IDRICA

WATER TECHNOLOGY TRENDS 2024

Shaping a smart future for the water sector

Contents

FOREWORD

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Water is essential in our daily lives. It is not only a source of life but also of prosperity, playing a crucial role in the economic development of societies. Its contribution to agriculture is well known, but its role as a source of energy, as well as in other areas such as industry, transportation and public health, should also be underscored.

However, the current situation shows the need to start making drastic decisions in many countries around the world. As the World Bank points out, nearly two billion people do not have access to safe drinking water, 3.6 billion do not have reliable sanitation services, and over 2.3 billion people lack basic handwashing facilities.

Moreover, this context includes population growth and "super-industrialization" which increase water use, not to mention climate change, making it essential to implement solutions that use water more efficiently and sustainably.

In 2024, water utilities will be focusing on improving water management and energy efficiency, which are intrinsically linked to digital transformation. These watchwords will be at the core of the main discussion forums in 2024, such as WEX Global, the Smart Water Summit, IWA Water Loss and the AEAS Congress, to name just a few. Digital transformation involves implementing technologies to reduce water losses, deal more effectively with extreme events, improve water quality, and achieve energy savings. They also advocate the use of centralized management platforms that provide a holistic view of data to extract value and improve decision-making.

In this aspect, irrigation is set to be one of the areas where the deployment of new technologies will have the greatest impact. At a time like the present, based on the data provided by the World Bank and the FAO, water efficiency in agriculture will be key in 2024. Given that 70% of extracted water is used in agriculture, the introduction of efficient irrigation technologies, as well as effective monitoring and management of assets and water resources, will be a key strategic trend to ensure food security and minimize environmental impact.

However, digital transformation must go hand in hand with security. Unfortunately, cyber threats to both drinking water and wastewater plants are also on the rise. Interconnecting control and monitoring systems with digital infrastructure creates significant risks. A successful cyberattack has the potential to tamper with treatment processes, alter water quality and disrupt supply. Therefore, the risks associated with cyberattacks should not be underestimated, and investment in protective measures is crucial to safeguard public health and preserve water resources.

In line with this last point, we need to remember that 2023 will go down in history as a year of drought. The report presented at the end of last year by the United Nations Convention to Combat Desertification (UNCCD), in partnership with the International Drought Resilience Alliance (IDRA), warned of the need for a "transformational change" in water resource management. Therefore, tools such as Decision Support Systems (DSS) and Early Warning Systems (EWS) will be the decisive technological trend to address these extreme events. The response to these challenges goes beyond traditional structural solutions, instead requiring a philosophical and technological approach.

Finally, in the current race towards boosting energy efficiency and savings, two trends are set to play a key role in 2024: smart buildings and District Heating and Cooling (DHC) networks.

In short, 2024 promises to be a year of water challenges in which the use (or not) of digital transformation to improve resource management and sustainability is key for water utilities.

1

Drinking Water

1.1. Digital transformation and automation of DWTPs

Automating and monitoring the main water quality variables will guarantee optimum drinking water in terms of cleanliness and health.

Water treatment plants are undergoing unprecedented digital transformation. **In 2024, DWTPs will continue to invest in automated technology-based plant management,** streamlining their operations.

First of all, digital transformation helps to centralize and control data management and therefore bring different DWTP processes together under one umbrella.

These processes can be optimized using advanced predictive control with algorithmic models that are capable of learning and resolving situations, strengthening the processes and ensuring that operating variables perform at optimum levels on a constant basis.

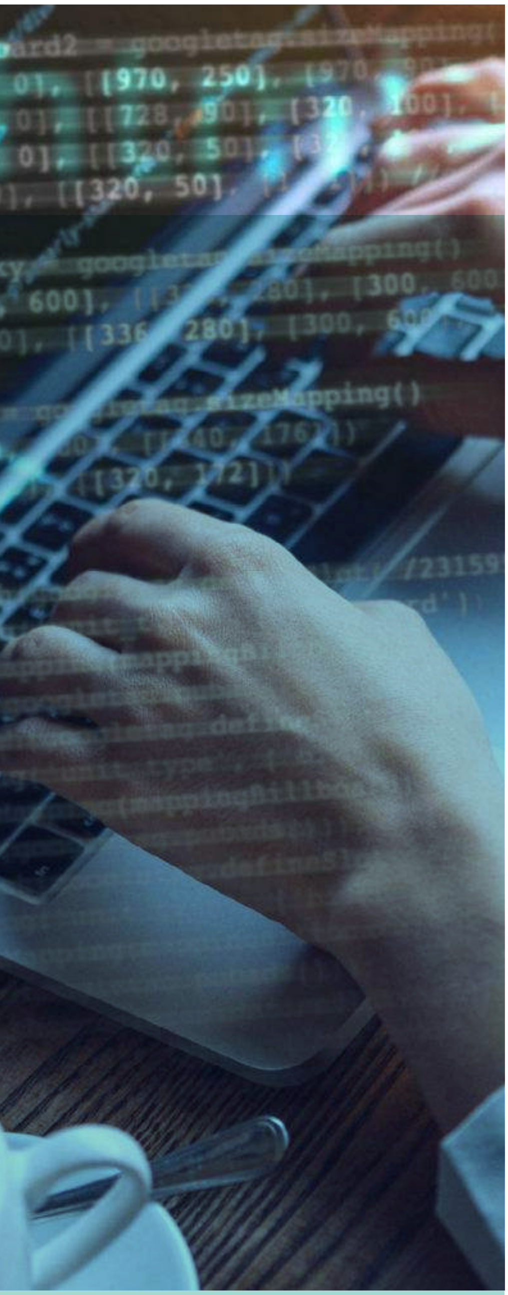
Centralized management provides many benefits, such as predicting the quality of the collected water, automating coagulant reagent dosing, simulating the properties of stored chemicals, monitoring decanter performance and intelligently sequencing filter backwashing. **It also improves energy efficiency by optimizing storage and pumping, and factoring in electricity tariffs and photovoltaic generation, if available.**

Digital transformation and water quality

This year, digital transformation will continue to make progress in detecting events occurring in water supply networks, thus enhancing water quality. This includes incidents that take place from the point the water leaves the treatment plant and/or tank to the point of consumption, which may pose a threat to public safety. **Thus, automating and monitoring the main water quality variables will guarantee optimum drinking water in terms of cleanliness and health.**

In addition, the deployment of new state-of-the-art sensors has revolutionized the ability to measure key variables more accurately, facilitating the implementation of more sophisticated quality control algorithms.

To achieve these goals, it is essential to integrate the DWTP's different technologies and operations to prevent source and data fragmentation and thus break down information silos in water treatment plants. In essence, digital transformation should not respond to specific needs in isolation. Instead, it should be part of an overall strategic plan. **This involves deploying platforms that integrate and analyze data from different sources, and offer centralized, automatic plant control, facilitating decision-making.**



Cybersecurity in DWTPs

It is clear that digital transformation brings many advantages and progress to the water sector, but it also brings risks such as increased exposure to cyber-attacks, which can endanger public health. **Utilities are therefore going to spend more time and effort on increasing their cybersecurity in 2024.**

Digital transformation must therefore also be geared towards guaranteeing cybersecurity, not only through the implementation of technological solutions, but also by tackling the problem holistically. **An effective security policy in utilities is vital to water preservation, as it provides guaranteed access to this scarce yet essential resource.** Protecting the data handled by water utilities is equally important, as it contains sensitive user information (personal and financial data) and also includes key business information for utilities' operations.

Attacks on water utilities include tampering with water purification processes, which can have serious consequences such as possibly poisoning the population. Therefore, **having security systems in place to alert of and prevent such attacks is a way of improving plant productivity as it reduces the number of unscheduled shutdowns that have to be made to remedy the incident.** Thus, robust online and offline security at utilities will give customers reassurance and enhance their business reputation as a result.

Ultimately, **cybersecurity is crucial in the water treatment sector, as water plant and distribution control and management systems are increasingly connected to networks and IT systems.** Protecting these systems is essential to prevent potential cyber-attacks that could compromise water quality, operations and public safety.

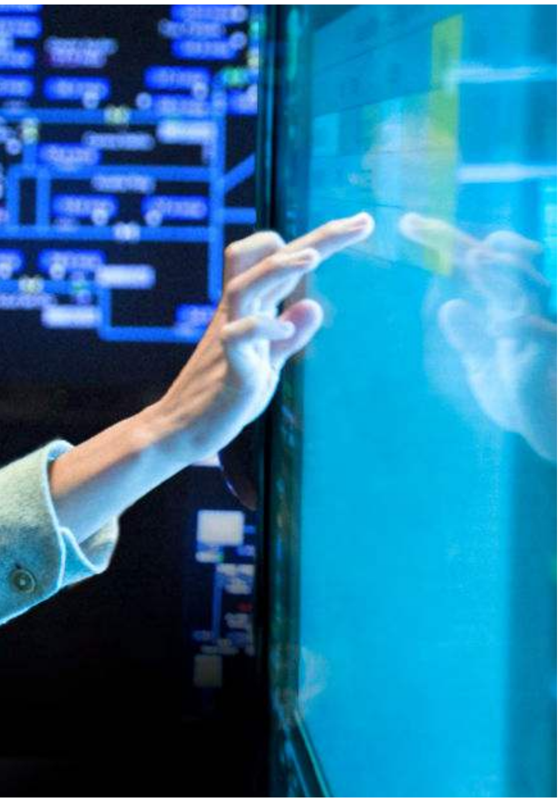
Accordingly, new trends in integrated water cycle treatment, such as improved management, automation, early warning systems and water reuse, pose major challenges in the short term and inevitably introduce new attack vectors that cybercriminals can exploit. **Cyber threats can have serious consequences, such as tampering with treatment processes, information theft, ransomware, industrial espionage and supply disruption.** Utilities must therefore implement robust cybersecurity measures, such as network segmentation, multi-factor authentication, real-time intrusion detection, monitoring of variations in daily operations, and ongoing cybersecurity training for staff.

1

Drinking Water

1.2. Efficiency and sustainability in drinking water network management

In 2024, drinking water networks are looking at digital transformation processes that will foster greater management efficiency and sustainability. In this article, we explore the latest technology trends that are shaping the water management landscape, highlighting innovative advances that promise to revolutionize the sector. These trends include the implementation of digital twins for holistic overviews and advanced simulation, the adoption of Advanced Metering Infrastructure (AMI) for accurate consumption monitoring, the pivotal role of Geographic Information Systems (GIS) in strategic decision-making based on spatial data and, last but not least, leak detection technology, which is key to reducing losses and enhancing water network efficiency.



Digital twins

In 2024, digital twins will continue to be a crucial tool for decision-making in drinking water networks. **Their ability to provide a comprehensive overview of the system and simulate different scenarios enable sutilities to provide responses to a variety of circumstances.**

Digital twins require large amounts of physical system data to function properly. They rely on sensors and information provided by digital tools such as SCADAs, GIS and CMMS. **This presents a challenge for utilities in consolidating and standardizing information.**

Sensors in water distribution systems have facilitated the implementation of digital twins, increasing resilience and providing benefits such as rapid adaptation to different circumstances. **In addition, they boost operational and planning efficiency as they give a holistic vision of the system, enabling informed decisions that reduce energy costs and optimize hydraulic parameters.** They also improve citizen-oriented management by anticipating potential supply disruptions and adapting operations to cater for essential users, such as hospitals.

In addition, digital twins promote sustainability, which is a key concept in 2024, as **they raise awareness of responsible water use** by providing detailed information on water consumption.

Advanced metering infrastructure (AMI)

Advanced Metering Infrastructure (AMI) is set to be another key technology trend in drinking water distribution systems in 2024, setting the bar in the 4.0 revolution of the urban water cycle, which is people-centric in its approach. Unlike Automatic Meter Reading (AMR), AMI goes a step further as it carries out remote reading, but also integrates and processes information using big data technologies, making extensive use of digital platforms.

This disruptive technology brings direct improvements, as it provides value-added services such as leak detection and demand prediction through algorithms. **This, in turn, facilitates more efficient, sustainable water management.** Ideally, AMI needs to handle consumption data on an hourly basis to achieve this and it needs to be premium quality information. This is where new communication protocols such as NB-IoT and 5G come into play, helping not only to obtain this data more effectively, but also enabling more efficient management of meter batteries, which is essential for frequent data transmission in smart metering. **This efficiency can reduce operational incidents and therefore bring benefits to the end customer.**

The ability of AMI to generate significant amounts of information has led water utilities to recognize the value of measuring consumption beyond billing. Connecting this data to other sources of information, such as SCADA, CMMS, ERP, GIS and IoT sensors, optimizes operational processes and increases efficiency. In addition, the deployment of AMI not only enables remote reading, reducing energy consumption and the environmental impact associated with travel, but **also contributes to sustainability by performing hourly water balances, reducing the volume of non-revenue water and detecting fraud and leaks.**

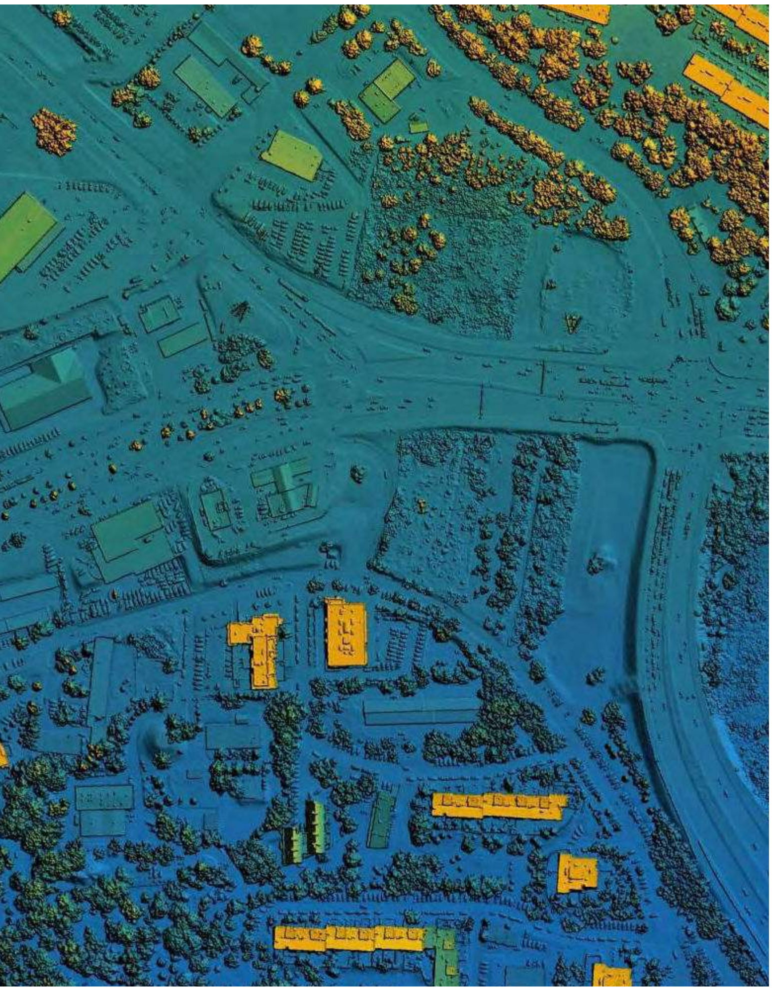
Digital transformation gained speed in the water sector in recent years, and the implementation of agnostic solutions is becoming essential to integrate information from various sources, helping utilities to become more competitive and efficient. I**n this scenario, 5G emerges as a key player, capable of connecting millions of devices in small areas (MIoT), and thus addressing the challenge of smart metering coexisting with other smart devices.**

Ultimately, AMI acts as an interface between utilities and consumers, providing detailed consumption information, **encouraging responsible water use and promoting transparent communication between both parties,** with services that enhance customer satisfaction.

Geographic Information Systems (GIS)

In 2024, Geographic Information Systems, better known as GIS, will cement their position as essential tools for water utilities. **Thanks to advances in infrastructure sensors, these systems include an increasing flow of information, making efficient, effective water management a leading trend.**

GIS are capable of representing any data with a geospatial component, from satellite imagery and sensor data to vector information, enabling better-informed decisions in supply systems. For example, **the location of pipelines and connections can be optimized by considering the orography of the terrain, and the layout of hydraulic elements can be planned based on topological rules and minimum requirements such as flow rate calculations.**



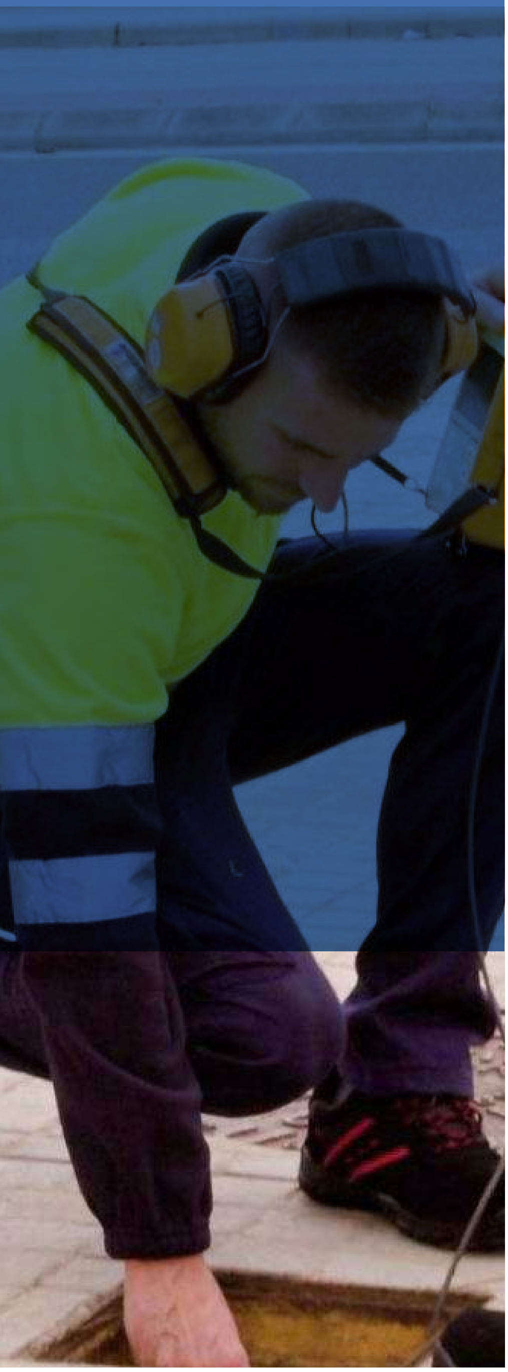
Centralizing data and information in a single tool, thanks to GIS platforms, can boost dynamic, collaborative management. **GIS experts play a crucial role in analyzing, interpreting and spatially managing data**, answering the issue of how utilities can efficiently use this information.

In addition, GIS help to understand patterns and trends in supply systems, analyze data and uncover relationships, **and are essential for monitoring infrastructure changes and solving problems, especially in the pursuit of sustainability.** They can anticipate service interruptions and alert users, thus optimizing the response of utilities.

GIS are vital in incident management to prevent failures by collecting crucial information such as the material pipes are made of and their installation date. Their geospatial dimension can target pipeline inspections intelligently and detect branches that should not be in use.

In addition, **Building Information Modeling (BIM) technology is set to play a key role in the field of Geographic Information Systems.** BIM improves information management related to building floor plans, and also facilitates the integration of three-dimensional (3D) data to provide more accurate, detailed representations. **When combined with emerging technologies such as 3D and 5G-NR, BIM increases the understanding and analysis of infrastructure, thus contributing to more informed decision-making.** In addition, remote interfacing with hydraulic elements using BIM can further strengthen water efficiency, enabling more agile, effective resource management.

In short, GIS will become crucial cornerstones in the advanced management of drinking water networks, harnessing their synergies with new technologies to improve efficiency and decision-making.



Leak detection

Real and apparent losses of drinking water in water networks are an environmental and economic problem, since every liter of water that is fed into the network to be consumed must be collected, made drinkable and pumped through thousands of meters of water networks. **It is also important to detect and repair water leaks in a hydraulic network in a short period of time,** as these could turn into larger breaks and cause damage to civil infrastructures or even affect normal service continuity and pressure at the end point of consumption.

Therefore, continuing to promote and improve leak detection through technology is one of the key trends in drinking water networks in 2024. This will require the consolidation of new technologies that go beyond sectorization, such as mathematical models and algorithms, acoustic leak detection and centralizing data on a single platform. **These technological advances, based on sensors and communications, will provide more efficient water resource use, which is the ultimate goal of the water cycle.**

Locating leaks through big data analysis, using mathematical models and algorithms in data processing, is an alternative to sectorization, which is an expensive option. **This method is also more accurate, as it reduces the inspection area in which the leak is located.** This requires access to data to develop the mathematical model (GIS, demand distribution and operational control), installing flow meters at strategic points and monitoring night-time users. This practice obviously adds considerable value. However, **utilities need to implement advanced software to be able to define the network area where the possible leaks are located to obtain optimum results.**

A further step in this practice is detecting leaks by installing acoustic loggers at specific points in the drinking water network. The data generated through these electronic devices is fed into water efficiency management platforms to locate leaks and improve decision-making, and this is **a trend that will grow in 2024 thanks to advances in telecommunications infrastructures.**

In short, these trends point to a future where water management will not only be smarter and more efficient, but also more resilient and sustainable, in a context in which innovation and digital transformation are inextricably linked.

2

Wastewater

2.1. Digital transformation of WWTPs

The implementation of new technologies in 2024 is particularly relevant to help improve the efficiency and quality of treated water.

In the current era of digital transformation, the uptake of new technologies has revolutionized numerous industries, and the wastewater treatment sector is no exception. **As environmental concerns grow, wastewater management is also changing to deal with emerging challenges more efficiently and sustainably.**

We are at a critical juncture; the decisions and actions taken today about a scarce commodity such as water will shape its availability for years to come. Therefore, **the implementation of new technologies in 2024 is particularly relevant as a lever for change.** These technologies will help to improve the efficiency and quality of treated water.

The technological revolution in WWTPs

1. Automation and control

Automation and control have taken on a key role in industrial safety and optimization in the age of science and technology. **This revolution is the confluence of operational technology (OT) and information technology (IT),** creating a perfect match between technological innovation and efficiency in the wastewater treatment sector.

The integration of OT and IT enables real-time process supervision and regulation through control and monitoring systems, taking operational productivity to the next level. A greater variety of superior-quality sensors on the market is already creating large volumes of data on the quality of water and the efficiency of the processes involved in its treatment. This data includes detailed measurements of contaminant concentrations and physical, chemical and biological parameters. **However, the real value of this information lies in knowing how to process and harness it.** Larger numbers of monitored variables and the increase in on-site, cloud and edge-computing processing capacities have created robust, cutting-edge solutions based on complex algorithms. This revolution, which is already underway, will gather momentum over the next few years.

2. Internet of Things (IoT)

The Internet of Things (IoT) is playing a leading role in the digital transformation of wastewater treatment plants (WWTPs), and its uptake is expected to increase in 2024 and beyond. IoT devices, such as smart meters, are strategically placed at key locations in the plant system so they can collect relevant data in real time on a continuous basis. Increasingly, sensor information is transmitted to centralized platforms, where it is processed and transformed into high-value data, providing a detailed, real-time picture of the system's status.

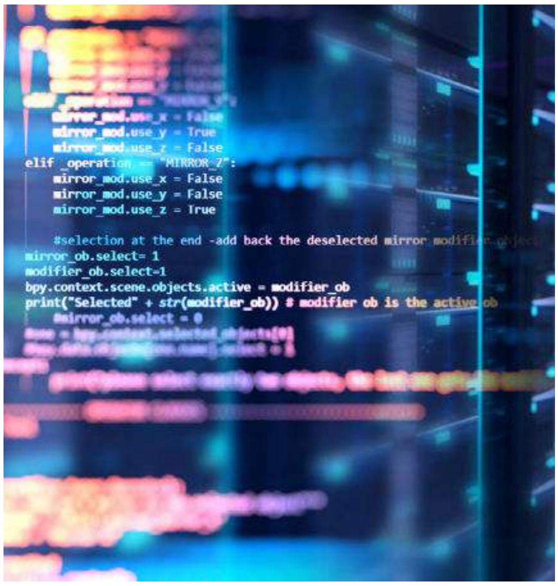
The IoT uses wireless technology to transmit monitoring signals, bringing greater control and supervision outside the plant's facilities. Firstly, in the receiving stream of the discharge, controlling its quality and detecting illegal dumping. However, **one of the most significant advances is real-time monitoring of the WWTP's downstream basin,** detecting illegal discharges into the sanitation network at an early stage and taking preventive action to mitigate the impact that these will have when they enter the WWTP. In addition, more effective investigations can be carried out to detect pollutant sources in the network.

In addition to improving the quality of the purification process, **IoT technology is also driving more efficient management of the resources used in WWTPs, such as energy and reagents, by optimizing their use and reducing waste,** thus lowering operating costs.

3. Big data and advanced analytics

The vast amounts of information generated by WWTPs can be harnessed through big data and advanced analytics techniques. Patterns, trends and correlations can be identified by collecting and analyzing historical and real-time data to optimize treatment processes.

Advanced analytics can also predict and preempt potential problems, making it easier to make proactive decisions and implement corrective measures before serious incidents occur. Big data is also being implemented in wastewater treatment plants **to monitor the use of energy required to start up the wastewater treatment system, thus seeking to maximize cost savings and energy efficiency.** Big data could also be harnessed for the next step in wastewater treatment: the reuse of treated water. Given all the advantages it has to offer, the use of big data and advanced analytics will be one of the main trends in 2024.



4. Advanced treatment and innovative technologies

The technologies that are making inroads in the urban wastewater treatment sector, and which will be trending in 2024, include:

ADVANCED OXIDATION.

This is a process in which chemical reagents or free radicals are used to break down persistent organic pollutants in wastewater. This technology is especially effective for treating chemical compounds that are resistant to conventional treatment methods.

ULTRAFILTRATION AND REVERSE OSMOSIS.

High pressure is used to force water through membranes, leaving contaminants behind and producing purified water that is suitable for reuse in a variety of applications.

PHOTOCATALYTIC OXIDATION.

This is based on the use of a catalyst (titanium dioxide) that is activated by ultraviolet (UV) light to break down organic pollutants and microorganisms in wastewater. The UV light activates the catalyst, generating free radicals that oxidize and degrade the pollutants.

ULTRASONIC REACTORS.

These use high-frequency ultrasonic waves to treat wastewater. These waves create microbubbles that collapse violently, generating high temperatures and pressures that decompose contaminants and microorganisms, efficiently decontaminating water.

NATURALLY AND GENETICALLY ENHANCED MICROORGANISMS.

This technique centers on the use of naturally enhanced microorganisms to treat wastewater with refractory TOC/COD or specific pollutants. It consists of choosing microorganisms, improving variants and then feeding them into the treatment process.

ELECTROCOAGULATION AND ELECTROOXIDATION.

This applies an electrical current to remove pollutants through coagulation and oxidation processes.

5. Renewable energies

Two of the key factors for efficient management of wastewater treatment plants are reducing their carbon footprint and lowering their operating costs. Therefore, improving energy efficiency has become one of the main objectives for WWTPs in 2024, based on four complementary strategies that will be increasingly used in the near future:

Monitoring and control of consumption in real time. This enables the development of new strategies to lower energy consumption, as well as to efficiently detect faults in real time.

Optimization of biogas production, the volume of biogas generated and the strategy for its use. This increases the volume of biogas produced in the anaerobic digestion process and helps to apply strategies to manage its storage and use.

Optimization of the biological reactors' aeration system. This requires adjusting the amount and distribution of air in the biological reactors to optimize treatment process efficiency.

Installation of photovoltaic panels. Solar energy is used to produce electricity and cater for part of the WWTP's energy needs.

6. Digital twins

A digital twin is a real-time virtual replica of a physical wastewater treatment plant, created from sensors and monitoring systems that collect data about its operations. This data is sent to software that processes and simulates the behavior of the plant, generating a constantly updated digital model. **The digital twin monitors and analyzes the WWTP's performance. Thus, potential problems can be preempted, and processes can be optimized.** It also serves as a platform to test and simulate changes or improvements before physically implementing them, thus lowering costs and operational risks.

These virtual replicas in WWTPs can incorporate biokinetic mathematical models and self-calibration algorithms with machine learning to simulate the behavior of biological and physicochemical processes in real time, improving the plant's performance and efficiency. Therefore, more and more utilities will be investing in the implementation of digital twins in WWTPs as a tool to optimize operations.

As a result, digital transformation and the adoption of new technologies are set to revolutionize WWTPs in 2024, improving their efficiency and sustainability and the quality of treated water. **Automation, IoT, data analytics, advanced treatment technologies, energy efficiency and digital twins are just a few examples of how digitalization is revolutionizing this pivotal sector.** As we move into the future, it is imperative to continue to explore and implement new technological solutions that ensure sustainable and efficient water management, thereby safeguarding our environment.

2

Wastewater

2.2. Sanitation networks: technology to protect people

Sanitation systems are another core part of the water cycle as they manage the entire network from their source to their point of use or end-of-life disposal. Technology is also set to play a key role in these networks in 2024, not only to ensure that they run smoothly, but also to respond to extreme events and control the spread of disease.

Sanitary sewer overflows

Most sanitary sewer overflows (SSOs) occur during extreme rainfall events, when the system is unable to decant and treat all the water it collects. **These discharges of untreated water bring environmental issues, causing water eutrophication, an increase in pathogens, as well as contaminating groundwater, seas and oceans.**

Technology that can predict events based on real-time monitoring of key points in sanitation and urban drainage networks, and also factors in meteorological information, is essential to prevent these problems from occurring. **These are the so-called "early warning systems", which facilitate decision-making by generating alarms, and reduce the time required to respond to these episodes,** which are expected to become increasingly frequent and difficult to forecast in the current context of climate change.

SSOs also occur as a consequence of clogging, mainly caused by fats (a phenomenon that has worsened due to today's fast-food diets) and inappropriate disposal of wipes. In turn, infiltrations and broken sewers, caused by aging infrastructures, also lead to overflows. Infiltrations cause unwanted water to enter the network, with the consequent loss of hydraulic capacity and increased energy costs in the pumping and purification processes. The system must be monitored to detect sedimentation, infiltration and blockages in the sewers to prevent this phenomenon.

Therefore, sensors need to be perfectly positioned throughout the sanitation system to collect all the data needed to monitor performance and ensure its proper functioning. **Over the next year, utilities will continue to rely on digital platforms to integrate and analyze all the data sent by sewer level and quality sensors,** which will also include information on the status of the WWTP's main sewers, pumping stations and relief points.

This will lead to optimal preventive maintenance plans based on the risk of each asset, replacing the remedial cleaning schedule. Thus, optimal cleaning programs can be put together based on historical and real-time information from integrated systems and data (previous SSOs, the latest preventive and reactive work orders, GIS, etc.), and the application of risk-based statistical models.

These smart digital platforms will also help to take action in the case of an extreme event, as the detection of sensor anomalies in sewers, assets and manholes will serve to assess the overflow risk. **In addition, AI algorithms can provide the location and minimum number of sensors needed to prevent SSOs.**

Wastewater-based epidemiology

Another challenge for sanitation systems is the control of infectious diseases. Population growth and climate change have brought new infections, and other previously eradicated diseases have now reappeared. **Monitoring the spread of pathogens is essential to prevent and control these situations and protect the population.**

Wastewater-based epidemiology (WBE) is based on the analysis of wastewater to control infectious diseases. **WBE acts as an early warning system to comprehensively monitor the emergence of new diseases** via sampling campaigns and subsequent laboratory analysis of any biological threats in the sanitation network.

In recent years, the growing interest in wastewater-based epidemiology shown by global organizations such as UNESCO and the World Economic Forum, as a result of the Covid-19 pandemic, has made technology a powerful ally in refining this preventive practice.

Molecular technologies, such as the polymerase chain reaction (PCR), which can detect and quantify the genetic material of specific pathogens in wastewater, are an example of this.

In 2024, the digital transformation of WBE will also enable integration with public health systems, i.e., wastewater data can be combined with other epidemiological surveillance systems. This will bring a more holistic view of public health at community and national levels. **At the same time, the use of advanced software and algorithms (via artificial intelligence) to analyze the collected data will help to identify trends and preempt outbreaks.**

Digital solutions can centralize the entire process on a single platform, including sample scheduling and monitoring at relevant locations, results obtained in the laboratory and the representation of these outcomes to assist the relevant authorities in their decision-making.

This creates a unique data model that brings together information from ERP, SCADA, clinical laboratories, GIS and third-party applications. If this data is further combined and standardized with demographics, hospital occupancy rates and government statistics, **the model can provide valuable information to monitor the spread of viruses and act more quickly.** An inclusive digital platform will therefore be able to combine different data sources, analyze them holistically and draw conclusions to generate reports and issue warnings if necessary.

In 2024, WBE technology will progress, offering new use cases in the near future, including monitoring of other parameters, such as antibiotics, to track antimicrobial resistance. These are prevalent in wastewater, due to the occurrence of emerging contaminants. **An additional use case can be developed in WWTPs.** They are currently focused on the removal of organic matter and nutrients but, with technological advances, they will also be able to remove these types of emerging contaminants through sophisticated treatments.

In short, in 2024, smart digital solutions open up major opportunities for sanitation systems to prevent and preempt SSOs and respond to them, and to put wastewater-based epidemiology to new uses, even including it in the smart cities roadmap.

3

Sustainable irrigation through process digitalization

Agricultural irrigation is facing new challenges that mean irrigation associations will need to digitalize their processes.

The irrigation sector has a key role to play in ensuring food security in the current global context, marked by a changing geopolitical situation, climate change and the scarcity of water resources. **Thus, agricultural irrigation is facing new challenges that mean irrigation associations will need to digitalize their processes.** Initiatives such as Spain's PERTE (Recovery, Transformation and Resilience Plan) to digitally transform irrigation water user associations, promoted by the European Next Generation EU funds, are an example of the widespread digital transformation that the sector is set to experience in 2024.

Therefore, **irrigation water user associations are expected to implement holistic platforms that include remote control and decision support.** Other new trends which are set to take root in the agricultural irrigation sector in 2024 include better water governance, the implementation of geographic information systems, remote sensing targeted at soil moisture, and improved energy efficiency.

Better water governance through monitoring

The first of the trends for 2024 in the digital transformation of agricultural irrigation is better water governance to improve the sustainable management of this precious resource. In response to the scarcity of water resources, **growers will be looking to increase control over their water consumption through the monitoring of withdrawals and other public water resources (PWR).**

Irrigation associations are obliged to effectively control the volumes of water used in withdrawals, returns and discharges to and from PWR, and to report this information to the competent authority.

The associations will require technologies such as remote reading and technological platforms that enable the connection and exchange of data with third parties, including interoperability with assets in the SARA network (Government Application and Network System) if they are to be able to duly report this data to the competent authorities (Directorate General for Water, water authorities, etc.). In addition, remote reading at plot level enables more accurate consumption information, faster leak detection, fraud control, demand forecasts as well as monitoring the amount of water allocated. **This will lead to more responsible use of water and improve hydraulic, operational and energy efficiency in irrigation.**

Remote sensing for monitoring and controlling soil moisture

Remote sensing will be an effective tool in 2024 for monitoring and managing agricultural areas. This technology brings comprehensive monitoring of crop development, facilitating the assessment of crucial aspects such as plant growth, the presence of water stress and variability in soil moisture. **This level of detail provides valuable information for making informed decisions about agricultural practices and resource management.**

In addition, time series data can be used to analyze changes in fields over time. Observing how conditions alter over time provides a historical perspective, as well as a solid basis for predicting and anticipating future patterns.

The availability of regular detailed information and over a period of time enables **more accurate decision-making and more efficient and sustainable plot management.**

Implementation of Geographic Information Systems (GIS)

Another trend for 2024 in agricultural irrigation is the implementation of Geographic Information Systems (GIS) in irrigation associations. **These GIS can manage data from the different irrigation association management processes through a single tool and in a visually appealing way.** This means that decisions can be made directly and more intuitively.

Integration with GIS also enables users to obtain plot information, such as their land registry references and the water inlet code which supplies it. Moreover, as the system is connected to the WMS service, **this information is always up to date, is accessible from mobile devices and can be checked quickly and compared with the plots registered in the irrigation association,** thus detecting possible discrepancies and correcting them at a later date. This point is of paramount importance in terms of water efficiency, since water allocations must correspond to the actual irrigation area.

In addition, **these systems can connect to geospatial data services such as the WMS (Web Map Service) and the WFS (Web Feature Service), to check the cartography of the different public administrations in each region.** For example, they can be integrated with layers of areas of special environmental protection, such as Special Protection Areas (SPAs) for birds, and Sites of Community Importance (SCIs), in Europe, as well as with nitrate-sensitive areas, flood zones, and with the digital terrestrial model and the national soil map.

Irrigation association assets can be georeferenced thanks to the GIS. **Having this information about pipelines, nodes, infrastructures, hydrants, etc. in a single technological environment facilitates maintenance work,** as it provides advance knowledge of the material needed to repair a breakage, avoiding unnecessary trips and, consequently, improving operational efficiency and reducing fossil fuel consumption. Plots with active irrigation can also be monitored at the time of the query and flow rates can be ascertained in real time. Similarly, the integration of the GIS framework in the management platform offers navigation within the map through the association's management processes, as well as access to the synoptics of each of the irrigation facilities.

Improving energy efficiency

The quest for energy efficiency will be paramount in 2024, in response to the climate change situation. It will therefore be another of the trends that will mark the agricultural irrigation sector this year. In this sense, the use of non-conventional energies will also be driven by technology.

Companies that are experts in the digital transformation of the water cycle will be able to provide irrigation associations with monitoring systems that can calculate **energy ratios for different processes and analyze changes in consumption over different time periods and track them constantly.** They can also display energy data for each asset in real time, such as the motor load factor, pump efficiency, and pumping rates. This detailed analysis delivers key information about the efficiency of the installation.

These monitoring systems can also be used to configure set-point values to detect deviations and trigger alarms when necessary.

In addition, the installation of solar plants as a non-conventional, sustainable energy source will be promoted as a way to enhance energy efficiency. The installation of floating solar panels on irrigation water storage reservoirs will also reduce water evaporation, diminish the proliferation of algae and sediment deposition, and boost the efficiency of the photovoltaic panels.

Digital platforms can integrate data from solar photovoltaic plants and provide tools to optimize their operation and production. For example, **they can provide information about the renewable energy forecast for the following days and about power consumption,** compared to the price of electricity in the analyzed period of time.

In short, the digital transformation of irrigation will bring major benefits to the agricultural sector in 2024 at a time when the use of water and energy resources needs to be optimized more than ever. Consumption control through monitoring, as well as the use of remote sensing, **will bring more efficient use of water without compromising crop productivity, thus improving sustainability.** The progressive implementation of GIS will increase the degree of control over irrigation association assets, facilitating their management and maintenance. If we add the integration of data from energy analyzers into an intelligent platform, the result will be an increasing number of irrigation associations that can make informed decisions, becoming more sustainable and efficient.

4

Challenges and solutions for integrated water resource management

Tackling the challenges in water resource management call for answers that go beyond traditional engineering solutions, requiring instead a holistic and technological approach.

It is a critical time for water resource management, which is facing a series of major challenges including climate change. This phenomenon is generating longer periods of drought and more intense rainfall. **Tackling this issue, along with the problems of demographic growth and urban development, poses multiple challenges in different areas for water management authorities,** which call for answers that go beyond traditional engineering solutions, requiring instead a holistic and technological approach.

Thus, in 2024, digital transformation will emerge as an essential tool to address these challenges. **Analyzing data, identifying trends and applying technologies such as big data, machine learning and artificial intelligence are set to play a fundamental role in the new era of water management.** However, this approach also calls for major investments in gathering and processing valid, high-quality data.

In addition, climate change is also affecting the data sets that have traditionally been used for studies and forecasts, as not all of them reflect its impact. **This requires resilient responses, i.e., the capacity to adapt, anticipate and foresee the most adverse scenarios to optimize water management,** minimizing the risk of floods and droughts.

In this sense, tools such as Decision Support Systems (DSS) and Early Warning Systems (EWS) represent a key technological trend to address these extreme events.

The repercussion of extreme events on water management

The repercussions of increasingly frequent, more intense droughts go beyond surface water, affecting groundwater bodies and decreasing their quality due to overexploitation of aquifers during dry periods. **Effective management must address both water quantity and quality in the context of prolonged droughts,** as overexploitation not only depletes resources, but also worsens their quality and may increase the concentration of pollutants and saltwater intrusion. Therefore, decision support systems must include hydrogeochemical models to assess and manage water quality during drought episodes.

Droughts also have an economic and social cost, affecting agriculture, triggering crop failures and increasing production costs. In addition, many communities are facing drinking water shortages, thus exacerbating poverty and causing social unrest.

Flash floods, which are fueled by extreme weather events, represent another emerging challenge in the 21st century. The frequency of torrential rains has increased dramatically, generating flooding in areas that were not previously deemed to be vulnerable.

These events have wreaked economic and social havoc around the world. Loss of life, damage to infrastructure, loss of property and displacement of communities are just some of their multiple consequences. **In economic terms, direct and indirect losses amount to billions of dollars, affecting the financial stability of entire regions.**

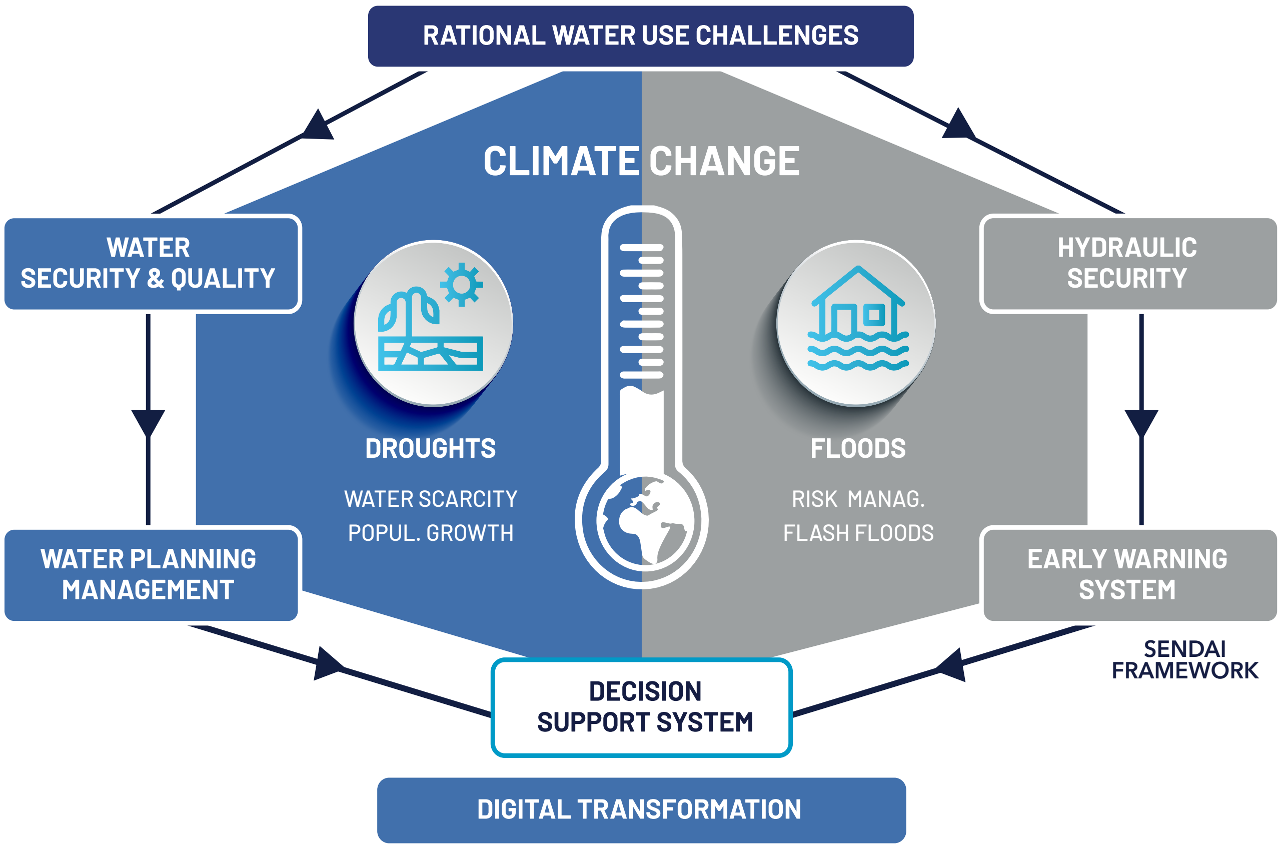


Figure 1. Digital transformation and the challenges of water resource planning and management

Harnessing technology to respond to water management challenges: EWS and DSS

Decision Support Systems (DSS) are fundamental tools that enable relevant agencies to make decisions based on analyzed data. These systems address medium- and long-term planning and management through the use of digital technologies to analyze data, identify trends and implement AI-based strategies.

Early Warning Systems (EWS) focus on preventing and generating warnings for short-term extreme weather events. The ability to pinpoint these events 2-3 days in advance is essential. The UN Sendai Framework (2015-2030) highlights the importance of increasing resilience to natural disasters and addresses the need to deploy early warning systems.

It is essential to highlight the differences between DSS and EWS. While DSS focus on medium- and long-term decision-making, EWS focus on early warnings and short-term prevention. **Both are vital components of integrated water resource management and complement each other.**

Both systems aim **to ensure water security and bring efficient resource management.** Decision support systems provide a decision-making framework by developing medium- and long-term forecasting models, while EWS focus on rapid analysis of immediate situations and responses.

The application of new technologies based on predictive algorithms and real-time access to data seeks to improve the accuracy and speed of models and their analysis. DSS use advanced algorithms to build increasingly accurate predictive scenarios, while EWS take advantage of real-time access to quickly assess critical scenarios.

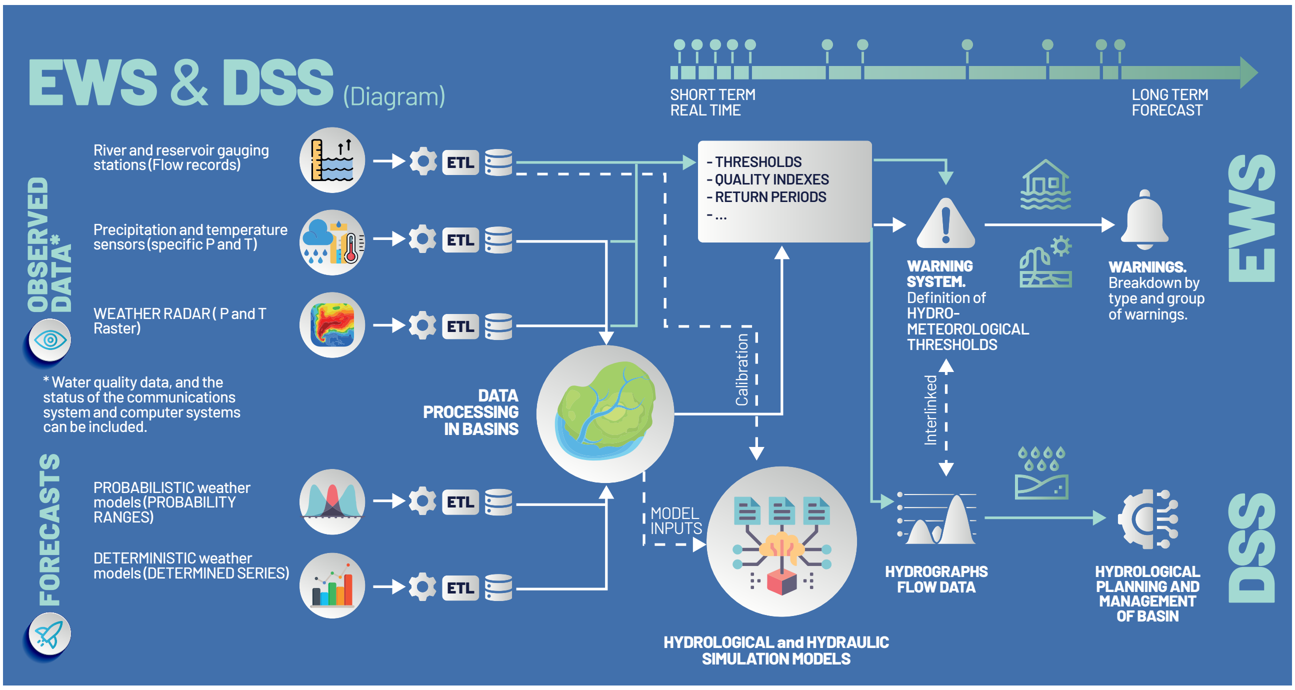


Figure 2. DSS and EWS diagram

DSS and EWS applications in water resource management

Early warning and rapid response

An early warning system needs to deliver rapid responses, highlighting the need for tools and software that can provide accurate data in the shortest possible time, given that the provision of effective warnings is essential for emergency management agencies. The use of artificial intelligence for meteorological and hydrological forecasting has its shortcomings in these stochastic (they do not respond to any pattern) and convective (they occur suddenly and are concentrated in very specific areas) scenarios, which means that any early warning software must be based on physical processes and supervised by an expert.

EWS, which are designed to help in short-term situations, are essential to manage flash floods. **Their main purpose is to quickly analyze the magnitude of an event and issue real-time warnings.** They enable fast, effective responses to emergencies by directly informing security forces and civil defense agencies.

Changes in precipitation patterns require continuous operational improvements. **The use of satellite technology to analyze rainfall provides a more accurate assessment of extreme events.** This improves EWS' ability to forecast flash floods and enhances emergency planning and response.

Dam management and operating rules

Smart reservoir and dam management is vital to address water stress and flooding. **These infrastructures must have optimized systems that take into account the quantity and quality of stored water.** Artificial intelligence has a crucial role to play in operational strategies based on preset rules and objectives that minimize damage and optimize water use.

Operating rules must be carefully defined, and systems must be optimized to minimize parameters such as personal injury, the areas affected, and economic costs. **Systems that comprehensively analyze how reservoirs are operated and AI-based intelligent reservoir operation proposals** are a crucial tool for dam operators, highlighting the need to be able to make quick, effective decisions.

Emerging technologies and practical solutions

In 2024, some technologies such as self-correcting algorithms, access to real-time data and satellite technology will be leveraged to respond to the aforementioned water management challenges. The trends for the coming year are detailed below.

Self-correcting algorithms and smart reservoir management

The application of self-correcting algorithms in rainfall series and meteorological data is essential. **Early identification of faults in measuring devices and the introduction of smart reservoir management,** based on preset operating rules, are key factors to ensure system efficiency.

Real-time data access and satellite technology

Real-time access to data is a challenge, but also an urgent need. Satellite technologies play a key role **in enabling continuous spatial observation of weather conditions and rainfall patterns.** The use of advanced communication systems improves data availability and deliver better responses.

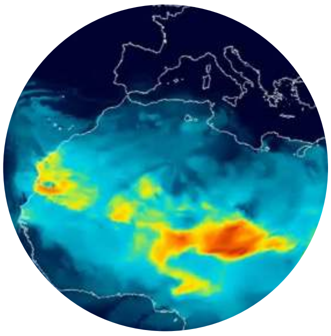
Application of technological tools

The practical application of technological tools, such as comprehensive digital platforms for monitoring and displaying data at gauging stations and wells in real time and predicting surface and groundwater reserves, demonstrates how digital transformation is influencing water management. **The deployment of DSS and EWS are a fast and flexible response to the sector's ongoing challenges.**

Resilient and sustainable management

DSS and EWS are essential tools to combat growing challenges in water resource management at global level. **The expansion and continuous improvement of these systems, together with the application of emerging technologies, are key to achieve robust and sustainable water management.** DSS and EWS will complement each other in the coming year in building resilient communities to address extreme weather events, from drought forecasting to rapid flood response.

Smart reservoir and dam management, supported by advanced algorithms, will provide solutions to water stress, ensuring the availability of a quality water supply. Satellite technology and real-time access to data will become vital tools for rainfall analysis and critical situation analyses.



International cooperation is seen as a key factor in the Sendai framework to address the planet's water challenges. The creation of shared platforms and system integration at global level strengthens anticipation and response capabilities, contributing to reduce the risk of disasters and increasing countries' resilience.

In short, moving towards resilient and sustainable water management implies ongoing integration of innovative technologies, international cooperation, and a holistic approach ranging from prevention to rapid response. **DSS and EWS will be instrumental on this journey to build a future where water is efficiently, adaptively, and sustainably managed.**

5

Smart buildings and DHC networks

DHC networks are a trend that is set to take center stage in the coming year in the transition towards more sustainable energy.

There are two trends that are set to play a key role in today's race for energy efficiency and savings in 2024: **smart buildings and district heating and cooling (DHC) networks.** Smart buildings use advanced technology-based facilities and systems that can be holistically controlled and automated, increasing their energy efficiency, sustainability and safety.

DHC networks are infrastructures that supply thermal energy to multiple buildings at the same time. They work by harnessing energy from a variety of sources, such as industry and wastewater treatment plants. **This is another of the trends that is set to take center stage in the coming year in the transition towards more sustainable energy** and in reducing the emissions generated by cities.

Smart buildings

Smart buildings are set to shape the future of cities and the way we interact with technology. **We use the term "smart building" to refer to an infrastructure that uses advanced technologies to control and optimize its operation and efficiency.** These buildings are often designed to maximize the comfort and safety of occupants, as well as reducing running costs and environmental impact.

The smart building market is expected to grow at a rate of 10.5% over the next few years, reaching a total value of $108.9 billion by 2025. Over the next year, smart building solutions for safety, security and emergency management are expected to gain momentum, with the industrial building segment set to grow the most, as **ensuring efficiency through optimum maintenance management, temperature control, safety and security become increasingly relevant.**

There are several **factors driving the growth of smart buildings,** many of which are related to the digital transformation agenda that is being implemented in all industries and locations. Six technological developments have been pinpointed within this trend that are expected to shape the smart building market in 2024:

1. Behavior prediction

The growth of the sector is directly linked to the development of IoT and artificial intelligence, enabling smarter use of building spaces. Solutions based on these technologies bring predictive controls to optimize building operation costs based on performance forecasts **to reach the ideal operating point.**

2. Digital twins

This tool enables simulations to anticipate events thanks to the representation of a product, service or process that emulates the functioning of its physical twin. **When the design process of a building begins, the digital twin comprehensively examines all the information generated from the building management system,** data from heating, ventilation and air conditioning (HVAC) systems, lighting, fire prevention systems, security, as well as data related to the building's assets and the people who interact with it, such as occupants, building staff and visitors. According to Gartner, 50% of industrial organizations are expected to use digital twins in 2024, boosting efficiency by 10%.

3. Increased focus on people

The consolidation and standardization of smart buildings does not only center on the pursuit of energy efficiency. It also prioritizes the safety and welfare of people. **One of the main issues affecting built-up environments in the last two decades has been the so-called "Sick Building Syndrome",** a term that describes situations in which the occupants of a building experience health problems that disappear when they leave it, such as headaches, eye irritation and nausea. These problems are often due to poor indoor air quality and ineffective HVAC system management. These issues have been solved thanks to the advent of HVAC (Heating, Ventilation and Air Conditioning) control panels, which not only cut down on unnecessary costs, but also ensure the protection of the system's smart devices, thus ensuring a healthier, more comfortable environment for occupants. The focus in 2024 is also on giving people tools for them to make better decisions, thanks to the collection and analysis of real-time data provided by sensors and monitoring systems in buildings.

4. Energy efficiency

Energy efficiency will continue to be one of the cornerstones of smart buildings. **The aim is to implement efficient solutions to ensure user comfort in their daily lives whilst minimizing energy consumption to reduce energy bills** and environmental impact. Some of the initiatives set to be implemented in 2024 are:

- Regular preventive maintenance of air conditioning and heating systems to prevent any possible waste of energy and money.
- Upgrades of energy-related systems, taking into account the useful life of the assets.
- Implementation of renewable energies such as photovoltaic energy, using solar panels.
- Digitalization of buildings to optimize energy management.
- Implementation of district heating and cooling systems, which we will talk about below.

5. Full integration

It is vital to have **a comprehensive management platform to automatically process and manage all the data collected from the different elements and sensors in a building,** so that its overall status can be viewed and monitored from a centralized dashboard. These platforms combine data from different sources, such as sensors, databases and external information systems, and process both real-time information as well as past events.

Buildings need a brain to properly manage their subsystems. These platforms provide total control of the different parts of a building thanks to the integration of watering systems, air conditioning, lighting, waste management, influx of people, elevators, security, fire protection and car parks, among others, regardless of the supplier. As a result, they collect all the necessary information to be able to make smarter decisions while increasing the comfort, safety and productivity of the building's occupants and the building itself.

6. Sustainability

This is a key concern for a wide range of sectors, including smart buildings. **In 2024, IoT platforms will be deployed to monitor energy consumption patterns and to provide specific recommendations to cut energy use.** The same approach can be leveraged to reduce water consumption, implement recycling initiatives and explore renewable energy options.

District Heating & Cooling (DHC)

The DHC market is expected to reach $243.4 billion in 2024. According to Transparency Market Research, district heating is the dominant segment of the two, based on consumption data. Over 50% of final energy demand in the EU comes from heating and cooling consumption in buildings. Over the next few years, the growing deployment of heating and cooling networks in cities and municipalities (known as DHC) will promote energy efficiency and reduce user billing costs. **DHC networks optimize the production of thermal energy (heating and cooling) and then distribute it to a neighborhood, area or group of buildings.**

District heating and cooling networks play a crucial role in the sustainable energy transition and in lowering emissions in cities. This is achieved by harnessing renewable and waste energy sources in a circular model. **These networks have local energy systems that exchange supply between multiple users and producers which, in turn, promotes energy efficiency by matching supply and demand in real time.**

A DHC grid is an urban infrastructure that uses locally sourced renewable energy sources and waste energy. **It harnesses energy resources that would otherwise be wasted,** such as energy generated in industry, wastewater treatment, data centers, and even waste management. In addition, it can include heat pumps that recover waste energy and return it to buildings.

DHC networks have two variants that are compatible with each other:

District Heating

These networks supply domestic hot water and heating to several buildings simultaneously, taking advantage of thermal surpluses that would otherwise be wasted. The energy used comes from renewable sources such as biomass, geothermal energy and solar thermal energy.

District Cooling

This approach uses local resources to provide cooling and lowers the temperature of buildings through a network of pipes carrying chilled water. This reduces primary energy consumption, improving efficiency in both performance and operations.

The trend towards the implementation of DHC networks comes from the numerous advantages they bring, compared to individual air conditioning systems. They include:

Upgrades of older building infrastructures by incorporating state-of-the-art systems.

Significant reductions of the installation footprint, occupying only 10% of the space required by conventional equipment, thus freeing up space for other uses.

Improvements in the aesthetic appearance of buildings, as DHC networks eliminate air conditioning equipment and chimneys from rooftops and facades.

Added value for cities as they encourage the construction of sustainable buildings with better energy ratings.

Reduction of noise generated by installations, as there is no boiler equipment.

Reduction of equipment operation and maintenance costs.

Energy supply is guaranteed, providing more reliable delivery thanks to process automation and constant monitoring by experts.

All these advantages make DHC networks a trend that will boost sustainability and energy efficiency in the coming year, making them an attractive model to deploy in cities and smart buildings.

Conclusions

The World Bank figures could not be clearer: **the world is facing one of the worst water-stress scenarios in its history,** with burgeoning water demand, increases in the number of people living in water-scarce areas, and an escalating number of climate change-related events. Addressing water stress requires a holistic approach in which digital transformation plays a leading role, enabling more efficient, sustainable use of resources thanks to the use of data.

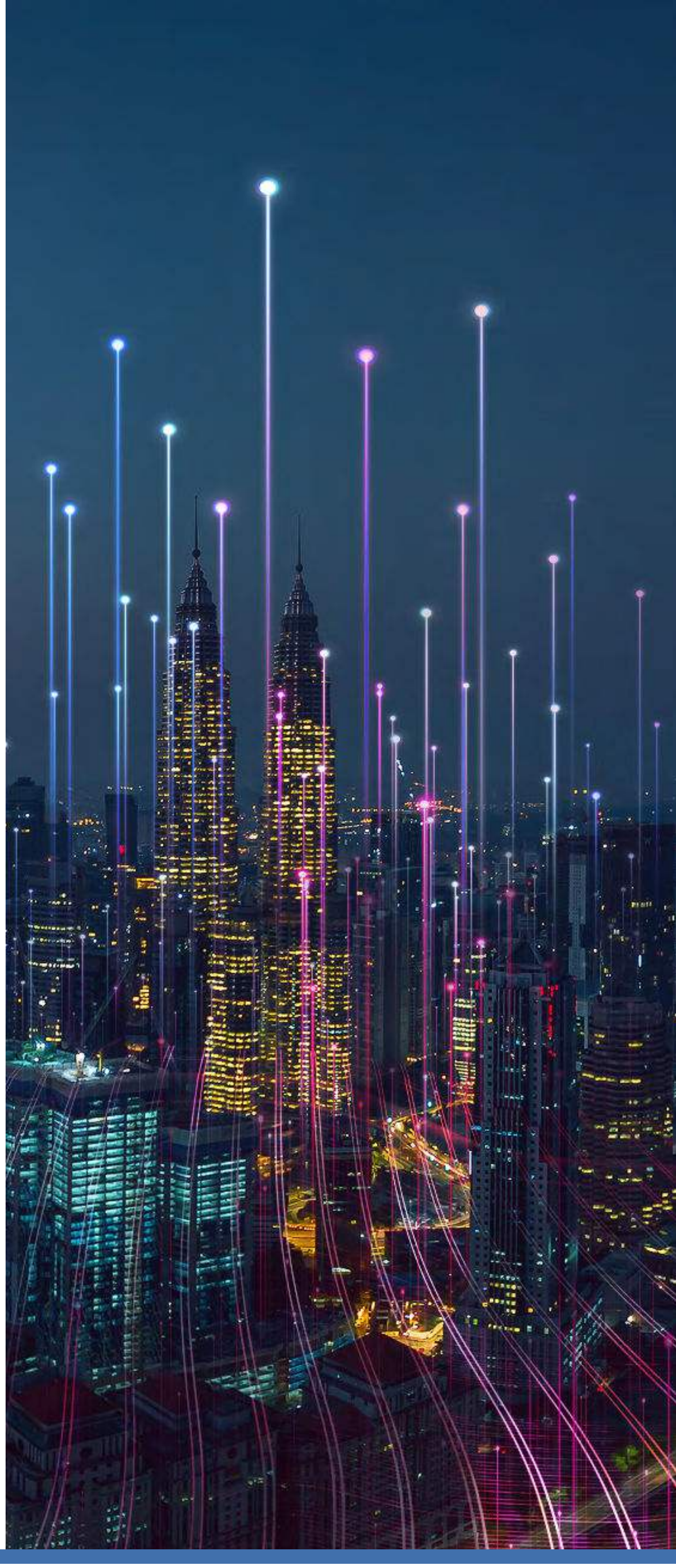
2023 was the year in which Artificial Intelligence was democratized. In 2024, utilities will continue to expand **digital transformation to improve water quality**, mainly in water treatment plants, where the use of data facilitates process automation, optimizing them and making them more robust.

However, digital transformation is not the sole preserve of DWTPs; **wastewater treatment plants (WWTPs) can also harness data mining as the cornerstone of their digital transformation, in which the implementation of new technologies dovetails with the use of advanced treatments.** Thus, in addition to streamlining their operations, utilities will be able to upgrade the quality of the treated water, reduce costs and increase the value perceived by the customer.

There are also two economic mainstays that are set to play a major role in shaping the agenda for 2024. The first is **agricultural irrigation, which will continue to play a leading role to guarantee food security.** The implementation of initiatives such as the PERTE (Strategic Projects for Economic Recovery and Transformation) in Spain, will drive the necessary digital transformation of irrigation associations, optimizing water resources. boosting sustainability and increasing crop efficiency. The second is the **growing trend towards smart buildings and the energy savings they bring,** which will be a key factor in 2024 and the years to come. The necessary optimization of operational costs, as well as energy efficiency, are the cornerstones of the digital transformation of buildings.

In this context, comprehensive water resource management will continue to be crucial in an environment marked by climate change. **Unlocking the value of data will help to anticipate extreme events caused by climate change, as well as to make better decisions, optimize resources and reduce costs.**

In short, **the water sector in 2024 will be characterized by the convergence of technology, sustainability and cooperation.** As we face increasing challenges on the world water scenario, these trends point to a future in which water management is fairer, more efficient and more resilient. Embracing these innovations is crucial to ensure the availability of this vital resource for future generations.



WATER TECHNOLOGY TRENDS 2024

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+34 963 86 05 00

sales@idrica.com

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