the US has faced issues with in other sectors.

- **South Korea – Government-Driven Smart Water:** South Korea (GDP ~$1.6T) is an example of a government taking a strong hand in pushing water tech. The state-run K-water corporation has implemented an AI-powered water treatment system that has even been showcased globally. They seek to set international standards for AI in water treatment – an effort supported by their Ministry of Environment as part of climate tech leadership. They have "smart water cities" where every part of the water cycle is digitized. **Lesson:** A clear mandate to a national water authority to innovate can yield results. Türkiye's DSİ could be similarly empowered to develop an AI center of excellence for water. Also, Korea's example shows tying water innovation to national pride and export potential (they demo at CES tech fairs) can galvanize support. Türkiye could envision exporting successful home-grown AI systems to neighbors in the Middle East/Central Asia, creating economic opportunities.
- **Gulf States (e.g., Saudi Arabia, UAE):** These higher-income countries are investing in AI as part of broader smart city initiatives. Saudi Arabia's NEOM project, for example, promises fully AI-managed utilities (including 100% recycling of water). While their context (small population, vast funds) differs, they often serve as testbeds for new technologies. For instance, the UAE uses AI-controlled drones to monitor water networks and even seed clouds for rain. **Lesson:** Ambition can be a technology catalyst. If Türkiye sets bold goals (like "zero water loss city" or "fully reclaimed wastewater in agriculture" by a certain date), it can drive concentrated efforts akin to these countries. Of course, funding must follow, but Türkiye has considerable resources when prioritized (e.g., large infrastructure budgets could allocate a share to smart upgrades).

In summary, internationally Türkiye is in a *middle position* – not an early adopter but not a laggard either. The Imamoğlu project results show Türkiye can achieve world-class outcomes (70% water saving is exceptional by any standard). To generalize those successes, Türkiye should learn from peers: the strategic vision (Israel's mindset), the heavy investment and compliance culture (EU's model), the innovation drive (Korea's approach), and adapt them to its own governance style. Doing so will help ensure Türkiye's water sector is on par with or ahead of other G20 countries by 2050 in terms of efficiency and resilience.

Chapter 6: Policy Recommendations for Leveraging AI in Water Governance

Drawing together the analysis of current use, potential applications, and international insights, we propose the following actionable recommendations for Turkish policymakers and stakeholders to ensure AI is effectively leveraged in irrigation and WASH, steering toward a sustainable 2050 vision:

6A. Develop a National "Smart Water 2050" Roadmap

Formulate a dedicated roadmap or strategy that aligns with Türkiye's broader Vision 2053/2071 but focuses on water and AI. This should set clear targets (e.g., "reduce total national water losses by X% via digital means," "AI decision-support in all major river basins by 2030," etc.) and outline phases for technology adoption. The process of creating this roadmap should involve the Ministry of Agriculture and Forestry, Ministry of Environment, the national Digital Transformation Office, and key stakeholders (universities, private sector, NGOs). By having an official plan, it will be easier to coordinate resources and measure progress. It can also signal to international partners Türkiye's seriousness, potentially unlocking funding or partnerships.

6B. Invest in Data Infrastructure ("Digital Plumbing")

AI is only as good as the data it learns from. A top priority is to strengthen the data collection infrastructure across all water systems:

- **Sensors and IoT:** Allocate budget for widespread installation of sensors – soil moisture sensors in irrigated areas, flow and pressure sensors in municipal networks, water quality probes in treatment plants and water bodies. Consider incentives or cost-sharing for farmers or industries to install sensors on private wells and pumps, contributing data to public systems. Ensure interoperability (following standards so different devices can communicate).
- **Communication Networks:** Expand robust communication links (fiber, LoRaWAN, 5G) to connect remote canals, wells, and treatment plants. In rural areas, piggyback on existing telecom towers or deploy satellite IoT for truly remote sites.
- **Central Data Platforms:** Create integrated data platforms at basin and national levels. For example, a National Water Data Center could receive real-time feeds from DSİ projects, municipal utilities, meteorology service, etc. and organize it for easy use by AI algorithms. This might involve cloud computing solutions given the volume of data. Emphasize open data where appropriate – non-sensitive data could be shared to spur innovation by researchers and startups. (Security measures should protect critical systems from cyber threats, of course).
- **Data Quality and Standards:** Mandate standard protocols for data (consistent units, time-stamps, metadata) across agencies. Provide training and tools so that field staff maintain sensors and validate data (AI can help flag anomalies, but human oversight is needed). Basically, treat water data as a strategic asset.

6C. Capacity Building: Train the Water Workforce in AI

Human capacity must evolve with technology:

- **Technical Training:** Initiate programs to train existing water engineers and managers in data science and AI basics. Short courses or certifications could be developed in partnership with universities or international agencies. The goal is not to turn every staff into a coder, but to ensure they can interpret AI outputs and integrate them into decision-making.
- **New Roles:** Create dedicated roles in agencies for "digital water officers" or data analysts. For example, each regional DSİ office or big utility could have a small data science team working alongside hydrologists and engineers.
- **Youth and Talent Attraction:** Encourage bright young talent to enter the water sector by highlighting the high-tech transformation. Scholarships for students in AI who focus on water applications, or hackathon competitions on water problems, can generate interest. Perhaps launch a "WaterTech Challenge" annually to crowdsource AI solutions for specific problems (like predicting sinkholes in irrigation canals, or optimizing a specific city's water network) – awarding winners with contracts or incubation support.
- **Knowledge Exchange:** Facilitate exchange programs where Turkish engineers visit countries or companies with advanced digital water management (e.g., a study tour to Israel's Mekorot water company, or to a smart utility in Europe) and vice versa. Practical exposure can rapidly build understanding of possibilities and pitfalls.

6D. Pilot Projects and Scaling Mechanisms

It's crucial to move from isolated pilots to large-scale implementation:

- **Living Labs:** Establish "living lab" pilot areas – choose one or two irrigation districts and one city as intensive testbeds for AI integration. Provide them extra support (technical and financial) to implement multiple AI applications simultaneously (e.g., an irrigation district gets smart scheduling + drone monitoring + AI maintenance prediction all together). Document and evaluate results over a few seasons.
- **Public–Private Partnerships (PPP):** Use PPP models to deploy AI solutions. For instance, tender a contract to reduce water loss in a city not by specifying equipment but by specifying outcomes (e.g. bring loss from 40% to 15% in 5 years); allow bidders to utilize AI techniques freely. Successful outcome-based PPPs will effectively outsource innovation to the private sector while ensuring the public goal is met. Ensure to include knowledge transfer clauses so the utility learns how to maintain the AI system post-contract.
- **Incentivize Farmers:** For irrigation, create incentives for farmers to use AI-based advisory tools. This could be via subsidies (e.g., 50% government grant on purchase of approved smart irrigation kits, similar to how drip irrigation was subsidized), or through water pricing schemes that reward efficiency (if farmers save water, let them either pay less or trade saved water rights). When it "pays" to use the AI, adoption will jump.
- **Donor Coordination:** Align donor projects with scaling goals. If, say, JICA (Japan) is funding a new treatment plant, ensure it includes a budget for AI control systems. If EU funds a rural development project, have a component for digital irrigation management.

This requires Turkish agencies to proactively request and design such components in project proposals.

6E. Regulatory and Institutional Reforms

To integrate AI, some regulatory updates are needed:

- **Finalize and Enact the Draft Water Law:** This law should formally recognize modern concepts like integrated basin management, data sharing mandates, and possibly the creation of a central water data authority. It should empower use of remote sensing and digital evidence for enforcement (e.g., allowing groundwater abstraction to be monitored by smart meters legally). Including clauses about technological innovation (e.g. directing basin councils to consider digital tools) can set a tone.
- **AI Ethics and Guidelines in Water Sector:** Collaborate with the AI regulatory taskforce to ensure sector-specific guidelines. For example, guidelines might say: any AI used in allocating water must be auditable and its criteria transparent; customers should have access to recourse if an AI-estimated bill is disputed; data privacy of consumers (smart meter data) must be protected. This builds trust and avoids backlash.
- **Standards for Technology Procurement:** Develop national standards for things like smart meters, sensor accuracy, interface compatibility, so that when cities or irrigation schemes buy systems, they get ones that meet a baseline and can connect to national systems. This prevents fragmentation where each city buys an incompatible system.
- **Institutional Roles:** It might be beneficial to create a *"Center of Excellence for Water Innovation"* perhaps under DSİ or as a joint unit of relevant ministries. This center would coordinate R&D, pilot oversight, and capacity building across the country, ensuring lessons from one region are shared with others. It can also liaise with international networks (like the UNESCO IHP programs) on behalf of Türkiye.

6F. Financing the Transition

Adequate funding is a perennial concern. To finance AI adoption:

- **Leverage Climate and Green Funds:** Frame many water-AI projects as climate adaptation (they truly are – e.g., saving water mitigates drought impact, optimizing energy in pumps cuts emissions). Then seek funds from sources like the Green Climate Fund, Climate Investment Funds, or bilateral climate finance. Türkiye's recent ratification of the Paris Agreement and development of a Climate Action Plan open doors for such funding, where water is a key sector.
- **Public Investment with Long-Term Savings:** Make the economic case in budgeting: many AI interventions pay for themselves via water saved (which is future water supply cost avoided) or energy saved. Perform cost-benefit analyses and include these in Treasury and development bank discussions. For instance, if an AI leak program costs $5 million but saves $1 million worth of water and energy annually, it's a 5-year payback – a solid investment.
- **Private Capital and Innovation Funds:** Encourage venture capital in the water-tech space. Government can de-risk it by providing matching funds or guarantees to venture investors who support Turkish startups working on water AI. Also, state banks or development banks could offer low-interest loans to utilities for digital upgrades, to be repaid from efficiency gains.

- **Tariff Reforms:** In the urban sector, if necessary, adjust water tariffs gradually to reflect the cost of improved services – but couple this with efficiency gains so that consumers don't see net bill increases (i.e., if AI reduces waste, the utility can supply the same output with less cost, ideally avoiding tariff hikes). Any tariff changes should be combined with communications highlighting service improvements and possibly with lifeline rates to protect low-income households, maintaining social equity.

6G. Monitor, Evaluate, and Adapt

Finally, implement a strong monitoring and evaluation (M&E) framework for these initiatives. AI itself can help monitor progress (dashboards showing real-time performance metrics). Set up key performance indicators such as:

- Reduction in non-revenue water (%) each year.
- Improvement in irrigation water productivity (kg crop per m^3) in pilot vs non-pilot areas.
- Number of incidents (pipe bursts, water quality breaches) detected by AI vs by traditional means.
- User satisfaction surveys for farmers and consumers regarding the new systems. Track these and publish annual "Digital Water Transition" reports. This transparency will help sustain momentum and allow mid-course corrections. If a particular approach isn't yielding results, analyze why – perhaps the AI model needs retraining with local data, or maybe it's a social issue of adoption – and adjust strategy accordingly.

By following these recommendations, Turkish policymakers can systematically integrate AI into water governance, not as an end in itself, but as a means to achieve the enduring goals of water security, economic efficiency, and equitable access. The year 2050 can then be viewed not with apprehension of crisis, but with confidence that Türkiye has the tools and policies in place to provide clean water and sustainable irrigation for all its people in a challenging climate future.

Chapter 7: Conclusion

Türkiye's journey towards harnessing AI in its irrigation and WASH sectors is both promising and necessary. This report has shown that current pilot efforts – from AI-managed irrigation schemes saving vast amounts of water to machine learning models enhancing wastewater treatment – already foreshadow the potential for transformation. In a Vision 2050 scenario, we picture a Türkiye where digital water management is the norm: agriculture thrives on precision irrigation that wastes almost no water, cities run smart water grids with minimal losses and round-the-clock safe supply, and water-related disasters are mitigated by predictive analytics and rapid response. Achieving this vision will require sustained commitment across the techno-political spectrum. The government must lead with clear strategy and enabling policies, investing in infrastructure and skills. The private sector must innovate and scale solutions, supported by sound market incentives. Civil society and academia should continue to pilot ideas, keep authorities accountable, and ensure social implications are managed. International partnerships can accelerate learning and provide resources.

Crucially, the introduction of AI should be seen not as a magic wand but as a powerful toolkit – one that augments human decision-making, optimizes resource use, and reveals insights from data that we could not otherwise discern. It will not replace the need for integrated water planning, stakeholder consensus-building, or good governance – in fact, it makes those even more important, as AI works best in a transparent, well-regulated environment with clear objectives. As Türkiye moves forward, balancing the technological possibilities with human-centric considerations (like ethics, equity, and capacity) will be key to a smooth and successful transition.

In conclusion, the effective use of AI in irrigation and WASH offers Türkiye a strategic lever to overcome water challenges and enhance its water governance for decades to come. With wise policy choices and collaborative effort, Türkiye can ensure that by 2050, water – the "blue gold" – is managed in a smarter, safer, and more sustainable way than ever before, securing the foundation for its people's well-being and its economy's prosperity in the 21st century.

Glossary of Key Terms

- **Artificial Intelligence (AI):** In this context, a broad set of computer techniques (including machine learning, neural networks, etc.) that enable machines to perform tasks normally requiring human intelligence – such as learning from data, recognizing patterns, and making decisions or predictions. In water management, AI can analyze complex datasets (sensor readings, weather, etc.) to optimize operations (e.g., irrigation schedules or leak detection).
- **WASH:** An acronym for Water, Sanitation, and Hygiene. It refers to the sector encompassing clean water supply, sewage/wastewater management, and hygiene practices. Ensuring access to safe WASH services is a fundamental public health goal.
- **Techno-political Dynamics:** The interplay between technology and politics/policy. It recognizes that adopting new technologies (like AI in water management) depends on political will, regulatory frameworks, power structures, and stakeholder interests, and conversely that technology can shift these dynamics by changing how services are delivered and who has access to information.
- **Vision 2050:** A long-term planning perspective aiming for the year 2050. In this report, it refers to Türkiye's aspirational goals for what its irrigation and water sectors should look like by mid-century, aligned with sustainability and advanced technology use.
- **Smart Irrigation:** Irrigation methods that use modern technology (sensors, automated valves, weather data, AI algorithms) to deliver water to crops in an optimal way, minimizing waste. Smart irrigation systems adjust watering based on real-time conditions rather than fixed schedules.
- **Precision Agriculture:** A farming management concept that uses technology to observe, measure, and respond to variability in crops. Involves GPS, drones, sensors, and data analytics (often AI-driven) to optimize inputs like water and fertilizer for specific zones of a field, thereby increasing efficiency and yield.
- **IoT (Internet of Things):** A network of physical devices (sensors, meters, machines) that collect and exchange data via the internet. In water management, IoT devices might include moisture sensors, smart water meters, or pump monitors that send data continuously for analysis.
- **Non-Revenue Water (NRW):** Water that is produced and lost or unaccounted for before it reaches customers, often due to leaks, theft, or metering inaccuracies.

Reducing NRW is a major goal for utilities; AI can help by detecting leaks and improving meter accuracy.

- **SCADA (Supervisory Control and Data Acquisition):** Industrial control systems used to monitor and control infrastructure like water treatment plants or distribution networks. Traditional SCADA collects data and allows remote control; when enhanced with AI, it can become predictive or autonomous in decision support.
- **Digital Twin:** A virtual model of a physical system that mirrors its state in real time using live data. A digital twin of a water network, for example, would simulate water flow and quality continuously, allowing testing of scenarios or diagnosing issues digitally.
- **Graph Neural Network:** An advanced type of AI model that is particularly suited for data represented as graphs (networks of nodes and links). It was mentioned in context of river networks; such models can analyze relationships in networked data (like water flows between connected points).
- **Geographic Information System (GIS):** A system for capturing, storing, and analyzing spatial or geographical data. Widely used in water management for mapping resources, networks, and integrating location-based data (e.g. locations of pipes, sensors, land use). When combined with AI, GIS helps in visualizing and predicting spatial patterns like where leaks or drought impacts might cluster.
- **Machine Learning:** A subset of AI where algorithms improve their performance as they are exposed to more data over time. Examples include learning to predict water demand from historical usage patterns, or classifying sensor signals as “normal” or “leak” after training on examples.
- **Deep Learning:** A subset of machine learning using multi-layered neural networks. It’s effective for complex pattern recognition (like image analysis from drones or finding nonlinear relationships in water quality data). Deep learning was referenced in the context of the Imamoğlu project’s use of “deep learning technology” for irrigation management.
- **Early Warning System:** A system that provides advance notice of a problem (like floods, droughts, or pollution) so that proactive measures can be taken. AI can significantly enhance early warning by rapidly detecting precursors to events (such as unusual weather that might lead to flood, or sensor spikes indicating pollution) and issuing alerts.
- **Automation:** The use of control systems to operate equipment with minimal or no human intervention. In water, automation might be as simple as a pump controlled by a timer, or as advanced as an entire treatment plant adjusting itself. AI-driven automation goes further by making decisions on the control actions based on learned patterns (smart automation).
- **Resilience:** The ability of a system to withstand or quickly recover from difficulties. A water system with AI might be called more resilient if, for instance, it can adapt to a drought by reallocating water efficiently or to a sudden contamination by isolating the affected part, thereby maintaining overall service.
- **Sustainable Water Management:** Managing water resources in a way that meets current needs without compromising the ability of future generations to meet theirs. It implies balancing use with replenishment, maintaining ecosystem health, and efficient service delivery. AI contributes by improving efficiency and foresight, thereby supporting sustainability goals.

Each of these terms is integral to understanding the future of water governance discussed in this report. Leveraging technology (AI, IoT, etc.) within sound political and institutional frameworks will be key to achieving sustainable, resilient water systems for Türkiye by 2050.

Sources: The analysis and recommendations in this report are supported by insights from academic research, policy documents, and industry case studies. Key references include Türkiye's official development plans and water strategy, findings from pilot AI projects in irrigation and wastewater, and international examples of AI applications in water management, among others, as cited throughout the text. These sources underscore both the opportunities and the challenges of integrating AI into Türkiye's water sector, reinforcing the conclusions drawn herein.

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ANNEX I: ACTUAL & POTENTIAL APPLICATIONS OF AI IN IRRIGATION AND WASH

A. Irrigation Sector

Area	Actual Use	Potential Use
1. Smart Irrigation Scheduling	AI models using weather, soil, crop, and satellite data to optimize watering schedules (e.g., FAO's WaPOR integrated with AI)	Predictive models for seasonal water demand forecasts and early warnings
2. Leakage Detection	AI applied to pressure and flow sensor data to detect leaks in pressurized systems	Drone and remote sensing integration to identify surface and subsurface losses
3. Water Allocation Optimization	Machine learning used in pilot basin-scale water sharing models (e.g., India, Israel)	Dynamic pricing algorithms for equitable and efficient water distribution
4. Crop Water Stress Detection	AI-driven image analysis from UAVs or satellites to detect early stress signs	Real-time AI-based advisory to farmers via mobile apps
5. Canal Operations	AI-based SCADA integration in lined canal systems	Reinforcement learning to adaptively manage flow based on real-time feedback

B. Water Supply and Sanitation (WASH)

Area	Actual Use	Potential Use
1. Urban Water Supply Management	Predictive analytics for demand modelling in cities (e.g., Istanbul pilot studies)	Autonomous system management in small towns
2. Leakage and Non-Revenue Water	Anomaly detection in flow meters and SCADA data	Integration with geospatial AI for pipe failure prediction
3. Wastewater Treatment Optimization	AI-based control of aeration systems and chemical dosing (e.g., in EU and China)	Real-time pathogen risk assessment using AI-powered biosensors
4. Hygiene Monitoring in Rural Areas	AI-driven image classification for latrine use, handwashing compliance	Chatbots and NLP for hygiene behavior change communication
5. Early Warning Systems	AI to detect contamination through pattern recognition in water quality data	AI-inferred alerts for emerging health threats from wastewater surveillance

Annex II: POLICY DEVELOPMENT ROADMAP FOR TÜRKİYE

A. Strategic Vision

Goal: Position Türkiye as a regional leader in AI-powered water resilience and efficiency by 2030.

B. Key Policy Actions

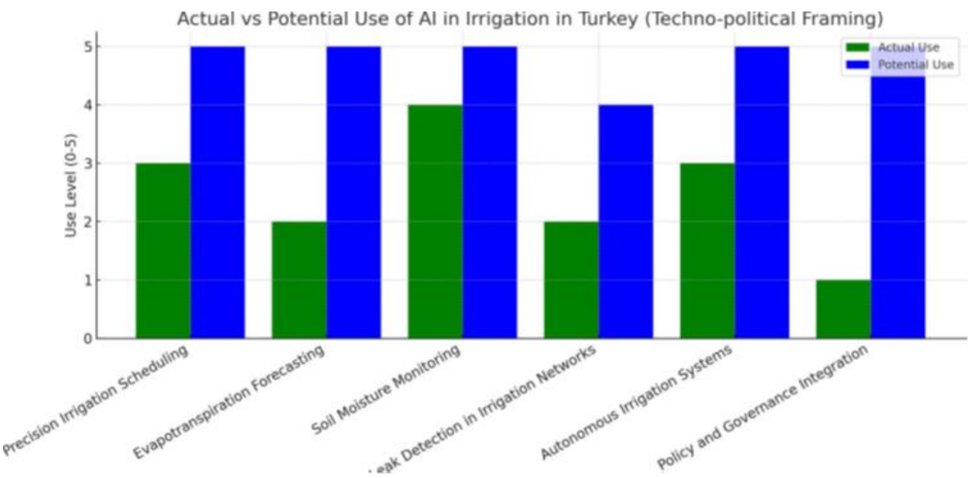
Area	Policy Action	Timeline
1. National Strategy	Integrate AI for Water into Türkiye's Digital Transformation Strategy; assign coordination to DSI and Ministry of Agriculture & Forestry	Q1–Q2 2026
2. Data Infrastructure	Mandate digitization and interoperability of irrigation and water utility data; promote open data platforms	2026–2028
3. Research & Innovation	Create a National AI-Water Innovation Lab under TÜBİTAK in collaboration with universities and tech startups	2026
4. Capacity Building	Launch certification programs for AI applications in WASH for engineers, data scientists, and planners	2026–2027
5. Regulation & Ethics	Develop governance framework for AI in water to ensure privacy, accountability, and inclusivity	2027
6. Pilots & Scale-up	Implement AI pilots in 5 GAP region irrigation schemes and 3 metropolitan water utilities (İSKİ, ASKİ, İZSU)	2026–2029
7.,International Partnerships	Seek funding and tech partnerships via World Bank, EIB, UNDP, EU Green Deal	Starting 2025

C. SUCCESS FACTORS FOR TÜRKİYE

- **Institutional leadership:** Assign DSI and SUEN as lead agencies.
- **Incentivized private sector role:** Tax incentives or co-financing schemes for AI-driven solutions.
- **Regional targeting:** Prioritize semi-arid areas (Konya, Southeastern Anatolia, Aegean basins) with high water stress.
- **Alignment with EU norms:** Ensure AI-for-WASH policies align with European AI Act and Green Agenda

ANNEX III: AI AND TECHNO-POLITICS IN THE IRRIGATION SECTOR IN TÜRKİYE

The chart below illustrates the actual and potential uses of AI in irrigation in Türkiye, framed through a techno-political lens. While current adoption is moderate in areas like soil moisture monitoring and precision scheduling, applications such as evapotranspiration forecasting, leak detection, and autonomous systems remain underutilized. However, their potential is rated high across the board. The most significant gap is seen in 'Policy and Governance Integration,' highlighting the techno-political challenge: despite the technological readiness, systemic factors like fragmented governance, data sovereignty concerns, and lack of policy incentives impede wider adoption.



Actual vs Potential Use of AI in Irrigation in Türkiye

Key Takeaways: AI & Techno-Politics in Irrigation (from Water Council Working Document)

Policy & Institutional Framework Gaps

While the document emphasizes modern management via information technologies, there is no explicit mention of AI. It does call for the use of GIS, remote sensing, and autonomous machinery across irrigation systems—offering a policy gateway to integrate AI capabilities into future governance.

Modernization via Digital Tools as Strategic Priority

One of the explicit strategies is: 'Sulama işletmeciliğinde bilgi teknolojilerinin kullanımı ile modernizasyona gidilerek suyun ve toprağın etkin kullanımı'. AI could be introduced here as the next step—embedding predictive analytics, sensor fusion, and decision-support intelligence atop existing IT.

Governance Actor Complexity & Fragmentation

Multiple institutions (DSİ, TRGM, TAGEM, user-associations) share responsibilities across planning, infrastructure, and implementation. This fragmented governance adds political complexity to centrally deploying AI systems. Standardizing institutional roles would be key to AI rollout.

Data Infrastructure & Monitoring Gaps

The document calls for performance monitoring models and systematic mapping of soil, drainage, and water quality parameters—foundations that AI systems rely upon. However, these systems are not yet digitalized at scale.

Equity & Sociological Dimensions

Sulama sosyolojisi (sociology of irrigation) is emphasized: farmers' sense of entitlement, varying economic perception, and social acceptance of technology differ across regions. These socio-technopolitical contexts matter when introducing opaque AI systems—explainability and participatory design will be crucial.

Strategic Entry Points: Action Plans & Coordination

Short/medium-term strategic actions include organizing panels and symposia, promoting demonstration, and creating performance evaluation models. These provide ideal platforms to introduce AI-based pilots, build consensus, and secure buy-in across stakeholders.

Summary

The Tarımsal Sulama Grubu Çalışma Belgesi establishes a techno-political groundwork ready for AI integration into Türkiye's irrigation sector. While AI isn't explicitly referenced, the document endorses digital modernization, autonomous tools, performance monitoring, and participatory stakeholder processes. The fragmented institutional structure, current lack of standardized data systems, and regional variations in farmers' acceptance highlight key governance challenges for AI adoption. However, planned policy forums, demonstration sites, and performance evaluation frameworks create bold entry points. Strategically introducing AI—especially explainable systems in drip scheduling, remote sensing integration, or predictive leak detection—can align with these priorities and catalyze systemic transformation.

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