The Roundtable on Financing Water

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Session 1. Rationale and aims of water-related investment: The case for resilience

BACKGROUND PAPER

THE BUSINESS CASE FOR RESILIENCE IN WATER INFRASTRUCTURE INVESTMENT

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1. The Business Case for Resilience in Water Infrastructure Investment

Lack of sustainable access to safe drinking water and sanitation systems persists as a global challenge, as do challenges of water quantity and quality for agriculture and ecosystems, and closely-related issues of water resource management investment. Emerging and systemic threats intensify the challenge of making a compelling case for water sector financing. Closing the financing gap despite these risks is essential for meeting the commitment of the global community to remedy these deficits. Resilience is a concept that should be adopted in international infrastructure develop help to facilitate action, even in the face of risk. This briefing describes the business case for resilience, a paradigm that will be necessary for shifting water sector financing norms for vulnerable locales and catalyzing financial and technological innovation in water systems of the future.

1.1. Background

Resilience of water systems is a feature of the 2030 Agenda for Sustainable Development; Sustainable Development Goals 6 on water and sanitation and Goal 11 on sustainable and resilience cities[1] both comprise, in large part, the improvement of the infrastructure and reliability of the water sector. To realize the aspirations for resilience though, there is much work that needs to be done to create a knowledge-base in how to assess and enhance the resilience of systems and, more relevant to this gathering, to explore pragmatic mechanisms to compel its creation.

Resilience is an objective related to how systems perform under stress[2],[3]. According to the U.S. National Academy of Science (NRC 2012), disaster resilience is the "the ability to plan and prepare for, absorb, recover from, and more successfully adapt to disruptive events". It is complementary to, but also fundamentally different from, the security focus that is long-standing in infrastructure and development efforts, namely the quest to achieve the highest level of safety by reducing down risk as much as possible. It is therefore natural that this roundtable of the OECD and members of the international community should lead an explicit effort to understand how to usher in a wave of resilient water system development and improvement that is suited to future realities of risk and resource limitations.

The Roundtable on Financing Water has, thus far, emphasized that scaling up financing for water-related investments requires an attractive risk-adjusted return for financiers. Discussions have explored various financing approaches and mechanisms and the roles different actors can play (e.g. development finance providers, public budgets, commercial banks, private investors, etc). The potential for innovation has so far been limited to finding new ways to achieve risk-based objectives. However, the discussion also needs to be inclusive of strategies to achieve the more recently prioritized objectives of resilience, including the capacities to recover from disruption and to be adaptive to new realities. The underlying engineering objectives for traditional versus resilient systems will yield designs and associated investments that diverge on many points. In this vein there has been increasing recognition of adaptation buffers arising from ecosystems, but little commensurate action to support this awareness. Ecosystem expenditures have been

[1] United Nations (2015). 2030 Agenda for Sustainable Development. Available at: https://sustainabledevelopment.un.org/post2015/transformingourworld

[2] Hollnagel, E., Woods, D. D., & Leveson, N. (2006). *Resilience engineering: Concepts and precepts*. Ashgate Publishing, Ltd..

[3] Woods, D. D. (2015). Four concepts for resilience and the implications for the future of resilience engineering. *Reliability Engineering & System Safety*, *141*, 5-9.

growing but with most funds driven by regulatory compliance, such as mitigation banking to offset impacts of development. The value of ecosystems for their services can lead to specific expenditures for sustaining those services.

1.2. Why Do We Need Resilience in Water Infrastructure?

Prior to making a much-needed wave of water sector infrastructure investment, to remedy aging infrastructure[4] and bring new water system benefits where they are currently absent[5], we need to adopt a new way of thinking about risk so that we can make wise financial decisions. Relying on traditional water sector system design and management is, in many ways, an untenable solution. The combination of processes (climate drivers and hazards) leading to a significant impact is referred to as a 'compound event'. Traditional risk assessment methods typically only consider one driver and/or hazard at a time, potentially leading to underestimation of risk, as the processes that cause extreme events often interact and are spatially and/or temporally dependent.

This is, in part, due to the enormous price tag it would present[6],[7], [8], as well as misfit of historical designs for a future that may look very different from the past. It is at the intersection of these two problems that resilience thinking should be applied especially where it can be shown that upfront costs will be retrievable in both near-term impacts reduction and longer-term sustainability. If we cannot characterize the future in a way that is informative for mitigating risk, how should we allocate limited resources to support continuously functioning water systems? Two arguments against status quo are:

A. *The future will not look like the past and investment in the water sector must be forward-looking*.

- There has long been speculation and there is growing evidence that the hydrologic record, which typically informs management, is non-stationary.[9] Temporal and spatial climate patterns are changing, rendering the historical record on which many water sector decisions are based inadequate. Climate change poses as systemic threat to reliable provision of water sector services, especially access to drinking water and storm water drainage.
- Non-physical realities are also changing the landscape of water service provisions including burden of demand from growing populations and political stability or will.

[4] ASCE Report Card, https://www.infrastructurereportcard.org/

[5] Financing water: Investing in sustainable growth. OECD Environment Policy Paper No. 11. http://www.oecd.org/water/Policy-Paper-Financing-Water-Investing-in-Sustainable-Growth.pdf

[6] Hossain, F., Arnold, J., Beighley, E., Brown, C., Burian, S., Chen, J., ... & Tidwell, V. (2015). Local-to-regional landscape drivers of extreme weather and climate: implications for water infrastructure resilience. *Journal of Hydrologic Engineering*, *20*(7), 02515002.

[7] Capodaglio, A. G., Ghilardi, P., & Boguniewicz-Zablocka, J. (2016). New paradigms in urban water management for conservation and sustainability. *Water Practice and Technology*, *11*(1), 176-186.

[8] NRDC, https://www.nrdc.org/resources/go-back-well-states-and-federal-government-are-neglecting-key-funding-source-water

[9] Salas, J.D., Obeysekera, J., & Vogel, R.M. (2018). Techniques for assessing water infrastructure for nonstationary extreme events: A review. *Hydrological Sciences Journal*. https://doi.org/10.1080/02626667.2018.1426858

- Traditional risk management methods center upon the abilities to prevent, absorb the impact of, and/or withstand threats. Unfortunately, this approach actually gives rise to new vulnerabilities, as it can leave systems more exposed and sensitive, and with less capacity to adapt to unexpected events. There are myriad emerging risks that cannot be ignored despite the difficultly of characterizing their probability and consequence. Additionally, infrastructure improvement effort needs to explicitly address the potential for creating new vulnerabilities. We elaborate on emerging risks in subsequent section.

B. Buying down risk has diminishing returns and resources for improvement are limited.

- Given the realities described above about systemic threats and emerging risk, it is important to recognize the limitations of traditional risk management and reliability planning. While some of these risks can be managed, i.e., the probability and consequence of their occurrence can be characterized to provide clear signals about how to reduce them, others will plague us with their uncertainty.
- Further limitation stems from the cost of limiting risk. As is recognized by the OECD, the aim of water security is to achieve an acceptable level of risk – eliminating risk completely is neither possible, nor desirable, from an economic point of view[10]. It is financially infeasible, not to mention futile, to try to safe-guard systems against all possible threats. Some portion of risk mitigation resources would be better spent on other measures that support continued functioning in spite of disruptive events.

Acceptable levels of risk and vulnerability should be set (and in some cases re-thought) so that resources are not inadvertently allocated to protective and preventative infrastructure and actions that are beyond the realm of what is cost-effective. Current design and investment considerations are focused primarily on water system security and risk management designed to prevent systems failure and property loss. However, recovery and adaptation of water infrastructure services (conveyance, treatment, etc.) are rarely discussed, due to a mentality that, if we design something right the first time, it will not fail. Despite advances to date, predicting future hydro-climate variables precisely will remain a major challenge. Nature is complex and observing and modeling its nonlinear behavior is very challenging especially reliability of high resolution information "generated" by models with limited data inputs. To avoid the trap of pursuing spurious certitude through spurious "rigor", factoring in resiliency in the design and planning of water resources systems is still the safest approach. Reducing consequences of disruption by investing in resilience properties for enhanced recovery and adaptation is the critical next step for continued improvement in the water sector.

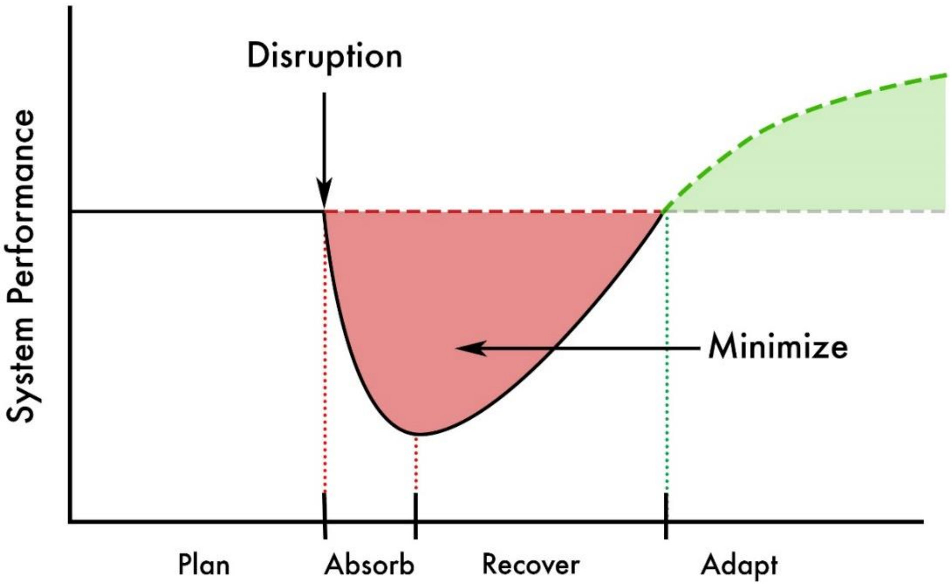
1.3. Defining Resilience

Importantly, resilience is concerned with the critical functions that are delivered by systems instead of with the hardiness of their constituent parts. Unlike risk, resilience has a temporal dimension; loss of critical functionality occurs when residual risk materializes, disrupting normal service, and characteristics and managers of the system act to restore it (Figure 1.1). The performative quality of an engineered system under stress is a function of the activities prior to and following disruptive events.

[10] OECD (2013) *Water Security for Better Lives*

A hallmark of resilience thinking is recognition that disruption of system functions will occur, sometimes due to expected events and other times due to unexpected ones, and we should therefore plan for how to recover them. It has come to pass that not planning for failure can result in enormously high costs, as was highlighted by Disaster Resilience: A National Imperative[11]. Recovery-oriented thinking represents an important deviation from traditional water systems improvements; characteristics and capabilities that come into consideration for recovery are different from those used to prevent failures.

Figure 1.1. Conceptual representation of resilience



Note: Conceptual representation of resilience where the functionality of a system falls due to a disruptive event and then is recovered, in time, following the event (after).
Source: Linkov, I. & Trump, B.D. (2019). *The Science and Practice of Resilience*. Switzerland: Springer. doi:10.1007/978-3-030-04565-4.

1.4. The Business Case for Investment in Resilience

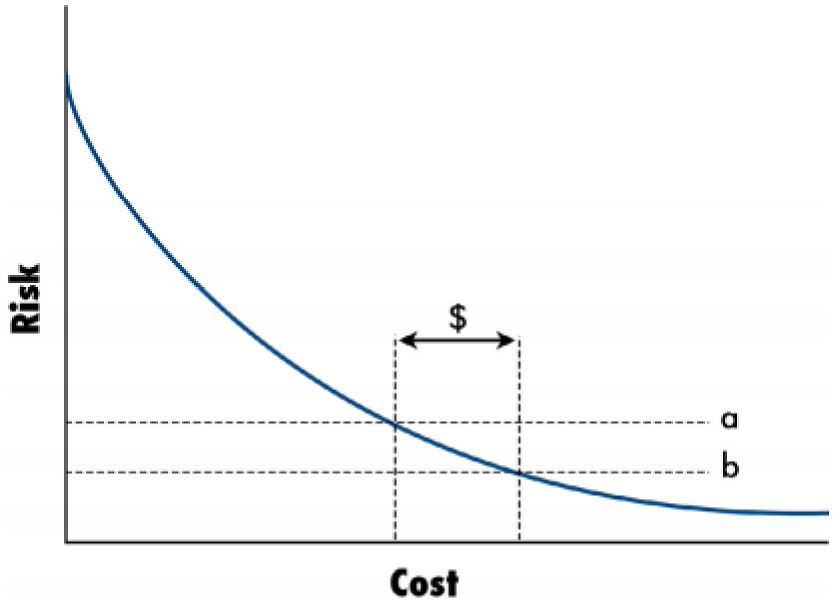
Balancing investment in risk mitigation and resilience enhancement intuitively means that a greater level of risk will need to be tolerated by governments and investors however, this intuition ignores the cost of not being resilient. While investment to safeguard against failure is important in minimizing losses, there is significant risk associated with not being prepared for failure. Failure due to unexpected disruptions can cascade and compound and recovery without advanced preparation can require catastrophic expenditure of resources. Therefore, while cost savings and similar financial metrics are central to evaluating alternative infrastructure investment actions, they are incomplete in their assessment of water related risks.

[11] National Research Council. *Disaster Resilience: A National Imperative*. The National Academies Press, Washington, D.C., 2012.

Resilience encompasses the ability of a disaster-impacted locale to recover quickly. Expeditiousness of system functionality recovery is crucial to avoiding the costs associated with delays, temporary services, and secondary losses. The close interconnectedness of water systems with other critical infrastructure and with public health point to substantial potential for cascading failures and compounding losses if disruptions occur. Planning and preparing for recovery of water system functions can mitigate the risk of secondary losses.

In the context of water sector financing, there is conceptually an optimal allocation of resources to buy down risk and enhance resilience. Resilience should be understood as a property that emerges, broadly, from a system, and therefore investment to enhance resilience is more diverse than traditional investment. Efforts to enhance resilience will essentially add features (structural and non-structural, and at different scales) to a system so that they can perform better prior to, during, and following a disruptive events. Investment possibilities include efforts to increase system modularity, redundancy, flexibility, cohesion, adaptability, to name a few system characteristics that have emerged from ongoing research.

Figure 1.2. Accepting marginally greater risk frees up resources to invest in resilience



Note: Accepting marginally greater risk (level a instead of b) frees up resources to invest in resilience, which will arguably yield greater cost savings.
Source: Bostick et al. (2018). Resilience science, policy, and investment for civil infrastructure. *Reliability Engineering and System Safety*. 175L 19-23.

1.5. Conclusion

Operationalizing resilience thinking in the water sector first requires that the purview of risk management be expanded to account for scenarios in which residual risk materializes. This is the starting point for identifying engineering designs and associated investments, as well as complementary governance, social, and informational capacities that will enhance the resilience of water-related systems. Barriers to impactful and innovative financing still exist and will be explored at the Roundtable. Time horizons, temporal and spatial uncertainty, externalities and policy misalignments all confound implementation of resilient designs even in the face of clear long-term economic benefits[12]. Although tools and methods to conduct resilience assessment are numerous and varied[13], work remains on how to consider risk and resilience in tandem[14] and trade-off the objectives in order to identify optimal allocations of resource among them. Norms for evaluating alternative investment actions will need to be adapted to accommodate resilience metrics and value the benefits associated with non-traditional management measures.

[12] Lall, U., T. Johnson, P. Colohan, A. Aghakouchak, C. Brown, G. McCabe, R. Pulwarty, and A. Sankarasubramanian, 2018: Water. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R. et al (eds). U.S. Global Change Research Program, Washington, DC, USA, pp. 145–173. doi: 10.7930/NCA4.2018.CH3.

[13] Koliou, M., Lindt, J., Mcallister, T., Ellingwood, B., Dillard, M., & Cutler, H. (2018). State of the research in community resilience: progress and challenges. *Sustainable and Resilient Infrastructure*. doi:10.1080/23789689.2017.1418547.

[14] Linkov et al. (2018). Tiered approach to resilience assessment. *Risk Analysis,* 38(9): 1772-1780. doi:10.1111/risa.12991