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Design of Adaptive Policy Pathways under Deep Uncertainties

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The design of large-scale engineering and infrastructural systems today is growing in complexity. Designers need to consider sociotechnical uncertainties, intricacies, and processes in the long- term strategic deployment and operations of these systems. In this context, water and spatial management is increasingly challenged not only by climate-associated changes such as sea level rise and increased spatio-temporal variability of precipitation, but also by pressures due to population growth and particularly accelerating rate of urbanisation. Furthermore, high investment costs and long term-nature of water-related infrastructure projects requires long-term planning perspective, sometimes extending over many decades. Adaptation to such changes is not only determined by what is known or anticipated at present, but also by what will be experienced and learned as the future unfolds, as well as by policy responses to social and water events. As a result, a pathway emerges.

Instead of responding to 'surprises' and making decisions on ad hoc basis, exploring adaptation pathways into the future provide indispensable support in water management decision-making. In this contribution, a structured approach for designing a dynamic adaptive policy based on the concepts of adaptive policy making and adaptation pathways is introduced. Such an approach provides flexibility which allows change over time in response to how the future unfolds, what is learned about the system, and changes in societal preferences. The introduced flexibility provides means for dealing with complexities of adaptation under deep uncertainties. It enables engineering systems to change in the face of uncertainty to reduce impacts from downside scenarios while capitalizing on upside opportunities.

This contribution presents comprehensive framework for development and deployment of adaptive policy pathway framework, and demonstrates its performance under deep uncertainties on a case study related to urban water catchment in Singapore. Ingredients of this approach are: (a) transient scenarios (time series of various uncertain developments such as climate change, economic developments, societal changes), (b) a methodology for exploring many options and sequences of these options across different futures, and (c) a stepwise policy analysis.

The strategy is applied on case of flexible deployment of novel, so-called Next Generation Infrastructure, and assessed in context of the proposed. Results of the study show that flexible design alternatives deliver much enhanced performance compared to systems optimized under deterministic forecasts of the future. The work also demonstrates that explicit incorporation of uncertainty and flexibility into decision-making process reduces capital expenditures while allowing decision makers to learn about system evolution throughout the lifetime of the project.