Societies face increasing complexity and uncertainty in decision making to cope with extreme weather events. Therefore oversimplified risk approaches should evolve to much richer resilience strategies. Yet, resilience is often more a policy buzzword or topic for theoretical debate than an actual operational paradigm. It is often not clear for policy makers and practitioners how they can translate the main notions of resilience thinking into practical implementation.

A team of researchers have translated the scientific debate on resilience into practical principles. These five principles can be used by policy makers and practitioners to develop strategies that enhance resilience to extreme weather events, such as droughts, floods and typhoons.

These principles are:
- Adopt a system’s approach;
- Look at beyond-design events;
- Build and prepare infrastructure according to ‘remain functioning’ principle;
- Increase recovery capacity by looking at social and financial capital; and
- Remain resilient into the future.

Three important global post-2015 agendas – the Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction, and the Paris Agreement under the United Nations Framework Convention on Climate Change – made an inspirational call for resilience. The paper Resilience in practice: Five principles to enable societies to cope with extreme weather events aims for these agenda’s to benefit from this practical approach to resilience. The findings were published in the international peer-reviewed journal ‘Environmental Science & Policy’ in April 2017 by the Institute of Water Policy of the National University of Singapore, the Faculty of Technology, Policy and Management of the Delft University of Technology and Deltares, the independent institute for applied research in the field of water and subsurface collaborated on this research.

Adopt a system’s approach

The first ‘Resilience in practice’-principle stresses the importance of a systems approach. Understanding of the entire system under risk of extreme weather events – including the physical, environmental, social and economic aspects – is required to define societal effective measures. A system’s approach means that the system is studied as a whole and that different subsystems, areas and processes within the system are viewed as interlinked. Disaster risk managers need to understand the chain of events from the first indications of an imminent threat due to extreme weather to the recovery of the impacts after the extreme weather event.

The consequences of an extreme weather event are often felt in the directly affected area and also in other regions. Drought affecting an agricultural area can affect the urban poor through increasing food prices. A typhoon hitting a power plant may affect electricity supply in a much larger area. The 2011 Thailand floods affected production processes globally through linkages in the supply chains of electronics and automotive industries. A system’s approach could be used to identify these potential linkages. The Mississippi floods in 2011 provide an example of applying a system’s approach in flood risk management when high-value areas (an urban area) were protected by deliberately flooding low-value areas (agriculture).
Look at beyond-design events

With the second ‘Resilience in practice’-principle we call for an additional focus on beyond-design events. Rare events with disastrous and lasting consequences may call for protection against higher costs than justified by a standard cost-benefit analysis. For instance, in the Netherlands, *societal disruption was added as a criterion* to inform the discussion on flood protection standards next to economic efficiency. A resilience approach considers the entire possible spectrum of events as opposed to a risk approach which often focusses on design events. Considering beyond-design events in disaster management has been called *“possibilistic” thinking*, which is a complement to the “probabilistic” thinking commonly employed in the risk approach. It stimulates thinking about the worst case, or even unimaginable scenarios.

In disaster risk management this is not yet common practice, though, for instance, in dam safety design it is often incorporated. To prevent catastrophic failure, most dams also have spillways, which may be deployed in case of a threat of dam collapse due to beyond-design events. The recent spillway utilization of the Oroville Dam in California, United States demonstrates this concept. Focussing at beyond-design events does not mean only looking at the most extreme events. The *multiple-tiered approach for flood risk management in the Netherlands* explicitly considers beyond-design events by also aiming to reduce the consequences of flooding through spatial planning and by planning for evacuation.

Build and prepare infrastructure according to ‘remain functioning’ principle

The third ‘Resilience in practice’-principle focusses on ensuring infrastructure will remain functioning once an extreme weather event occurs. With ‘remain functioning’ we refer to designing systems in such a way that consequences of failure are not catastrophic, but manageable. This principle is also known as fail-safe, as opposed to safe-fail systems where the focus is on high reliability. Making sure that a system remains functioning during extreme events acknowledges the fact that the possibility of failure cannot be eliminated altogether, and is typical for resilience thinking.

In the context of extreme weather events, a requirement for systems to remain functioning is that critical infrastructure remains in service. If critical infrastructure is damaged, emergency management will be more difficult, recovery will be slower and impacts may spread to non-affected areas. Initiatives such as the Critical Infrastructure Preparedness and Resilience Research Network (www.ciprnet.eu) bring together knowledge to support authorities in protecting critical infrastructure and tools are being developed to analyse and better understand the *cascading effects* of failure of critical infrastructure due to flood events.
Increase recovery capacity by considering social and financial capital

Our fourth ‘Resilience in practice’-principle advises to increase the recovery capacity of a society. The long-term impact of an extreme event partly depends on the time it takes to recover. The capacity to recover depends on social capital (the individual ability of people to recover), institutional capital (the ability to organise repair and reconstruction), and economic capital (the ability to finance repair and reconstruction). Increasing recovery capacity is thus closely linked to socio-economic development level, and hence measures are generally not specific for dealing with extreme weather events. Poverty alleviation, health improvement and education are sustainable development objectives that also increase a society’s recovery capacity. Yet some specific interventions can increase the speed of recovery from extreme weather events. Insurance can provide disaster-affected households with the financial means for recovery. Other financial assistance, such as loans, relief grants and reconstruction employment schemes can also increase the recovery capacity. Social capital for recovery can be improved by education and training as part of disaster preparedness programs.

Remain resilient into the future

With our fifth ‘Resilience in practice’-principle we emphasize to remain resilient into the future. Flexibility, the ability to learn, the capacity to adapt and the willingness to transform if necessary are crucial to cope with gradual but uncertain changes. It is important to realise that the current resilience of a system may be exhausted due to gradual geo-physical developments such as climate change or subsidence, and socio-economic developments such as migration, conflicts, urbanisation and economic growth. This may call for adaptation or transformation in order to be able to cope with future extreme weather.

Several tools, strategies and methods have been developed to help policymakers and practitioners design adaptive policies and systems. Adaptation pathways, relying on the identification of policy tipping points to establish when policies can no longer meet the societal objectives and on the mapping of possible alternative strategies, and adaptive policy making, which is a generic procedure for developing robust plans are such tools. For instance, the Singapore government has introduced a resilience framework that explicitly acknowledges that understanding of climate change is continuously evolving, and that plans may need to be adapted. The framework has a feedback loop so that future learning can be incorporated and adaptation plans are designed in a flexible manner.