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Digital Water

An overview of the future of digital water from a YWP perspective

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Foreword

The recent IWA Digital World Water Congress highlighted the importance of the digital revolution in the water industry. This was made clear during the Young Water Professionals panel event featuring in the Congress closing ceremony, where it was emphasized that *"the interest for digital processes has been rapidly accelerating in recent years. This is because the water industry is starting to see the potential of data analysis tools and digitalisation is becoming a standard in system design"* (Jedrzej Bylka).

Young Water Professionals have a vital role to play in this digital transformation of the water sector. Nurturing their skillset and preparing them for the challenges ahead is crucial if we are to ensure that the digital revolution is fully harnessed globally across the sector.

Building on the momentum around the Congress, this white paper has been developed by a diverse cohort of Young Water Professionals. It aims to provide a snapshot of the current situation on digitalisation of the water sector, as well as a vision for this transformation. The publication integrates the four Levels of Action set out in the IWA Water-Wise Cities Principles for the digital water journey and the intention is for it to provide a brief overview on the opportunities for digitalisation in the water sector. Early-career and senior water professionals alike are invited to consider this document, as it seeks to highlight digitalisation as a transgenerational phenomenon, presenting challenges and possibilities in finding new ways of working, collaborating with colleagues and delivering water services.

Digitalisation has the potential to bring about a range of benefits, from increased productivity, to improved water purity, to reduced energy usage. At IWA, we see a huge opportunity for this 'digital momentum' to bring about enhanced environmental, social, and economic outcomes for people across the world.

Kalanithy Vairavamoorthy
Executive Director of the International Water Association

This output forms part of IWA's commitment to the Young Water Professionals network, by empowering them to take a leading role in contributing to a more water-wise world. Young members can utilise IWA's network to connect and collaborate with international peers, enhance their career development, and raise their profile. Find more about ways to get involved with IWA's Young Water Professional Group: https://iwa-network.org/young-water-professionals/.

Learn more about IWA's Digital Water Programme:
https://iwa-network.org/programs/digital-water/

Summary

This white paper contains a snapshot of the current situation on digitalisation of the water sector as well as a vision for this transformation, gathered by the authors from a globally diverse cohort of Young Water Professionals (YWPs). Additionally, the document suggests a pathway to speed the digital journey, key skills that water professionals will need, and contains info boxes where the readers can find more information on the topics discussed.

Introduction

YWPs and Digital Water

Water professionals have a crucial role in the digital transformation of the water sector and whether this will happen in a fair, sustainable, equitable, and integrated manner. In particular, Young Water Professionals (YWPs), as 'digital natives' raised in a rapidly digitising world, have a unique view on the role that digitalisation plays in our sector, which will impact how the industry will develop in the next 25-50 years. Therefore, YWPs must be involved in the transition of the water sector into the 'digital water' age in a cyber-secure and sustainable manner that balances the short-term and long-term needs of the planet and people. At the same time, this transformation has to be attentive to the conditions of care for vulnerable populations and therefore guarantee their human rights to water and sanitation. Reaching a digitally enabled water sector that makes data-driven decisions requires people to be trained across a multitude of skills and be flexible enough to adapt to a rapidly evolving environment.

With this in mind, this white paper intends to lay out the YWPs perspective on the water sector of the future that will incorporate 'digital water'. In particular, the document considers the digitalisation across IWA's water-wise principle levels (i.e. basin, city, industry and utility, as well as decentralised water wise communities) as well as key skills that are needed at these levels now and in a water-wise future. In essence, this document presents a call to action for the water sector: *the water sector must embrace the digital transformation in an ethical and equitable manner; we must transform the sector together with end-users; we must get the digital transformation of the water sector right, and we need to invest in our skills so that we can start doing so now!*

A YWP Perspective on the Water Sector

Digital Water. Smart Water. Internet of Water. Water 4.0. These are some of the many terms that are being used to describe the rapid transformation that the water sector is experiencing (Sarni et al., 2018). Digital technologies will be integral to addressing the most pressing challenges of our time, namely climate change, population growth, public health crises, and the provision of basic services at risk from global shocks. To successfully address these challenges, it will be crucial to embrace a multi-stakeholder approach to problem-solving as well as benefit from all relevant experience and expertise. Additionally, a redesign of education and training will be needed to meet the needs of the water sector of the future while adopting an agile approach. The digital water transition has to aim for open data and data standardisation. In fact, open sharing of lessons learned and solutions ensures progress is not limited to countries with the requisite resources. By doing so, the digital transformation of the water sector should epitomise a 'no one left behind' approach to ensure ongoing equitable and sustainable development. For this purpose, innovation-enabling environments need to be the norm, including innovation-enabling policies, financing, risk tolerance, and more. Digital technology must be focused on needs and adopted at all levels – described in the IWA Water-Wise Cities Principles as regenerative water services, water sensitive urban design, basin connected cities, and water-wise communities (Figure 1).

The water sector needs to create future proof enabling frameworks that support safe, efficient, and effective technologies. As a sector where failure is not an option, we cannot apply the technology sector's mantra of "move fast and break things"; rather we need to "move fast and fix things".

Learn more about this topic!

- IWA (2019): Industry leaders chart the transformation journey
- Resocializing digital water transformations: Outlining social science perspectives on the digital water journey
- EU project on cyber security
- Smart Water Networks Forum Research Portal
- Global Water Intelligence Digital Water Portal

Figure 1. The "Principles for Water-Wise Cities" Framework: four Levels of Action – 1. Regenerative Water Services; 2. Water Sensitive Urban Design; 3. Basin Connected Cities; 4. Water-Wise Communities. Source: IWA Water-Wise Cities Principles

Changing the Game

As we look ahead to the challenges of the next 5, 20, and 50 years, it is evident that there needs to be a revolution not only of the water sector's technology, but also of its policies, governance, and culture. Most importantly, the digital transformation of the water sector should drive sustainable development and deliver a more equitable (water) world.

The next sections present a collective idea of the future of Digital Water, gathered by the authors from a globally diverse group of YWPs, across IWA's water-wise principle levels.

Water-Wise Basins

Globally, basins are under pressure due to floods, droughts, water quality issues (i.e., intensifying toxic algal blooms) and reduced water availability because of competing pressures on resources. It is estimated that around 48% of the world's wastewater flows back into our watersheds untreated (Jones et al., 2021) with drastic socioeconomic, health, and environmental consequences. According to IWA's Action Agenda for Basin-Connected Cities, "*protecting basins and restoring those that are already degraded is a priority to ensure a balanced approach to development that sustains cities and the ecosystems they rely on*". Well-managed basins can be the difference between water security and water scarcity for urban and rural stakeholders. Managing the top three risks identified by the Action Agenda - extreme events, declining water quality, and water availability - requires an integrated and data-driven approach. Added to these risks is the sheer cost of maintaining infrastructure to buffer the impacts of extreme events and manage water quality and availability. Integrating nature-based solutions into long term planning supports the triple bottom line but requires data-driven development and decision making. Digital water tools can support water professionals and basin level stakeholders with the pathways to action from assessment, planning, and implementation.

We envision a future in which Integrated Water Resources Management (IWRM) is mainstreamed, urban water is holistically managed and where nature-based solutions complement gray infrastructure. To help transform this view into a reality, digital tools have a central role to play. For instance, watershed Digital Twins, underpinned by solid real time data from IoT sensors and remote sensing, could be applied to support water management decision-making processes. Additionally, Artificial Intelligence (AI) could be used to monitor, evaluate, and analyse flows and processes at multiple scales within the basin. Also, predictive modelling capabilities would improve transparency and facilitate knowledge sharing between upstream and downstream stakeholders. The combination of these and other technologies will optimise the potential for basins to provide high quality ecosystem services to the world's cities and rural areas, while maintaining regenerative ecosystem flows.

Pilot programmes and proof of concepts are laying the foundation of what a digital future will hold at the basin level. On the data management and governance level, initiatives to standardise data and create open data platforms are transforming how basins are managed and leading to accelerated innovation. Various projects integrating digital tools (e.g., blockchain, new imaging technologies coupled with augmented reality (AR), drones, etc.) are proving the value of advanced technologies for improving water management at the basin level. However, some technologies are more mature than others. For example, the use of remote sensing, satellite imagery, and advanced imaging technology is well documented, and these technologies are already well embedded across the water sector. Where mature technologies meet less mature technologies, things get exciting. For instance, algal blooms in surface water due to agricultural runoff is an increasing problem of global proportion, causing environmental and economic damage to regions (Ho et al.,

2019). Stakeholders can better manage the risks and impacts by using Machine Learning (ML) to predict when, where, and for how long these blooms will happen (Yñiguez and Ottong, 2020). Advanced Earth-Observation data products are currently being used in the framework of the European H202 project PrimeWater which generates information on the effects up upstream changes on both water quality and quantity. For example, in the Mulargia reservoir (Italy), PrimeWater is assessing the predictability of algae blooms for time scales spanning from several days to a few weeks ahead employing both process-based and data-driven models.

Game-changing technologies like digital twins, IoT, blockchain, remote sensing, Fintech, and AI can allow for information-driven decision making, planning, and financing to a level we have not yet implemented basin-wide. Early investigations by groups in Denmark, the Netherlands, and the UK are exploring the possibility to create a national-level digital twin of their basins to improve how water is managed and used from source to sea (Bolton et al., 2018). Integrating AI for scenario planning can support stakeholders in data-driven decision making. In cases where trust and transparency are problematic, blockchain can be used in water markets to bypass traditional ways of trading water rights and implement traceable and transparent foundations for water allocations.

Some of the benefits of these technologies being used at scale include real-time and predictive insights, preventative management capabilities, transparent and integrated information sharing, as well as accurate water flow management. Successful pilot projects will accelerate scaling and adoption, although full scale adoption will take time and coordination efforts. The data challenges are not insurmountable but will require a coordinated approach among all stakeholders and the necessary investments to ensure that quantity and quality are at the level needed to move towards actionable intelligence. Innovative financing mechanisms that support digital basin scale projects will help establish more of these successful proof of concept projects.

Learn more about this topic!

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- Water online, How digital twins conceptualize the Water Industry
- The Jefferson Project
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- Opendatasoft, How open data can lead to smarter water management
- Alida Cantor et al., 2018, Data for water decision making
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- Ledger Insights, Australian government in Water Ledger blockchain for trading water rights
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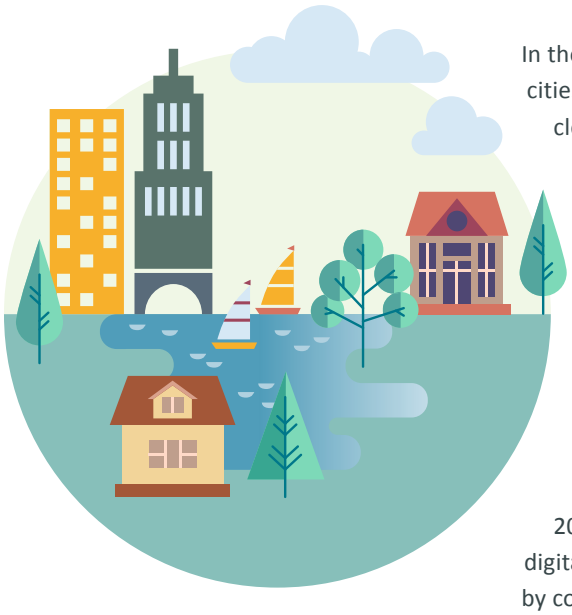
- IISD-ELA Report, 2018, Harnessing the Flow of Data: Fintech opportunities for ecosystem management
- Water Digital Twin

Water Sensitives Cities



In the face of increasing pressure from climate change and urbanisation, many cities around the world are struggling to provide basic utility services, such as clean reliable drinking water or sanitation. There is a need for investment in the most basic of infrastructure. Digital tools typically cost a fraction of the investment in 'hard infrastructure' but have the potential to result in significant savings by optimising existing infrastructure or delaying the need for developing new ones. For example, water loss is a significant issue in many cities of the world, where up to 60% (46 billion litres) of clean drinking water is lost on its way to users (Serranito and Donnelly, 2015). This is an issue where digital tools have proven highly effective. For example, the City of Cape Town has identified the need for a Decision Support System (DSS) to support its response to a recent severe drought. This system is current being implemented (Kamish and Cantrell, 2018). Another successful case is The Danish LeakMan project , which is applying digital solutions to reduce urban water loss in greater Copenhagen, Denmark, by combining multiple data sources in automatic leakage management. Noise loggers for automatic leakage tracking optimise leakage detection; smart water meters measure end user consumption and intelligent valves and pumps enable active pressure management. All data collected is combined with SCADA and GIS in real-time hydraulic modelling and processed in online management information systems to facilitate automatic leakage management and monitoring of KPIs, resulting in a significant reduction in Non-Revenue Water levels (Mikkelsen, 2018).

Cities have started utilising digital tools for many applications such as modelling flood risk and forecasting drinking water demand (Nkwunonwo et al. 2020). This trend will only strengthen in the years to come, but will require large investments in digital capabilities. The 'Smart City' market is expected to reach 252 billion USD by 2025 (Smart Cities Market Size | Industry Analysis, Growth, Trends, Forecast 2025), with further growth expected beyond this.

The water sector must be an integrated part of the Smart City of the future. Ideally, water should be linked in autonomous digitally driven systems to the rest of the functions of the city which utilise real time data and digital twins to ensure holistic and optimised management of all the services and resources. It will no longer be enough to optimise within our own sector: the water sector needs to prepare to 'plug in' to a larger platform that enables the integration of all utility services provided in the city.

A Smart City minimises its environmental impact through reuse and minimal resource consumption, in the spirit of sustainability. At the same time, cities must be as liveable as possible and provide safe and reliable water and sanitation services equally for all. In this framework, digital tools can improve the resilience of cities to water scarcity or flooding by optimal water allocation and forecasting (Groppo et al., 2019).

Moving from today's cities towards integrated smart cities will require investment in hardware, software, processes, and most importantly, people. Cities need to begin investing in distributed networks of sensors to improve a better management of valuable resources (i.e., monitoring, control, and reuse), as well as reduce the impact of the water system on the quality of life and environment in the city. This will ensure that new infrastructure to supply, drain, and treat water can be optimally designed, maintained and operated through the use of digital tools (Lund et al., 2019).

Digital tools help optimise the linkages between smart city systems. Data is still treated in silos within organisations and between separate utilities, leading to a suboptimal use of the resulting information. Attempts to create uniform data platforms are appearing and will have to be deployed at scale for cities globally (European Commission, 2020). For example, the European Union is investing in creating a digital marketplace for smart city solutions that will bring together key sectors. This cross-sectoral collaboration will require water professionals to acquire an understanding of interoperability as a core design component of digital systems.

For cities to become Smart Water Cities, there is an urgent need to ensure that water professionals, including YWPs, develop the necessary digital skills and integrate work plans across sectors. This requires capacity development on digital skills, systems thinking, and working in multi-disciplinary teams with experts from other areas of the Smart City Network.

Learn more about this topic!

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- Digital Water: The importance of knowing what we do not know

Water-Wise industry and utilities

The world's water infrastructure needs to keep pace with the increased growth in demand. Assuming business-as-usual, the global demand for water in the manufacturing industry alone will grow by 400% between 2000 and 2050, mainly from emerging economies (WWAP, 2015). Additionally, existing water infrastructure is ageing and faces large scale investment needs and associated control and design decisions.

The negative environmental impact of industry and ill-managed water systems is contributing to global water pollution. It is estimated that less than 20% of the world's drainage basins show near pristine water quality (WWAP, 2009). In this context, digital tools can allow for better monitoring and control of the negative impacts of the water systems. However, while there is an increase of digital adoption in water utilities, the sector still lags behind other industries in integrating new, smart technologies into the built water cycle, creating a largely fragmented market that challenges regulators, utilities, and industries.

Industry and utilities around the world should harness digital leapfrog opportunities to increase their efficiency and resilience. In fact, digital tools and the added insights they provide have the potential to enable circular resource use and more reliable and affordable basic water services. Additionally, partnerships across the utility and industry space should be established to improve innovation and integration of new digital technologies and sharing of lessons learned across sectors and geographies would be needed to accelerate the iteration cycle.

Digital tools need to enable transparency, real-time optimisation, mitigation of breakdowns, consistent monitoring, and minimisation of water consumption and losses. Consequently, daily operations need to be assisted by predictive maintenance, and automatic process optimisation. By doing so, digital transformation can provide new business models for utilities and industries, for example Data-as-a-Service (DAAS). Industries should build digital offerings around their existing physical components to assist utilities and cities in their digital transformation. Additionally, utilities should regularly interact with and empower customers with data-driven services collected at the point of consumption. Ideally, interactions with regulators should be automated (i.e., based on sensors and algorithms), allowing utilities more time to provide value for the customer. By doing so, digital monitoring tools and utility-industry cooperation will increase accountability for higher performance, and greater levels of engagement will reduce environmental degradation and pollution from point-sources.

The digital transformation will enable seamless integration between utilities and industry, facilitating the optimal use and reuse of resources between stakeholders.

To be ready for a 'digital water future', utilities and industry must be enabled by policy and regulation to adopt innovative technologies and ways of working. There needs to be a culture shift internally, which can be supported by third parties, partnerships, or by creating new digital transformation roles, led by champions who are able to drive change. By tapping into the potential of digital water, industry and utilities would ensure more efficient and environmentally friendly operations. Lund et al. (2019) illustrated how a digitally controlled urban drainage system can reduce environmental impact from the sewer system by linking surface water management infrastructure with below ground infrastructure. Li and Wang (2018) showed how a combination of domain knowledge and machine learning can improve water main repair based on predictive methods. Fuertes et al. (2020) showed that a digital twin mirroring a facility can ensure real-time optimisation, avoidance of breakdowns, and planning of staff tasks and maintenance. This transformation is forcing companies to have strict data governance to ensure that data and software is treated at the same level as physical assets.

Additionally, collecting large amounts of data is becoming increasingly important due to the quality of intelligent algorithms. Companies, utilities, and regulators will have to partner to get the maximum value from their data, while adhering to the highest privacy and cybersecurity standards. Furthermore, utilities and industry bring different key competencies to the table and will have to harness partnerships in order to solve the digital or domain capacity gap in each individual organisation. To achieve this outcome, there is a need for strategic mobilisation and capacity development of water professionals, through extended partnerships with the Information and Communications Technology (ICT) sector and other leading sectors in the digital transition (i.e., energy and telecommunications sectors).

Learn more about this topic!

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- Water and Wastewater Companies for Climate Mitigation

Decentralised water-wise communities

In emerging markets, most people do not have access to an improved water source or improved WASH services (WHO and UNICEF, 2019). Existing systems are inefficient micro-scale systems (i.e., septic tanks, pit latrines) or ill-managed large systems, both posing a risk to humans and the environment. Centralised systems in emerging markets are often unsustainably financed and ill-equipped to tackle climate change related risks, handle rapid changes in terms of population growth, and increased contamination of water resources due to pharmaceutical and agricultural externalities (Camdessus Report, 2003).

Decentralisation faces an uphill battle as regulations and laws need to be reviewed to allow for appropriate standards and compliance monitoring of decentralised approaches (Larsen et al., 2013). On a macro scale, governance issues pose a real problem for decentralised approaches, as centralised systems are preferred due to their prestige and large financial volumes, especially in emerging markets. As smaller, decentralised systems are harder to manage, operate, monitor, and oversee, there is a need to eliminate governance hurdles. Furthermore, local governing entities' personnel need to be enabled to assess and decide on infrastructure projects in a sustainable and socially beneficial way.

Integrating digital tools at the local level can support decentralisation (or decentralised approaches) which provides a huge opportunity, especially for emerging markets and growing cities due to lower entry level costs as well as the inherent capacity of flexibility and adaptability to local conditions. Effectively, decentralisation and respective digital solutions enable and increase the ownership by the communities including increased awareness that water is a valuable resource. Additionally, decentralisation and digital solution support job and wealth creation on a local level, and save resources by reducing extensive conveyance structures (Larsen et al., 2013).

There is a high potential to achieve sustainable and effective decentralisation by using digital tools to support activities like decentralised rain harvesting, irrigation and drainage for improved local catchment management. Also, well-designed decentralised small treatment systems can be operated and optimised remotely at low costs while using little to no energy for treatment and pumping.

Startups and small and medium-sized enterprises (SMEs) show that piloting new and innovative digital solutions is easier at a decentralised and small scale. Decentralised and intelligently optimised resource recovery enables local reuse, keeping negative as well as positive effects local, and must be an integral part of any activities in local IWRM. Lastly, as the water sector is in dire need of new financing models, the combination of decentralised and digital approaches is likely to harness innovative, small scale and locally owned financing approaches.

Digital tools for data acquisition and mining, data management, monitoring and evaluation as well as new DSS allow for increased cross-sectoral cooperation, involvement of all stakeholders and increased transparency. Moreover, digital tools can support democratisation through increased oversight and therefore increased accountability of decision makers by tackling prevailing governance issues. Digital tools have the potential to enable management of the complexity of both social and technological dimensions. For example, blockchain technologies could be used to increase the efficiency of an irrigation system as well as increase coordination and trust in communities (Robles et al., 2019).

Accepting the large capacity gap of knowledge in emerging and mature markets, particularly by technical O&M staff, policy and decision makers, is the first step in finding a solution: an increase of innovative, adaptable on-the-job training and qualification options via digital tools outside of slow-changing traditional structures (universities, institutes) must be driven by various stakeholders (i.e., civil society organisations, individuals, businesses).

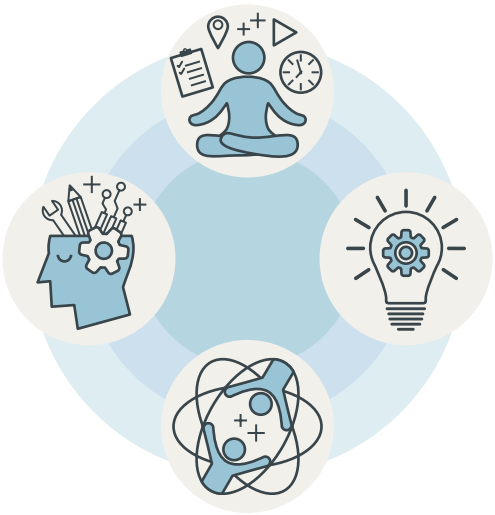
Including larger swaths of the society into discussion and decision-making processes will enhance the visibility of the water sector and gather interest by employees and businesses formerly not active in the sector. Decentralised systems will tap into novel small scale financial products, use digital payback schemes as well as community based digital financing solutions to drive access to safe and affordable drinking water and WASH provision.

Lastly, decentralised structures can be more resilient to large scale natural disasters and man-made cybersecurity attacks (Little, 2002; Leigh and Lee, 2019). With the right digital tools, decentralised structures can limit the extent of damage and increase resilience in emergency situations. Best practices will be shared and adapted to local needs by individual decentralised structures. YWPs will need to support the digital transformation of their local communities in this decentralised framework.

Learn more about this topic!

- The FundiFix model: Maintaining rural water services
- Sustainable Sanitation and Water Management Toolbox
- IWA, Time for utilities to embrace decentralisation
- Why collaboration is key to creating water-wise cities
- Revolutionise rural water services in Kenya
- How far has devolution come in Kenya?

Skills for Our Digital Water Future



A World Economic Forum Future of Jobs Report stated that '50% of all employees will need reskilling by 2025, as adoption of technology increases' and 'the vast majority of business leaders (94%) now expect employees to pick up new skills on the job' (WEF, 2020). It is therefore clear that there is a need for water professionals to view their training and education in a dynamic light, aiming for ongoing upskilling. Numerous platforms already exist to support this, including but not limited to IWA Learn, Udemy, GetSmarter, FutureLearn, edX, Coursera. Furthermore, Universities are increasing their online offerings. This confirms the urgency to adopt and adapt necessary skills and ways of working to achieve our digital water future.

Importantly, the water sector needs to acknowledge the crucial role that professionally trained water professionals and engineers can play in applying the right (digital) solution in the correct step of the water cycle. Technical and engineering skills need to be recognised as fundamental and acquired together with operational management skills to address the technical skills gaps that the industry is currently suffering. Without an in-dept knowledge of the water cycle, there is a risk of investing on the inappropriate technology or applying this in the wrong area.

Nevertheless, technical skills have to be developed together with soft skills (e.g., problem solving, self-management, interpersonal skills) which are also fundamental in adopting new ways of working (agile, scrum, systems thinking, distributed/remote working).

Conclusion

Digital Water is undoubtedly the future for the water sector and needs to be considered as a prerequisite in developing and managing the water sector.

The benefits of a digital water sector are clear as we are in dire need of a more sustainable, safe, and effective water world. Digitalisation has a role to play in making water affordable, ensuring safe and clean drinking water, and protecting water at an ecosystem level, while adapting to a changing climate.

It is evident that there are opportunities for adopting digital tools and ways of working at all levels of water management. Achieving this equitable digital water future requires a commitment to developing partnerships, innovative financing, capacity building, and a cohesive strategy. This collective digital water future connects basins, cities, utilities, industry, and decentralised water-wise communities with a call for a just and equitable transition, leaving no one behind.

This document has laid out how a digitally-enabled and data-driven water-wise future requires new ways of working, consistent and frequent upskilling and training. There is a need for the development of a roadmap to ensure that the water sector, as a whole, is appropriately skilled and fit for a digital water future. At the core, this is a people-led transformation and we need everyone to participate by bringing together their diverse strengths.

Join us!

Let's digitally transform equitably.
Let's transform together.
Let's get this right.
Let's do this now.
Are you in?

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The International Water Association (IWA) is the leading network and global knowledge hub for water professionals, and anyone committed to the future of water. IWA, which is a non-profit organisation, has a legacy of over 70 years.

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