



## Resilience of urban water supply systems to natural hazards and systemic risks

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Urban agglomerations exhibiting rapid population growth require a commensurate development of water supply, sanitation and water treatment infrastructure. The adjustment of infrastructure is especially difficult and not always strategically planned in peri-urban areas of large cities in developing countries and emerging economies. Standards for water supply and sanitation and guidelines for the sustainability of water supply help managing such adaptation processes. Still, sufficiency and sustainability seem to be necessary but insufficient principles for the development, adaptation and management of water supply systems: The resilience or robustness of urban water supply in the event of natural hazards appears to be a necessary additional principle. A review indicates that there is a need for quantitative or at least nominal scales of resilience and for viable operational concepts of its characterization. A comparison of water supply concepts in rapidly growing urban centres (Windhoek/Namibia, Fortaleza/Brazil, Capetown/South Africa) indicates that there are large discrepancies between the associated risks of failure in the advent of meteo-hydrological hazards (floods, droughts, heat waves) or other factors (pollution, algae bloom). Some systems also seem to become less stable by an increase of systemic risks, especially related to feedbacks between water quantity, water quality and socio-economic responses. Innovative concepts such as the integration of surface and groundwater supply, water re-use and managed aquifer recharge that undoubtedly have positive impacts on overall sustainability, may still lead to an increase of systemic risks of infrastructure failure. Based on the discussion of case studies, and on examples of system failure and recovery given, a framework for the characterization and management of resilience of urban water supply to natural hazard is proposed.