

# Crisis Preparedness for Critical Infrastructure: Challenges and Resilience Strategies in Water Systems

**Event:** *How to strengthen the crisis preparedness of critical infrastructures, workshop at World Water Week*

**Date:** *25 August, 16:00 - 17:30 CEST*

**Location:** *Room 27, Level 2*

**Organizers:** *IWA Sweden and partners: IVL, Luleå Technical University, RISE, Stockholm Environment Institute, Svenskt Vatten, Sweden Water Research.*

How can we ensure that critical infrastructure for water, wastewater, and electricity functions during times of crisis or conflict? This pressing question was the focus of a workshop held during World Water Week 2024, which explored the rising and multifaceted threats to water provision across different parts of the world.

The workshop addressed four key perspectives:

1. **Socio-economic shifts**
2. **Climate risks**
3. **Armed conflict**
4. **Cybersecurity threats**

Each theme was presented by an expert keynote speaker, who outlined the risks and offered potential solutions to strengthen water infrastructure. Afterward, participants broke into groups to discuss these themes from their regional perspectives. The workshop was moderated by Karina Barquet from the Stockholm Environment Institute (SEI), who guided participants to consider their local contexts and respond to three central questions:

1. What vulnerabilities require immediate attention?
2. Can you provide an example of a successful resilience strategy in your region?
3. What should decision-makers prioritize to strengthen critical water infrastructure?

The following sections summarize the keynote presentations and the rich discussions that emerged in the breakout groups.

# Socio-Economic Risks

## Keynote Presentation

**Diego J. Rodriguez, Lead Water Economist for Eastern and Southern Africa at the World Bank**, introduced the socio-economic risks affecting water infrastructure by focusing on how various socio-economic factors shape water security and resilience.

Rodriguez explained that population increases, growing water demand and how water is valued impacts how water systems function, but other factors must also be considered like urbanization, human mobility, and environmental degradation. This influences which decisions seem possible to make and the consequences of any route of action.

Diego J Rodriguez pointed to two sectors of critical importance: agriculture and mining. Agriculture is currently the biggest user of freshwater globally, but the sector's future water demand will be determined by population rise as well as food preferences, economic growth, trends and technologies. Mining, in turn, requires plenty of water but is also a heavy polluter. Which minerals that are sought after could change quickly as new technologies and trends evolve, with massive impacts on local water resources where mines open.

Diego J Rodriguez' main message was that these complex interdependencies must be understood and recognized in all decision-making. We cannot predict the future, but we can identify both the pressures that make our critical infrastructure vulnerable, and the interventions required to ensure adaptable and resilient systems.

## Group Discussions

Facilitated by **Professor Zahra Kalantari (KTH Royal Institute of Technology)** and **Professor Elisabeth Kvarnström (Luleå Technical University)**, the group delved into the socio-economic vulnerabilities and potential strategies for addressing them.

### Key vulnerabilities

Participants shared regional experiences, with insufficient maintenance and underfunding emerging as widespread concerns. In regions with aging infrastructure, such as the UK, water systems struggle to accommodate modern population demands, requiring immense investment. In countries facing economic instability—characterized by high inflation or weak financial systems—securing the necessary financing for infrastructure maintenance is particularly challenging. Additionally, corruption, crime, and armed conflict can further disrupt efforts to maintain or improve water systems, as seen in regions like West Africa.

Fast population growth, especially in informal settlements around megacities, was another significant vulnerability. These areas often lack connections to centralized water and sewage systems, leaving residents dependent on unsafe, self-provisioned water and sanitation services.

### Successful resilience strategies

Participants shared successful strategies for addressing these socio-economic challenges. These included earmarking funds specifically for infrastructure maintenance, promoting public-private partnerships, and encouraging cost-sharing across borders. Dubai's [wastewater reuse programme](#) was highlighted as an innovative circular water management solution.

## Recommendations for decision-makers

The group emphasized the importance of involving community stakeholders in decision-making processes. Phased implementation of infrastructure projects, aligned with economic growth, was recommended to make the development process more inclusive. Participants also stressed the need for better education, improved data systems, and results-based funding models to enhance efficiency and transparency. Circular approaches and nature-based solutions were also encouraged, though they are not yet mainstream practices in many regions.

# Climate Risks

## Keynote Presentation

**Ashok Swain, Professor at Uppsala University's Department of Peace and Conflict Research**, framed climate change as a source of growing uncertainty for water resources. As temperatures rise, [the water cycle is disrupted](#), leading to unpredictable shifts in precipitation patterns and water availability. Swain highlighted that these changes bring dramatic consequences, such as glacial melting, sea-level rise, altered river flows, increased flooding, and prolonged droughts. Our societies are not built for such extremes and constant uncertainties, which means that it becomes increasingly difficult to grow food, provide drinking water and treat wastewater.

To address this, Swain outlined a ten-step approach for improving crisis preparedness:

- 1. Risk assessment and monitoring** must be a continuous activity to assess the vulnerabilities of water infrastructure. New technology makes it possible to monitor in real-time.
- 2. Climate-resilient infrastructure design** is essential. Climate change projections must be incorporated into new design to ensure that it can adapt to future climate scenarios. Existing water infrastructure must be upgraded and retrofitted so that it can withstand extreme weather events.
- 3. Redundancy and diversification** will be increasingly important. Drinking water must be drawn from multiple sources, so that alternatives exist if one source gets contaminated. Power supplies must have back-up systems.
- 4. Advanced planning and scenario analysis** should be the backbone of any emergency response plan. It must of course be regularly updated.
- 5. Cross-sector collaboration** is of critical importance and must take many shapes and forms, including Integrated Water Resources Management.
- 6. Community engagement and capacity building** will require more attention, with campaigns to raise public awareness as well as trainings and drills for water sector professionals.
- 7. Regulatory and policy frameworks** must set and enforce climate-resilient standards. Grants or tax breaks can create additional incentives for individuals and companies to invest in resilience.
- 8. Innovation and technology** create new opportunities, ranging from grid technologies for better Smart Water Management Systems to green infrastructure and nature-based solutions, such as wetlands restoration and rainwater harvesting.
- 9. International cooperation and knowledge sharing** let countries and cities leapfrog by learning from others. The front runners can share their experiences in international networks and partnerships. It is especially important that low-income regions get access to knowledge and resources from other parts of the world.

**10. Financial planning and investment** will be decisive, with dedicated funds for climate adaptation. With so many competing needs, it is necessary to perform cost-benefit analyses to ensure that investments go to the infrastructure upgrades that offer the highest returns in terms of resilience and crisis prevention.

## Group Discussions

Facilitated by **Henrik Aspengren and Nina Steiner from Sweden Water Research**, the group focused on vulnerabilities caused by climate risks and successful strategies to enhance resilience.

### **Key Vulnerabilities:**

Participants noted that extreme weather events such as floods, cyclones, and droughts are already overwhelming water systems, leading to contamination of drinking water and damage to infrastructure. In Botswana, power failures frequently render water treatment plants useless, with severe consequences for public health, including high rates of infant diarrhea.

### **Successful Resilience Strategies:**

Emergency action plans were seen as critical in regions prone to extreme weather events. The "sponge city" concept, applied in cities like [Berlin](#), was highlighted as an effective approach to flood management.

### **Recommendations for Decision-Makers:**

Participants urged decision-makers to invest in robust decision-making tools, such as near-term forecasting and risk assessments. Open access to water data and increased investment in climate-smart technologies were seen as essential. There was also a strong call for more research on nature-based solutions and greater collaboration across countries and academic disciplines.

## Armed Conflict Risks

### Keynote Presentation

**Debora Falk, specialist in Contingency Planning for Water and Sanitation at Norconsult**, introduced the topic of armed conflicts. She called on countries to ensure that civilians are better protected during armed conflict since she sees a worrying trend where civilians are increasingly at risk.

This may occur when water is purposely used as a weapon, in breach of international law which offers special protection to water installations that are essential for water and food provision. Dams are protected due to the disasters caused if they burst.

But civilians can also unintentionally come in harm's way if there is a lack of separation between military and civilian objects, explained Debora Falk who has worked for different organizations in both crises and armed conflicts, including conflict zones like Israel/Palestine and, most recently, in eastern Ukraine.

Debora Falk noted that water infrastructure is often located in places that in times of armed conflict are likely to become prime locations for defense activities. Rivers can play a significant role in halting the enemy's advances, hills are important because of the far-reaching views they offer and access to water is in itself a prerequisite for the armed forces to be able to operate. The physical

structure of a water tower or wastewater plant may also be used by combatants who try to hide or get an overview of the surrounding landscape.

This, in combination with a rise in new technologies that have both military and civilian uses, could undermine the protection of civilians during armed conflicts. How civilians can be protected during armed conflict must be a consideration already in peaceful times and made part of discussions between the armed forces and the rest of society. Debora Falk hoped that more decision-makers would become aware of the growing risks and accelerate attempts to mitigate them.

## Group Discussions

Facilitated by **Karina Barquet (SEI) and Maria Sköld (SEI)**, the group shared experiences from conflict-affected regions.

### **Key Vulnerabilities:**

Participants from Syria and Nigeria highlighted the dire consequences of conflict on water infrastructure. In many cases, water plants are damaged or occupied by terrorist groups, making it impossible for civilians to access clean water. In northeastern [Syria](#), the conflict has severely disrupted energy infrastructure, further exacerbating water shortages.

### **Successful Resilience Strategies:**

Emergency preparedness plans are viewed as essential, with countries like [France](#) incorporating such strategies into national water policies. Redundancy in water and power supplies was also emphasized as a key resilience measure.

### **Recommendations for Decision-Makers:**

The group stressed the importance of decentralized water systems and stronger crisis planning at all levels of governance. Dams and other high-risk infrastructure require special protection, particularly in populated areas. Coordination between local, regional, and national authorities was seen as crucial for ensuring infrastructure resilience during conflicts.

## Cybersecurity Risks

### Keynote Presentation

**Heather Harrison Dinniss from the Swedish Defence University** emphasized the increasing vulnerability of critical infrastructure—particularly water and wastewater systems—to cyberattacks. These attacks can cause not only significant disruptions and costly downtime but also lead to human suffering by impairing access to essential services.

Dinniss explained that cyberattacks targeting water facilities can take different forms. Some are deliberate attacks by state actors or cyber criminals, while others are collateral damage from broader attacks on interconnected systems like electricity grids. Ransomware, sabotage, or insider threats—whether from disgruntled employees or careless current staff—can also jeopardize water systems.

To protect themselves, Dinniss proposed a five-point action plan that organizations should implement immediately:

1. **Conduct cybersecurity checks** to identify and fix vulnerabilities.
2. **Practice basic cyber hygiene**, ensuring that all staff:

- Regularly update and patch software, including antivirus.
  - Change all default passwords.
  - Implement multifactor authentication on critical systems.
  - Are educated on phishing and social engineering risks.
3. **Limit unnecessary contact with the open internet** by removing remote access if unnecessary and closely monitoring VPN and access permissions.
  4. **Establish a cybersecurity incident response plan** to prepare for potential breaches.
  5. **Adopt security-by-design principles** when installing new systems or upgrading old ones.

## Group Discussions

Facilitated by **Erik Lindblom from IVL**, **Anna Norström from RISE**, and **Henrik Wingfors from Svenskt Vatten**, participants discussed the key vulnerabilities and strategies for strengthening resilience against cyber threats in the water sector.

### Key Vulnerabilities

The group highlighted two major concerns: a lack of awareness of cybersecurity risks within the water sector, and processes that inadvertently create vulnerabilities. In [Sweden](#), for example, recruiting staff with the necessary knowledge has been challenging. Furthermore, the interdependence between systems such as electricity, energy production, and water heighten the risk of cascading impacts, where a breach in one system leads to failures in others. This can create confusion about who is responsible for managing these risks. Participants also mentioned that flood prevention and control, particularly in countries like Brazil, China, and Colombia, is especially vulnerable to such cascading effects.

### Successful Resilience Strategies

Several successful strategies were discussed, including the use of manual backup systems in Colombia and lessons learned from the Three Gorges Water Conservancy project in [China](#), which has implemented robust pipeline data protections. In Sweden, a mandatory information security assessment for water companies was cited as an effective way to safeguard water infrastructure.

### Recommendations for Decision-Makers

The group emphasized that decision-makers must recognize the growing risks of cyberattacks and develop comprehensive response strategies. This begins with identifying critical water infrastructure and assessing potential threats. Stakeholder involvement is essential throughout the entire risk management process, from initial identification to ongoing evaluation and review. Legislators have a key role in defining responsibilities for cybersecurity and criminalizing harmful behaviors.

To build broader societal awareness, participants advocated for integrating resilience thinking and cybersecurity education at multiple levels. Special emphasis should be placed on training to manage multiple and cascading risks, including scenarios where roles and responsibilities are unclear.

Robust monitoring and evaluation systems are crucial and should be based on evidence-driven methods. The group also stressed the importance of holding individuals accountable for security breaches, while simultaneously fostering an environment where mistakes can be acknowledged and used as learning opportunities. Planning must incorporate both green and grey infrastructure, with the goal of continuously improving institutional knowledge and frameworks for cybersecurity.

## Conclusions: The Need for Enhanced Collaboration and Specialized Knowledge

The workshop revealed strong connections between the various risks to critical infrastructure—socio-economic shifts, climate change, armed conflicts, and cybersecurity threats. Each of these themes shares a common thread: high levels of uncertainty, the potential for cascading impacts, and the increasing complexity of challenges faced by water, wastewater, and energy systems. Addressing these threats requires both cross-sector collaboration and deep specialization.

### **Interconnectedness and Cascading Risks**

Participants recognized that vulnerabilities in one area, such as water infrastructure, can quickly cascade into others, such as energy, health, or food security, particularly in times of crisis or conflict. For example, socio-economic instability can exacerbate infrastructure vulnerabilities, while climate change-related events like floods and droughts can disrupt services, sometimes in ways that are difficult to predict. Cyberattacks, similarly, often have ripple effects across interconnected systems, and armed conflicts directly target or unintentionally destroy critical water services.

### **The Importance of Rapid Information Sharing and Cross-Sector Collaboration**

Given the complex interdependencies, the ability to rapidly gather and share real-time information across sectors will be crucial. Decision-makers must engage with actors outside their usual networks, ranging from local communities to international partners. This includes fostering cooperation between government bodies, private companies, and civil society organizations to ensure that diverse perspectives are considered, and actions are coordinated across borders and sectors.

### **Specialization and Deep Expertise**

While collaboration is essential, the complexity of modern risks also necessitates deep, specialized knowledge. Each of the challenges discussed during the workshop—whether socio-economic, climate-related, conflict-driven, or cyber in nature—requires a detailed understanding to anticipate and mitigate risks effectively. For example, understanding the socio-economic impacts on water demand requires expertise in economics and demographic trends, while cybersecurity defenses must be built on advanced technical knowledge. As infrastructure threats become more sophisticated, decision-makers must rely on specialized experts to monitor ongoing situations, interpret shifts, and propose targeted interventions.

### **Rethinking Institutional Approaches and Crisis Preparedness**

Participants emphasized that all sectors of society, from local governments to global institutions, must rethink how they operate to build robust and resilient infrastructure. Phased implementation of strategies, investment in technology and innovation, and the adoption of

nature-based solutions were common themes across the discussions. Additionally, crisis preparedness must be integrated into long-term planning, ensuring that infrastructure is not only maintained but upgraded to handle future challenges, whether from economic shifts, climate change, armed conflicts, or cyber threats.

### **Concluding Reflections**

The workshop highlighted both the urgency and complexity of protecting critical infrastructure in an increasingly uncertain world. The solutions lie in blending specialized knowledge with broad collaboration, ensuring that every sector—from water management to energy, technology, and policy—can adapt to the interconnected and evolving risks. Only by embracing a multidisciplinary, cross-sector approach will societies be able to strengthen their resilience and safeguard essential services for future generations.

## **Resources**

[SEI Initiative on Gridless Solutions | Stockholm Environment Institute](#)

[Poverty, Prosperity, and Planet Report 2024](#)

[Integrating socio-hydrology, and peace and conflict research](#)

[Water under fire | UNICEF](#)

[Water and Armed Conflicts | How does law protect in war? - Online casebook](#)

[The Threat of Cyber Terrorism and What International Law Should \(Try To\) Do about It](#)

[Cybersecurity & Guidance - American Water Works Association](#)