Experiences with adaptive river management

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Water flowing into side channel behind longitudinal training walls along the Waal River (branch of the Rhine delta) at Wamel, the Netherlands

Introduction

Millennia of engineering have shaped the rivers in the Netherlands in response to flood events, wars, and socio-economic developments. Continuous adaptation mostly occurred ad hoc and was reactive without integrated long-term planning. Anticipating adaptive management is only a recent development. It uses scenarios of future developments but also acknowledges deep uncertainty. In hindsight, for instance, nobody foresaw the rapid French invasion in 1672 by wading through one of the Rhine branches, which was decisive for relocating the main Rhine bifurcation from Schenkenschans to Pannerden, and for stabilizing its distribution of discharges[1]. Adaptive river management seeks to maintain or improve rivers in ways that do not cause regrets, avoid lock-ins, and prevent adverse effects in the long run[2].

In this article we discuss three approaches to this. First, we argue that leaving sufficient space for rivers preserves options for adaptation, exemplified by our experiences with the Room-for-the-River project in the Netherlands and stabilization of the Brahmaputra-Jamuna River in India and Bangladesh. Second, we show experiences with open processes of planning and design that leave space for adaptation to the inputs from stakeholders. Third, we present a systematic approach based on dynamic adaptive policy pathways.

Sufficient space

Creeping development of flood protection (dikes), river training (groynes, riverbank revetments) and river regulation (weirs, dams) over decades or centuries has often reduced fluvial space and, thereby, options for adaptation to future developments, such as climate change, and future societal requirements. The resulting lock-in could be avoided or counteracted by maintaining or giving back sufficient space. We distinguish three flavours of this approach. First, space for retention areas can temporarily store water to decrease flood flows and increase dry-season flows downstream. Second, enlarged cross-sections of channels and floodplains increase conveyance capacity for flood discharges and acreage for riverine nature. Third, areas along the river where erosion is allowed form an erodible corridor[3], giving room for free geomorphological functioning and thereby supporting dynamic fluvial ecosystems. The Room-for-the-River programme in the Netherlands focused on increased flood conveyance capacity and was implemented as an alternative to dike reinforcement. It aimed at synergy between the benefits of reducing flood hazard and restoring nature, moving away from traditional single-target solutions for reduction of flooding risk. It contributed to fulfilling the requirements of European environmental legislation (Water Framework Directive, Natura 2000, Nature Restoration Law). An additional advantage of wider floodplains for increased conveyance capacity is that they decrease the differences between water levels at different discharges. A future increase in design discharge will then only modestly raise design flood levels, without demanding substantial new interventions. This renders the river flood defence system robust[4].

Confronted with adverse effects and lock-ins, developed countries increasingly engage in projects to restore rivers. Many developing countries, however, are still engineering their rivers to support economic development. Thanks to today's understanding of associated lock-ins and costly adverse effects, however, they do not need to make the same mistake of occupying too much space as happened in countries that developed their rivers earlier. An example is the stabilization of the Brahmaputra-Jamuna River in India and Bangladesh. Earthquakes like those in 1897 and 1950 produce tens of cubic kilometres of landslides that overload the river with sediment and thereby enhance bank erosion. The 1950 earthquake widened the river in Bangladesh from 8.5 km in 1973 to 12.2 km in 2009, after which the river started shrinking again. Apparently, space for an erodible corridor is needed to cope with frequent high-magnitude earthquakes and consequent high sediment supply. Moreover, the morphological processes in the Brahmaputra-Jamuna are so dynamic that changes occur faster than response measures can be assessed and implemented. Available data on riverbed geometry quickly become outdated. This calls for high flexibility in the planning, design, tendering and implementation of works. Master plans with detailed maps of future shape along with timelines for implementation of programmed infrastructural works would not make sense. A meaningful master plan presents an adaptive approach that accounts for uncertainty and gradual implementation of works over decades. Drawings may still be needed to calculate costs, assess environmental and social impacts, and compare different options for action. These drawings, however, should not be mistaken as blueprints[5].

Stakeholder involvement

Adaptive management includes explicit openness to designs and design modifications proposed by stakeholders. When it was decided in the Netherlands to achieve safety against flooding at the new design Rhine discharge of 16,000 m^3/s through lowering of water levels by giving more space to the river rather than through raising dikes, nobody knew how to design a corresponding programme in detail. The Dutch government therefore invited society to propose projects that could fit in such a programme. A broad array of stakeholders responded. Provinces, municipalities, non-governmental organizations for the environment, sand miners and the central government itself came up with a total of 693 proposals for local projects to give more room to the river. The measures included relocation of dikes, removal of obstacles, excavation of flood channels and secondary channels, lowering of groynes, and lowering of floodplains.

All proposals were analysed in detail. The effects on water levels were computed with a 2D hydrodynamic model. Costs and number of houses to be demolished were calculated. The effects on 'spatial quality', an amalgam of nature, landscape and cultural heritage, were evaluated by a group of experts that formed the 'Q Team'[6]. Delft Hydraulics (now Deltares) summarized all results in a database with a user-friendly interface that allowed everybody to set up his or her own Room-for-the-River programme by selecting a combination of local projects. This 'Planning Kit' or 'Blokkendoos' (Figure 1) became a tool for democratic decision making, popular even among people without any affinity with technology and computers. Its strength was that all information was accessible in the same way to all parties. Users could evaluate effectiveness and consequences of different combinations of projects themselves. This greatly contributed to the acceptance of the 34 projects selected finally for the programme.

The overall Room-for-the-River programme had been set up with close stakeholder involvement. Yet, opposition still arose when it came to detailed design and implementation. Again, openness and willingness to adapt was a factor for success. For every local project, Rijkswaterstaat, the executive body of the Ministry of Infrastructure and Water, appointed a community contact manager who was continuously present in the project area. These managers listened and discussed concerns, compensation and mitigation with the local population at what became known as the 'kitchen table talks'. On a higher level, Rijkswaterstaat even welcomed entirely different designs developed by local communities. An example was the dike relocation at Overdiep, where a part of the floodplain had been reclaimed and developed into agricultural land in 1904. Dike relocation would give this floodplain back to the river. As a consequence, the farmers would have to move out of the area. The farmers, however, proposed to relocate their houses and stables on mounds in a streamlined arrangement along the dike at the edge of the floodplain, allowing them to stay in the area without obstructing flood conveyance while living with inundation of their land about once every 25 years. The proposal was accepted, and funds were made available for its realization.

Adaptation pathways

A systematic approach to adaptive management is the mapping of adaptation pathways[7]. One pathway corresponds to the current practice of ongoing incremental adaptation. If dikes provide safety against flooding, incremental adaptation occurs through dike reinforcement. An adaptation threshold or tipping point occurs when adaptation along the existing pathway can no

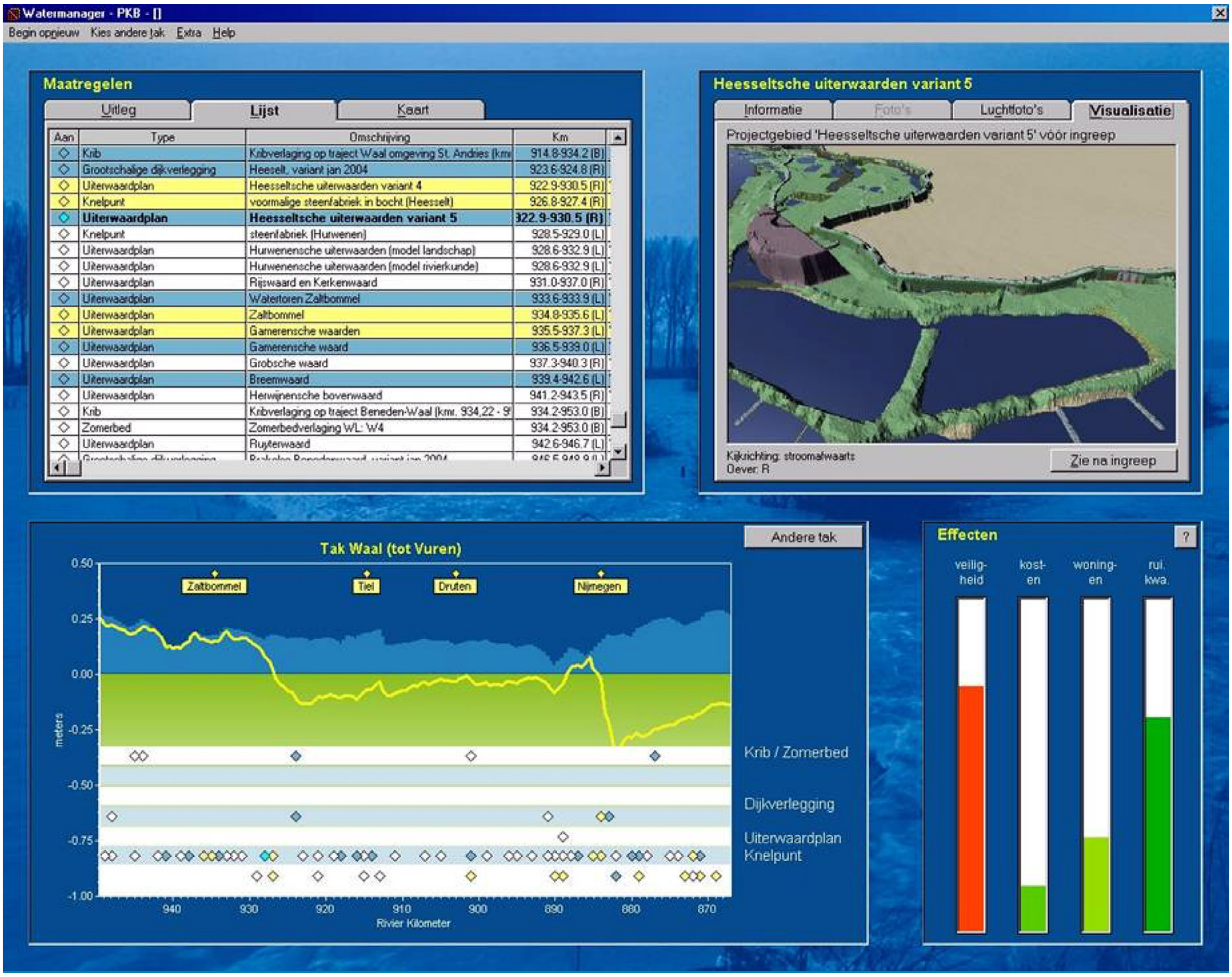

Figure 1 | User interface of the Planning Kit or Blokkendoos in 2006 for the Room-for-the-River programme along the branches of the Rhine delta. Upper left panel: selection of measures from database of 693 local projects. Lower left panel: combined effect of selected projects on water levels along the Waal branch. The zero level corresponds to flood levels at the old design Rhine discharge of 15,000 m^3/s for which the existing dikes are safe. The border between light blue and dark blue corresponds to flood levels at the new Rhine design discharge of 16,000 m^3/s. The yellow line shows how the selected measures lower these levels till below the safe zero level. The upper right panel visualizes one of the selected measures. The lower right panel shows thermometer representations of effectiveness for safety, costs, houses to be demolished, and spatial quality.

longer meet objectives and necessitates transition to another pathway such as basing protection against flooding on increased flood conveyance capacity. Realization of the transition may take decades, so it is important to detect early warning signals of tipping points by monitoring relevant indicators. Adaptive management also requires readiness. Drastic transition can meet resistance within business as usual but find broad support after extreme events. It then helps if plans for other pathways are already available, along with evidence of their feasibility[1]. In the Netherlands, dynamic adaptive policy pathways are now applied in the Delta Programme Rivers and Room for the River 2.0. With respect to the first Room-for-the-River programme, the scope has broadened from merely reducing flood hazard and enhancing spatial quality to improving low-flow conditions for nature, freshwater supply and navigability too.

Yet obstacles remain when applying the dynamic adaptive policy pathways in practice[8]. Policymakers and public administrators prefer concrete predictions of the future with a fixed end state. Scenarios seem to provide such predictions but are developed for a given time horizon, ignoring that the world will continue changing and that scenarios do not capture deep uncertainty. This remains a tension, especially when assigning land as spatial reservations for future adaptation.

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