



Towards a resilient society with smart water solutions

” *The main phenomena influencing water resilience are climate change, population growth and urbanisation. Climate change is leading to both more extreme weather events and long-term changes in the distribution of the world’s water resources. Increasing droughts and flooding influence water systems, and resilient solutions require novel innovations as smart processes, products and services.*

Too little or too much or too dirty, water is playing a major role in sustainability planning across the globe. A water resilient society implies wide participation of civil society, including businesses, in actions to achieve social and technological readiness to anticipate change and influence future events affecting our water security. The elements of a resilient water ecosystem are manifold, and when developed and demonstrated, represent a significant export potential.

This policy brief will discuss these wide opportunities and aim to pinpoint the niches for Finland’s cleantech export markets.

Water as a business

By 2030, the existing fresh water supplies will satisfy only 60% of the global need (Figure 1). The biggest gap will be in the developing and most populated areas of the globe, where the population growth and standard of living are also increasing at the highest rate. At the same time, other regions will be facing increasing flooding events, challenging infrastructure resilience and the quality of water discharge. Clearly, the *twofold challenge requires separate technological solutions, and modifications must be efficient.*

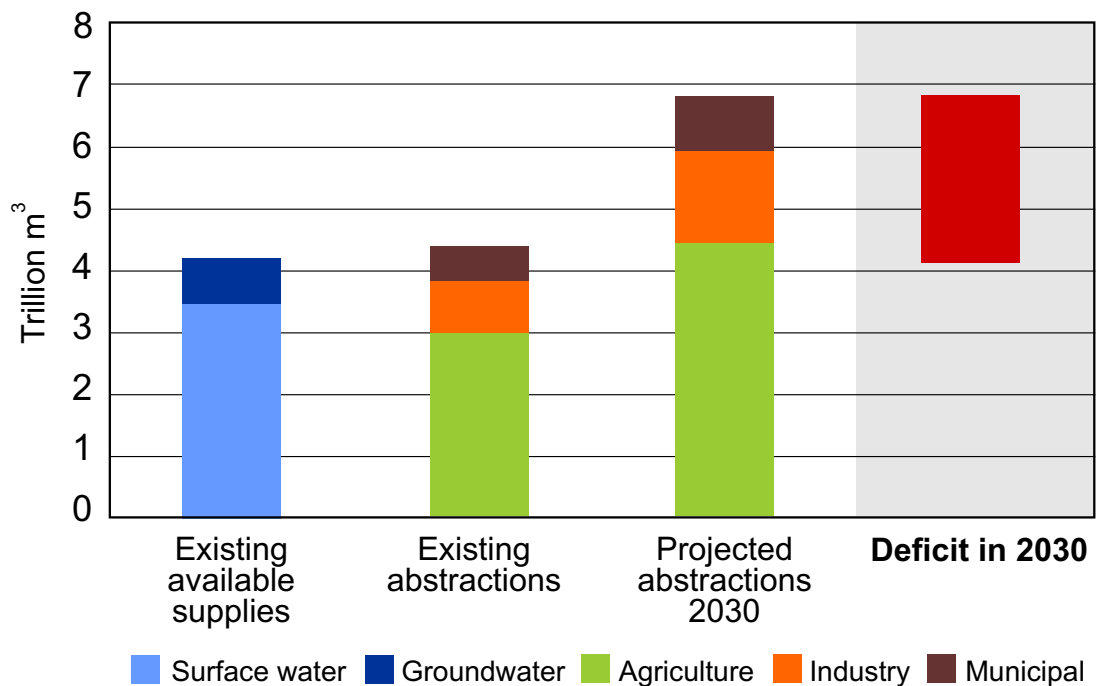


Figure 1. Water demand will exceed available supplies. Source: Global Water Intelligence, World Bank.

Increasing water scarcity presents not only a substantial risk, but in some cases also an opportunity for the private sector to stand out by investing in water efficiency innovation. Improving water productivity to close the worldwide gap between supply and demand for water is estimated to cost US\$50-60 billion annually over the next 20 years¹.

Overall, water-related activities represent a major industry, and the global markets are growing continuously. Revenues for the global water industry are estimated to 655 B\$ (2017), with an annual growth rate of ca 5%².

Opening water-related data and developing data-based services are emerging as a fast growing business. Considerable venture capital is currently available in Silicon Valley for water-related start-up companies, and the performance of these companies is better than that of many other technology-based companies³. Water is thus a vast market opportunity, being proposed as the next oil, yet more important.

Water-related business opportunities are available on each step of the Water Value Chain (Figure 1), through improving and increasing the overall water efficiency by innovative water treatment, distribution, industrial process technology, recycling and consumption solutions. Digitalisation and related tools, including those supported by deep learning (artificial intelligence), provide business opportunities for providers of systemic solutions in the water sector. This is also Finland's stronghold and opportunity. The Finnish forest industry has paved the way to profitable and sustainable water management in their processes. By integrating the knowledge, experience and skills from process industry and digitalization, Finland can be a frontrunner in sustainable water business. Water can be a business in a sustainable and ethical way.

Our water management standards do not deviate much from those of water scarce regions, due to stringent discharge regulations, driven by the requirement that societal and industrial activities are not permitted to significantly impact their surrounding ecosystem. Resource-efficient water recycling and reuse paves the way for a water resilient industry. Water recycling and reuse can turn into a significant economic benefit and reduce operational risks. Finland possesses the necessary know-how in industrial processes needed for optimising the effects of water recycling on process performance.

¹ UN WWAP 2017. The United Nations World Water Development Report 2016. Water and Jobs: Facts and Figures. United Nations World Water Assessment Programme.

² Frost and Sullivan 2017 Global Outlook of the Water Industry

³ CRUNCH NETWORK: Turning Water Problems into Business Opportunities, Posted Jun 22, 2015 by Tamin Pechet

Case: The Finnish pulp and paper industry

Today water efficiency is normal routine in the forest industry. This has not been always a case. As late as the 1970s, 250 m³ of fresh water was needed for the production of 1 ton of pulp. Today the need is only approx. 50 m³. Moreover, in a modern pulp and forest industry integrate the needed water is also recycled at least 15 times. Thus, the forest industry has changed from a water intensive industry to a water efficient industry in just a few decades - and has done it in a cost-efficient way.

The next step is cross-utilisation of mineral resources contained in the wastewater. The Finnish forest industry is also partnering with the fertiliser industry to develop a nutrient solution that contains the correct ratio of recycled and mineral nutrients, using industrial waste water sludge as raw material.

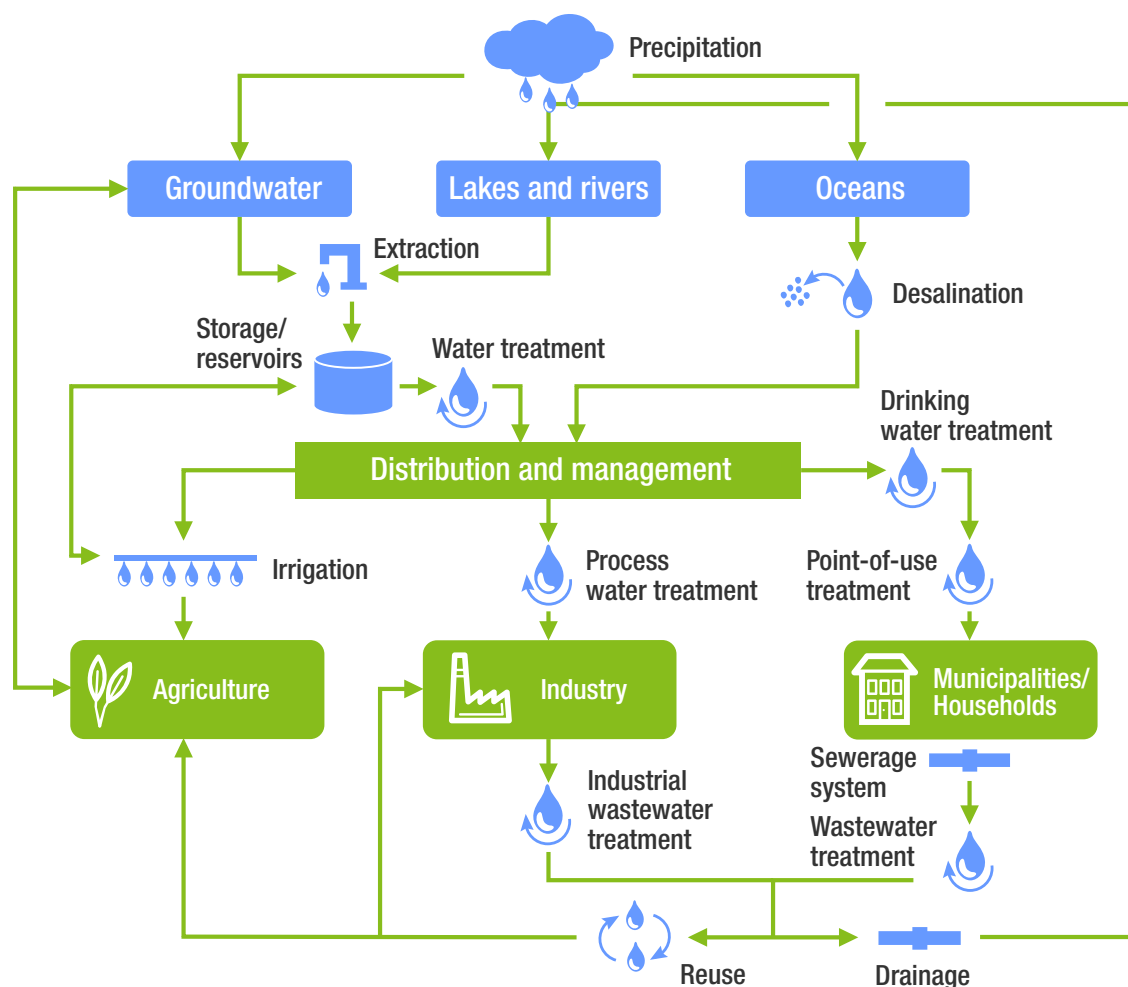


Figure 2. The Water Value Chain (Modified from RobecoSAM)⁴.

Secure industrial activities - zero discharge

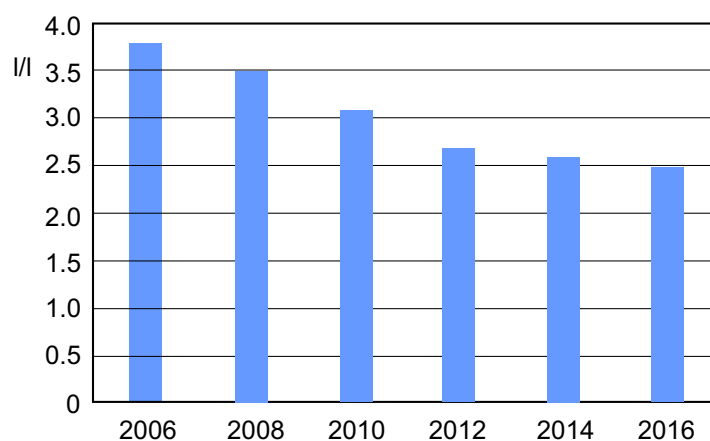
Globally, industry has the highest water footprint, m³/m² surface area, compared with the domestic and agricultural sectors. Moreover, industrial water consumption is predicted to increase proportionally more than consumption in the other main sectors, as depicted in Figure 1.

⁴ RobecoSAM 2015. Water: the market of the future. RobecoSAM Study 06/2015. 44 p.

Better quality and profitability with water-efficient processes

Limited fresh water resources as well as resource- and energy intensive wastewater treatment motivate companies to review their water use and water dependence on a more detailed level - especially when driven by discharge regulations (see box The Brewing Industry). The former can be quantified by a water footprint⁵ analysis, whereas the dependence relates to risk management. Water-related risks may be associated with the availability of a sufficient quantity and/or quality of water, which both ultimately have an impact on the profitability of business operations. Technically, the business continuity perspective of water risks underlines the importance of sustainable water abstraction, closed water cycles and the quality management of process waters. The water intensive industry recognizes that water footprints should be further reduced in order to secure water supplies in future. Therefore, water recycling and reuse can become an economic benefit and reduce operational risks. Reuse of water in industrial operations will require both water recycling equipment and knowledge on how altered water quality affects the process itself. Furthermore, many processes can be developed to use less and/or lower quality water. Being less dependent on external water resources gives a wider choice of siting and freedom to scale up production

Case: The brewing industry



Water consumption by the Finnish brewing industry (litres of water per litre of product) has decreased by ca. 35% during the past decade*, and is currently well below the global average for breweries.

For example, Heineken breweries operating in a very water scarce area are implementing water balancing schemes, such as restoring wetlands, water-saving barley irrigation technologies and soil infiltration methods, all lowering longer term regional water risks and increasing the company's social licence to operate**.

*The Federation of the Brewing and Soft Drinks Industry

**Heineken

For increased resilience and efficiency, internal recycling can be widened to external, cross-sectoral use among regional stakeholders and actors. Corresponding models already exist in Finland's energy sector in trading between industry and the society. Advanced industrial companies will move from their own water solutions to holistic water management including both quality and quantity aspects of the total regional or local water need. Cases already exist in which the industry is producing potable water for the nearby community from its own discharge⁶. Holistic water management has the potential to address the needs of industrial operations simultaneously with the needs of the local domestic community and agriculture to deliver social and business value at the same time.

⁵ Water footprint is the volume of freshwater used to produce the product, measured at the place where the product was actually produced. It refers to the sum of the water use in the various steps of the production chain. Water footprint provides information about the water flows and their environmental impacts on both water quantity and water quality in the various steps of the companies' global product chains.

⁶ http://www.iwa-network.org/filemanager-uploads/WQ_Compendium/Cases/The%20eMalahleni%20Water.pdf

Wastewater as a resource

In the future, industrial water flows should also be seen as the sources of resources which they are. Traditional end-of-pipe water management usually considers the effluents as valueless or of negative value. Instead, industrial water streams can and should be utilized as resources of nutrients, minerals, chemicals, metals and energy, which are embedded in them. Water is the enabler for creating entirely new industry in the blue economy. Finland's aquatic nature makes us well positioned to be a forerunner in this future sector. Targets for increasing renewable resources, food security and clean water together with a growing recreation industry are driving the blue economy development. In addition, Finland has specific expertise of water treatment in sensitive Arctic areas. Although the majority of water processing solutions have been developed for warm climates, not all technologies (chemical, biological) can always be directly applied in Arctic areas.

In the water scarce global future, the value of Finland as a country rich in water will become higher. Here Finland can compete in a wide range of water-intensive industries. Water footprint⁴ enables focusing on the most relevant measures and investments towards improved water efficiency. Footprint thinking also strengthens a company's sustainability strategy: by understanding the impacts of their own operations, companies can enhance their risk tolerance and improve their water stewardship.

Urban water resilience

Between 2015 and 2030, the world will gain 1.1 billion new city dwellers, increasing the global urban population from 4 to over 5 billion. Virtually all the future growth of the world's population will be concentrated in cities. Although this phenomenon provides governments certain economies of scale in the supply of supply infrastructure services, at the same time it sets enormous pressure to build up new and improve existing water infrastructure. Clearly new approaches will be pursued both for drinking and wastewater management. At the same time, integrated wastewater management may also provide some of the answers to other challenges, including local food production and industrial development. Reclaimed water offers opportunities for a sustainable and reliable water supply for industries and municipalities, especially with a growing number of cities relying on more distant and/or alternative sources of water to meet increasing demand. Urban water utilisation accounts for about 30% of total water use globally. However, an estimated 30% of the water abstracted globally is lost through leakage⁸.

The major part of all future infrastructural investment will go to water

By 2025, investment in urban water infrastructure will comprise the bulk of global infrastructure investment. Spending on water infrastructure is expected to exceed €1 trillion in the OECD countries and Russia, China, India and Brazil, which is nearly triple the required investments in electricity or transport. This anticipated investment in new or improved urban water infrastructure represents a key opportunity for businesses to develop and deploy innovative water infrastructure solutions. Resilient urban water ecosystems require strong institutional support for innovations in the water sector by both governments and companies. We can use digital technologies to highlight the benefits/co-benefits of alternative 'green' water management schemes, etc. Through co-creative and co-design processes, we can also engage citizens in water management decision-making to build support.

Urban water resilience is associated with recovery from disruptive events - either caused by human actions or by extreme natural events - as well as with the capacity of the urban water ecosystem to adapt to change. In order to keep pace with the growing number of dwellers, cities will need to move from traditional centralised systems to the inclusion of diverse solutions. Decentralisation is seen as one main component of urban water resilience, while multiple, conventional or non-conventional water resource, treatment, storage and conveyance options need to be constructed throughout the urban water system. Decentralisation also reduces water-related risks associated with extreme weather events and climate change. Reduced loads to sewer networks as a result of storm-water capture by localised systems decrease wear and tear on sewer infrastructure. In addition, decentralised treat-

⁷ UN 2015. Population 2030. Demographic challenges and opportunities for sustainable development planning

⁸ UN WWAP 2017. The United Nations World Water Development Report 2016. Water and Jobs: Facts and Figures. United Nations World Water Assessment Programme.

ment provides a barrier to contamination of local surface waters by combined sewer overflows when the capacity of centralized treatment systems is exceeded.

At the same time, wastewater management may also provide some of the answers to other challenges, and through treatment and reuse systems reclaimed waste water will increasingly support local food production and industrial development.

Digitalisation is the key

Urban systems are complex social-ecological systems that continuously change and adapt. Genuine integration of new urban processes taking advantage of e.g. synergies between water and waste management for resource recovery, or combining green infrastructure with waste water management in such a system, is challenging. In general, centralisation of water services is a challenge. Modularity and independence of treatment/storage units yields increased reactivity to unforeseen events. Combining existing technologies, such as ICT, with green and grey infrastructural solutions and advanced water treatment, however, provides means to begin systematically addressing contemporary urban water challenges in a cost-efficient way. Digital technologies provide opportunities for adaptive management of integrated centralized-decentralised water infrastructure networks, including real-time monitoring of water quality and quantity. The most promising developments for urban water are improved sensor capabilities and holistic digital water management platforms in urban areas that encompass wastewater, drinking water and storm-water, so that we can adaptively control flows, treatments and re-use as needed.

Cyber-secure open data management platforms, decision support tools and related monitoring technologies will enable transformative action across the urban water sector. New governance and business models are expected to support the integration of water sector operations in a viable and beneficial process, taking into account the diverse administrative and organisational models used in different regions. Finnish businesses, with expertise across the urban water sector and great capacity for digital and technological innovation, have an excellent opportunity to support the worldwide transformation of cities into dynamic, climate-resilient urban centres.

According to one global study*, the Finnish public sector has the second best preconditions for digitalisation, and in the utilisation of digitalisation Finland's public sector is scoring number one. In the private sector, Finland's companies are second with regard to digitalisation utilisation, whereas we are running fifth concerning companies' readiness for digitalisation.

*Taloustieto Oy. Digibarometri 2017. http://www.digibarometri.fi/uploads/5/8/8/7/58877615/digibarometri_2017.pdf

Smarter water

An all-connected society requires that water becomes smarter as well. Digital Water⁹ is an opportunity for Finland and a solution to some of the main threats that the society is facing. Water scarcity, the multiple water concepts, parallel water infrastructures, and increasing value of water need more accurate and real-time understanding of water management. Smart technologies can help manage the risks and secure water supply. For example, remotely readable water meters provide online data and help to identify leakages in water supply networks. Finland is one of the few countries in Europe that are rich when fresh and clean water resources are considered. This is a clear competitive advantage.

Create access to multi-dimensional real time information

- **Situational awareness** is a prerequisite for all decision-making in all digital systems, and for

⁹ ICT will make water management smarter by creating a real-time correct situational awareness of water management systems, by enabling the automation of actions in water management, and by enabling the optimisation of water management activities together with other systems in society. These capabilities are "Digital Water".

making systems smarter. It means understanding both the system status and its external context. Creation of situational awareness requires sensing of both the system and its environment (e.g. water flows, water levels, water quality), monitoring of the system components (e.g. pipes, valves, pumps), and understanding how the perceptions relate to overall knowledge of the system. Technically, these require the development of new low-cost sensors, adaptation of Internet of Things (IoT) technologies to the water management domain, [big] data analytics for identification and extraction of relevant information, and adaptation of semantic modelling and artificial intelligence (AI) techniques for creation of situation knowledge.

Enable immediate decision making

- **Automation** is the ultimate goal of ICT. In water management, the challenges are to make automation adaptive to unexpected events such as storms, flooding or drought, and the ability to guarantee both the availability and quality of water in more closed systems. Both of these challenges require more than just digital control. The decision-making must combine different information sources, it must understand what is relevant in each situation, and it must estimate the consequences of possible actions.

Energy efficiency in processes

- Smarter water enables **optimisation** of water-related parameters such as consumption/waste, acquisition and purification, optimisation of energy and other resources, and optimising the maintenance of the water system itself. In the use of water, the estimation of water need is critical. In the agriculture domain, the optimisation of crop against used water needs advanced sensors and analytics. In urban environments, the prediction of users' behaviour could lead to similar solutions as in smart grids in the planning of infrastructure. Pumping of water is a significant element in power consumption. Its scheduling should be decided as part of optimisation of the energy grid.

Along with the opportunities created by new digital and smart systems come also new types of risks, vulnerabilities and challenges. In addition to traditional safety aspects, security issues (cyber security, intentional actions and terrorism) play an increasingly important role in water risk management. In digital water systems, information infrastructure becomes a vital part of the critical infrastructure. In order to ensure service continuity, both cyber and physical risks must be identified and managed as combined cyber-physical risk scenarios. This can be turned to an advantage, as Finnish companies have high-level cyber security expertise and Finland has the status of a safe and reliable nation. Thus, we have excellent opportunities to develop trusted and secured water solutions.

Digitalising the water and water management systems creates new possibilities for empowerment of people, increasing the awareness of water and the creation of water data-based business ecosystems. The possibility to see what happens in this critical infrastructure allows us to use water more efficiently. When privacy is properly addressed, it will be possible to balance the need and supply with cost- and resource-saving solutions. Interoperable interfaces and secure digital solutions allow the creation of systems from optimal solutions and optimal technologies. All these are business opportunities for Finnish water-related ICT industries, starting from sensor manufacturers, monitoring and measurement device companies, data analytics companies, system providers, etc. In addition to these the water-related data, when suitably opened, shared and combined with other data, open up totally new open service markets, in which new combinations of information can provide new possibilities for intelligent services.

Benefiting from these possibilities needs open attitudes from both companies and policy makers. The water business is very infrastructure focused and fragmented. Adopting new technologies and recognising the value of data imposes new risks for infrastructure owners, but on the other hand provides opportunities for smaller players. Risk management can act as a tool to support the dialogue and trust building between infrastructure owners and technology companies. Risk management can also provide documentation and bases for proving of product quality, safety and security.

Water ecosystem stakeholders should invest in the creation of a digital water business ecosystem. In addition to technical adaptation and development, this sector needs to involve measures from both the ICT and the water sector for understanding how value can be created in such a common domain. Demonstrations and dissemination of success stories act as efficient seeds for wider business development.

The realisation of business potential needs support from policy makers. Opening of data, collaboration and co-creation must be encouraged. There are clear needs for definition of interoperability standards and guidelines for data sharing, ownership and data markets. Finland is an excellent environment for developing new approaches, but it is also true that Digital Water is a hot topic globally. International cooperation is therefore necessary.

Summary

Finland is one of the few countries where access to water rarely causes problems. Having said that, we are still far from optimal with regard to smart and sustainable management of this abundant resource. Support for innovations to eliminate the water-related risks for industrial and societal needs can pay back in long-term sustainable businesses and in a major share of the global water markets.

Finland is an excellent environment for developing new approaches and employing our process know-how in water-intensive industries to become a forerunner in Europe's blue economy. Digitalisation of water and water management systems creates new possibilities for empowerment of people, increasing the awareness of water, and creation of water data-based business ecosystems. Along with the opportunities created by new digital and smart systems come also some new risk types, vulnerabilities and challenges. When privacy is properly addressed, it will be possible to balance the need and supply with cost- and resource-saving solutions.

Finland has additionally specific expertise of water treatment in sensitive Arctic areas. Adaptation of treatment technologies to very different climatic conditions and advanced water quality monitoring solutions will be needed when developing economic activities sustainably in Arctic areas.

VTT suggests the following measures to ensure Finland's competitiveness in increasing future global water resilience:

The public sector should support the launch of a *digital water ecosystem* with targeted public procurement actions, preparing enabling regulation and raising the public awareness both in Finland and globally. Smart technologies can help with managing the water risks and securing water supply, but only if the technology is safe and reliable. There is a need for high-level strategic support for e.g. the further development of innovative sensing and situation prediction technologies for climate-informed decision-making concerning urban water management. We should use our unique safe nation status and promote our technology and cyber capabilities to develop secured water solutions.

Finland should stand out as a *safe area for industrial investment, where water resilience will appear as one of our obvious assets*. In addition, there is significant interest and room for growth in industrial water reuse and recycling. Resource-efficient water recycling and reuse paves the way for a water-resilient industry. Water recycling and reuse can turn into a significant economic benefit and reduce operational risks. Finland possesses the requisite know-how in industrial processes for optimising the effects of water recycling on process performance.

Most population - and economic - growth will be in cities, which will require new approaches to water management. Water ecosystem stakeholders should invest in the creation of a digital water business ecosystem with great export potential. This needs to involve measures for changing attitudes, both for understanding of value creation in the domain, and for technical adaptation and development. Such ecosystems could be a *public-private partnership* tackling the following topics:

- Enforcing the opening of water-related data for enabling the water and cross-domain digital service markets

- Enforcing the interoperability of technologies and systems, and accelerating new technology adoption in the water domain (as a source of new innovation potential targeting to export markets).
- Enforcing cooperation across sectors for understanding the systemic cyber-physical risks and how to provide secure solutions and products

In order to utilise the business potential, new solutions must be demonstrated. Water entities should be encouraged to host technology demonstrations, so that the technology benefits and possible risks could be understood and concretized. Demonstrations should be supported by appropriate cyber-physical risk management.

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