# Editorial: Decisive moments in climate change adaptation

## INTRODUCTION: THE CHALLENGE OF ADAPTATION TO CHANGING CONDITIONS

While adaptation to changing circumstances is a phenomenon of all times, climate change has fuelled an interest in approaches and methods to anticipate longer-term change and uncertainty. Actors are looking for ways to navigate between ignoring uncertainties, for example by basing decisions on a single future scenario, and inaction, overwhelmed by uncertainty about the future.

An opening is offered by shifting attention from investing in *reducing* future uncertainties (better knowing the future) to the question: 'What can we best do now to achieve our goals, knowing that the future is uncertain?' This shift will require adjustment of regular planning approaches. Notably, *problem analysis* will have to include exploring the performance of current management approaches under a range of possible futures. Furthermore, the *design and evaluation of options and strategies* will have to explicitly account for future uncertainties.

A new approach for adaptation planning, *adaptive delta management* (ADM), was introduced in the context of the so-called Delta Programme in the Netherlands (van Rhee 2012; Delta Programme Commissioner 2014; Bloemen 2015). Key elements are: to explicitly take future uncertainties into account; to identify adaptation tipping points (Kwadijk *et al.* 2010; Jeuken & te Linde 2011); to develop adaptation pathways (Haasnoot *et al.* 2012; Ranger *et al.* 2013); to include and value flexibility; and to avoid 'lock-in' (Delta Programme Commissioner 2014).

In this special issue of *Journal of Water and Climate Change* we share and reflect on experiences with ADM in Europe and Asia. In particular, the special issue focuses on two central elements of ADM:

1. the identification of adaptation tipping points by asking under what conditions the performance of the current management approaches drops below a decisive level; and
2. the construction of adaptation pathways: sets of measures and decisions to be implemented progressively, depending on how the future unfolds.

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To this end the special issue presents a set of case study papers ranging from civil engineering to socio-ecologically defined adaptation challenges. An additional set of papers discusses methodological and governance implications. A practitioner's reflection augments the special issue.

In this editorial we summarise the individual papers and conclude with lessons learned as well as challenges remaining. Thus we aim to contribute to the on-going debate on adaptation planning and to support a community that actively seeks to foster adaptation.

## OVERVIEW OF THE CONTRIBUTIONS IN THE SPECIAL ISSUE

Riquelme-Solar *et al.* (2014) explore the impact of climate change on the navigability of the river Rhine for inland shipping. To identify conditions under which inland shipping faces insurmountable navigation restrictions, both physical thresholds (e.g. ship characteristics and water depth) and societal thresholds (e.g. duration of a low water period which stakeholders can handle) are assessed. Based on these thresholds, inland navigation is projected to face unacceptable performance thresholds from 2085 onwards, which motivates adaptation actions.

Van der Vlist *et al.* (2015) explore the replacement of hydraulic structures used for fresh water supply and flood risk management. The performance of hydraulic structures is determined by age, as well as changes in society, the economy, and the physical environment. The timing of replacement is essential to avoid loss of invested capital or societal benefits. The authors show how deterioration, biophysical change, and socio-economic change together determine the moment of replacement. They conclude that management objectives, maintenance, as well as operations of hydraulic structures need to inform replacement.

Koukoui *et al.* (2015) explore mainstreaming the implementation of adaptation options to reduce costs and open up alternative pathways for adaptation. The Adaptation Tipping Point-Opportunity method (ATP-O) for urban flood risk management under climate change is applied for the case of flood management in the city of Dordrecht, The Netherlands. The paper assesses when the current management strategy would fail, offers an alternative adaptation strategy, and shows how the alternative strategy becomes attractive when integrated in other activities such as planned street renewal.

Jeuken *et al.* (2014) compare the planning of flood risk management in four cases: the Dutch Delta Programme, the Thames Estuary 2100 project in the UK, the plan to adapt New York City after Sandy, and the Jakarta Coastal Defence strategy in Indonesia. In particular, three elements of ADM are compared: use of future scenarios; decision-making in the light of uncertainty; and developing monitoring plans to inform readjusting decisions. The cases are all found to consider a range of future scenarios, short-term decisions are coupled with long-term options in adaptation pathways, and opportunities to link to investments from other agendas are seized. Barriers to adaptive management remain: using multiple scenarios in the exploratory phase only, past structural flood protection constraining future choices, and low observability of variables to inform readjustment within project lifetime.

Ahmed *et al.* (2014) appraise major policy revision or institutional reform in flood management in Dhaka, Bangladesh over the last decades. The paper observes that major changes have resulted not only from extreme events, but also from a set of co-drivers, such as uncontrolled urban growth, socio-economic constraints, and foreign intervention. Thus, strategies and policies can be replaced before full implementation. The ineffectiveness of policy adaptation in Dhaka suggests that opportunities lie in considering the objectives of different sectors such as water management, ecology, and land use in conjunction rather than competition.

Van der Brugge & Roosjen (2015) propose an analytical framework to assess the difficulty of implementing adaptation pathways from a governance perspective. The framework is illustrated using a simplified example of fresh water supply in the Netherlands. It is concluded that the governance challenges for implementation of adaptation pathways are substantial and therefore should be addressed more extensively, and be taken into account when selecting or prioritizing adaptation strategies and pathways.

Dewulf & Termeer (2015) analyse ADM, as operationalised by the Dutch Delta Programme, in its capacity to climate proof the Dutch delta. In particular, they evaluate the provisions made for five selected governance capabilities: reflexivity; responsiveness; resilience; revitalization; and rescaling. The conclusion is that ADM can contribute substantially to resilience and rescaling. Its contribution to reflexivity and responsiveness is ambiguous. They conclude that ADM requires a prolonged commitment in the broader governance system to iterative policy revision, flexibility and learning.

## DISCUSSION AND REFLECTION

The starting point for this special issue is ADM (Delta Programme Commissioner 2014) and the 'adaptation tipping point' (ATP) and the adaptation pathways concept in particular. ATP borrows its terminology from ecological system behaviour where it refers to a critical point in an evolving situation that leads to a new and irreversible development (e.g. Lenton *et al.* 2008; Russill 2015). Such tipping points are intrinsic properties of a system. Applied to adaptation decision making however, tipping points contain a normative component: an ATP indicates a shift to a socially or politically non-desired situation. This non-desired situation is not necessarily irreversible (no collapse) nor fundamentally different (no major regime shifts). This is why some authors prefer the term adaptation turning point (Werners *et al.* 2013; Riquelme-Solar *et al.* 2014).

While applying the basic concept of ATP ('moments at which the performance of the current management approaches drops below a decisive level') the authors in this issue expand its original meaning and in some cases introduce new terminology. The papers emphasize different aspects in use and elaboration of the concept, in particular: (1) the (normative) performance criteria that define the ATP; (2) the drivers of change; (3) the timing

of an ATP; and (4) the adaptation response following identification of an ATP, leading up to adaptation pathways.

With respect to the criteria defining critical performance of the 'managed system' under consideration the papers offer a range of examples from relatively well-defined physical thresholds (water depth, storm surge heights etc.), to more complex socio-economic parameters like risk levels and social acceptance. Some papers define multiple levels of critical performance. For instance, in replacement and maintenance of water infrastructure, van der Vlist *et al.* (2015) distinguish between functional criteria (demands of water users) and more technical criteria for the constructions (e.g. strength/size). Riquelme-Solar *et al.* (2014) argue that stakeholder preferences are key to motivate action, and that, hence, social acceptability should be guiding in the identification of turning points.

With respect to the drivers of change, the papers illustrate that next to physical drivers induced by climate change (for example sea level rise), a set of co-drivers may determine the conditions that necessitate adaptation. Examples of co-drivers are subsidence (for example Jakarta (Jeuken *et al.* 2014)), economic and population growth, and untimely implementation of incumbent policies (for example Bangladesh (Ahmed *et al.* 2014)). In effect, multiple drivers determine the moment in time when action becomes necessary, complicating the assessment.

With respect to the adaptation response, the above discussed perspectives on performance criteria and drivers lead to different types of action. There is a wealth of choices to be made in bringing together structural or non-structural measures in adaptation pathways. Next to taking measures, objectives may be altered, for example by allowing for lower performance levels. In addition to the projected surpassing of performance levels, opportunities originating in other domains can be a trigger for taking action. For example, maintenance and replacement cycles of water infrastructure (dikes, sluices) can offer windows of opportunity to take action (van der Vlist *et al.* 2015). The same can be said of pressing challenges in traffic and city development (Jeuken *et al.* 2014), and retrofitting neighbourhoods (Koukoui *et al.* 2015).

By incorporating windows of opportunity in adaptation planning, the timing of decisions to adapt may shift from when it is necessary to adapt to when it is appropriate. As a result, the timing of implementation may critically depend on developments in other sectors (Ahmed *et al.* 2014). A major lesson to be drawn from the ineffectiveness of the adaptations in the Dhaka case is that opportunities lie in considering different sectors such as water management, ecology, and land use in conjunction (Ahmed *et al.* 2014).

Adaptation pathways are constructed to be implemented depending on how the future unfolds. A complication here is that trends in decision variables with a high natural variability (such as peak flows) do not become statistically significant within project lifetime (Jeuken *et al.* 2014). Moreover, appropriate timing of decisions depends on the time required for implementation of a policy (change).

This brings us to the perspective of governance. Van der Brugge & Roosjen (2015) emphasize that the governance challenges for implementation of future adaptation decisions can be substantial and therefore should be addressed more extensively, in particular when selecting or prioritizing strategies and pathways. More generally, Dewulf & Termeer (2015) conclude that ADM can contribute to resilience, yet also requires a prolonged commitment in the broader governance system to iterative policy revision, reflexivity, flexibility and learning (Dewulf & Termeer 2015).

While the need for multi-disciplinarity is evident, it also has its drawbacks in terms of conceptual clarity. This is illustrated perfectly in this issue where different authors coming from different backgrounds and traditions propose and use different terms to indicate the same, or largely overlapping phenomena. For example, the terms Adaptation Tipping Points and Adaptation Turning Points are rooted in different scientific traditions, yet overlap as both refer to 'situations that are considered unacceptable and demand (policy) action'. While this is normal for a developing field, it confuses communicating conceptual advantages to the outside world.

Summarising, ADM adds the dimension of timing to adaptation planning under uncertainty by asking under what conditions the performance of the current management drops below a decisive level, and by constructing

adaptation pathways: sets of measures and decisions, which can be implemented progressively, in response to how the future unfolds. The papers in this issue illustrate the relevance of multidisciplinary approaches in adaptation planning. Decisive moments for adaptation are defined by social acceptance criteria in combination with physical thresholds. In implementing adaptive management a number of challenges remain. First, there is a need to design monitoring and evaluation schemes fit to inform switching between strategies (e.g. Jeuken *et al.* 2014). Second, the assessment should be extended to adjacent decision fields to benefit from opportunities for synergy (e.g. Koukoui *et al.* 2015; Van der Vlist *et al.* 2015). Third, the governance dimension requires attention in support of monitoring, evaluation, implementation and learning over time (e.g. Van der Brugge & Roosjen 2015; Dewulf & Termeer 2015). Fourth, there is a need for more clarity and consistency in the use of terminology (e.g. Riquelme-Solar *et al.* 2014; Jeuken *et al.* 2014). Fifth, there is a need for designing visualisations of results to support communication and planning (e.g. Bloemen 2015).

While all these points represent challenges for further research and experimentation, the case studies presented in this special issue of *Journal of Water and Climate Change* offer inspiring evidence of the relevance and promise of adaptation planning under uncertainty.

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## REFERENCES

Ahmed, F., Gersonius, B., Veerbeek, W., Shah Alam Khan, M. & Wester, P. 2015 The role of extreme events in reaching adaptation tipping points: a case study of flood risk management in Dhaka, Bangladesh. *Journal of Water and Climate Change* **6** (4), 729–742.

Bloemen, P. 2015 Practitioner review. *Journal of Water and Climate Change* **6** (4), 666–669.

Delta Programme Commissioner 2014 *Delta Programme 2015. Working on the Delta. The decisions to keep the Netherlands safe and liveable* (English version). Ministry of Infrastructure and the Environment, Ministry of Economic Affairs. Dutch National Government, The Hague, The Netherlands, p. 175.

Dewulf, A. & Termeer, C. J. A. M. 2015 Governing the future? The potential of adaptive delta management to contribute to governance capabilities for dealing with the wicked problem of climate change adaptation. *Journal of Water and Climate Change* **6** (4), 759–771.

Haasnoot, M., Middelkoop, H., Offermans, A., Beek, E. & Deursen, W. 2012 Exploring pathways for sustainable water management in river deltas in a changing environment. *Climatic Change* **115** (3–4), 795–819.

Jeuken, A. & te Linde, A. 2011 *Working with Tipping Points and Adaptation Pathways – A Guideline* (in Dutch). Deltares, Delft, The Netherlands.

Jeuken, A., Haasnoot, M., Reeder, T. & Ward, P. 2015 Lessons learnt from adaptation planning in four deltas and coastal cities. *Journal of Water and Climate Change* **6** (4), 711–728.

Koukoui, N. R. A., Gersonius, B., Schot, P. P. & van Herk, S. 2015 Adaptation tipping points and opportunities for urban flood risk management. *Journal of Water and Climate Change* **6** (4), 695–710.

Kwadijk, J. C. J., Haasnoot, M., Mulder, J. P. M., Hoogvliet, M. M. C., Jeuken, A. B. M., van der Krogt, R. A. A., van Oostrom, N. G. C., Schelfhout, H. A., van Velzen, E. H., van Waveren, H. & de Wit, M. J. M. 2010 Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands. Wiley Interdisciplinary Reviews: *Climate Change* **1** (5), 729–740.

Lenton, T. M., Held, H., Kriegler, E., Hall, J. W., Lucht, W., Rahmstorf, S. & Schellnhuber, H. J. 2008 Tipping elements in the Earth's climate system. *Proceedings of the National Academy of Sciences* **105** (6), 1786–1793.

Ranger, N., Reeder, T. & Lowe, J. 2013 Addressing 'deep' uncertainty over long-term climate in major infrastructure projects: four innovations of the Thames Estuary 2100 Project. *EURO Journal on Decision Processes* **1** (3–4), 233–262.

Riquelme-Solar, M., Slobbe, E.v. & Werners, S. E. 2015 Adaptation Turning Points on Inland Waterway Transport in the Rhine River. *Journal of Water and Climate Change* **6** (4), 670–682.

Russill, C. 2015 Climate change tipping points: origins, precursors, and debates. *Wiley Interdisciplinary Reviews: Climate Change*. Online first 10.1002/wcc.344.

van der Brugge, R. & Roosjen, R. 2015 An institutional and sociocultural perspective on the adaptation pathways approach. *Journal of Water and Climate Change* **6** (4), 743–758.

van der Vlist, M. J., Ligthart, S. S. H. & Zandvoort, M. 2015 The replacement of hydraulic structures in light of tipping points. *Journal of Water and Climate Change* **6** (4), 683–694.

van Rhee, G. 2012 Handreiking Adaptief Deltamanagement (Guidance Adaptive Delta Management, in Dutch), *Staff Delta Programme Commissioner*. Stratelligence, Leiden, The Netherlands.

Werners, S. E., Pfenninger, S., van Slobbe, E., Haasnoot, M., Kwakkel, J. & Swart, R. 2013 Thresholds, tipping and turning points for sustainability under climate change. *Current Opinion in Environmental Sustainability* **5** (3–4), 334–340.