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Savenije, Hubert; Kwadijk, Jaap; Mynett, Arthur

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COASTAL RESERVOIR (PAST AND FUTURE) IN THE NETHERLANDS

BY HUBERT SAVENIJE, JAAP KWADIJK & ARTHUR MYNETT

The Netherlands, situated in the delta of the Rhine-Meuse-Scheldt estuary, contains a large number of coastal reservoirs. For centuries the Netherlands have been constructing so-called 'polders' to reclaim land from the sea for agriculture and urbanisation. After the flood of 1916, a 32 km long closure barrier (de Afsluitdijk in the North of the Netherlands) was constructed in the 1930's to protect the area along the former Zuider Sea against flooding.

Gradually, this water body, now called IJssel Lake, turned into a fresh water reservoir that is being used for excess floodwater storage as well as drinking water supply. Parts of the lake were developed into reclaimed land for agricultural use and urban expansion. More recently the emphasis has been on increasing the recreational capacity of the coastal reservoirs in the Netherlands, while plans are being developed to extend the airport capacity of part of the reclaimed land, notably for the tourist industry.

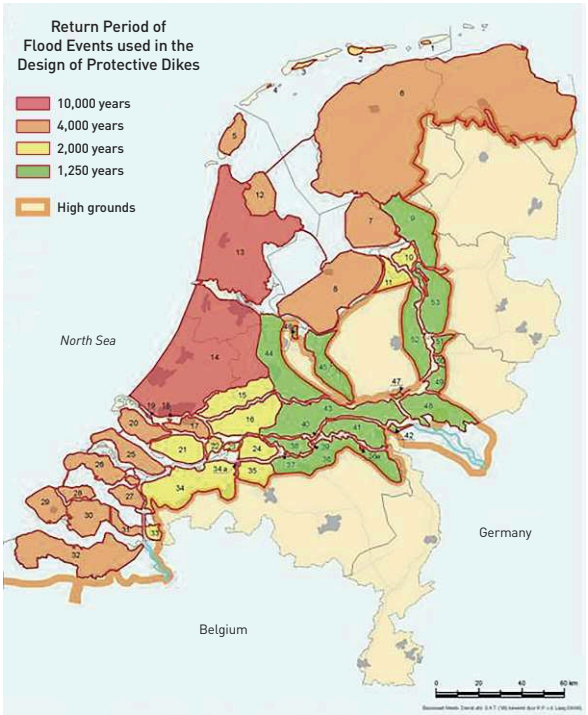

Figure 1. Coastal reservoir areas in Central and Southwest

In the 1970's and 1980's four major branches in the Rhine-Meuse estuary were closed following the major 1953 flood that severely damaged a large part of the Southwest of the Netherlands. The main purpose of these projects was to provide safety against flooding while additional objectives were to reduce salt-water intrusion and provide fresh water storage for agricultural use and drinking water supply. Already during construction of these "Delta Works" the importance of environmental considerations increased. The design of the Eastern Scheldt storm surge barrier was changed from a completely closed dam to a semi-open barrier that could be closed during extreme storm surge conditions if needed, but was to remain open during most of the time in order to sustain fishery demands and service environmental needs.

Similarly in the IJssel Lake, the purpose of land reclamation has changed considerably over time, in response to environmental considerations. In fact, the last polder planned in the lake was never completed and the water body now serves as a much-appreciated recreational are for water sports. At present, a part is being converted into an environmental reserve with the intention to restore biodiversity and attract migratory birds. A large part of one of the existing land reclamation areas has been converted into a national park with free roaming wildlife, where it was originally designed as an industrial complex. At the same time the IJssel Lake land and water areas are now host to numerous wind turbine parks for sustainable energy generation.

With several centuries of experience in the design and construction of coastal reservoirs, the Netherlands has long been engaged in providing expertise to other countries around the world. About one century ago, Johannes de Rijke was one of the pioneering engineers who worked in Japan to contribute to developing solutions for numerous water management problems at hand. In the 1960's and 1970's Professor Adriaan Volker provided the scientific foundation for including hydrological science and fundamental hydraulics into the design of coastal reservoirs and land reclamation works within such reservoirs. He brought the expertise developed for the IJssel Lake to various parts of the world, including Portugal and India. One of his important contributions was to consider not only the water balance but also the salt balance when assessing the feasibility of constructing coastal reservoirs. In the past, many mistakes had been made in particular regarding the salt balance, whereby expensive projects turned out to become failures. Properly accounting for the salt balance is a crucial element in assessing coastal reservoir feasibility, particularly in hot climates. But also in temperate climates, as was demonstrated by the failure of the Braakman coastal reservoir in the Netherlands where seepage from old marine deposits and saline groundwater caused significant salinity intrusion into the empoldered area.

Meanwhile experience in the design and construction of coastal reservoirs has grown considerably. At the same time, the motivation for the construction of coastal reservoirs has changed over time. In the past the main consideration was to create additional land for agriculture and urbanisation. At present, the dominant considerations for coastal reservoir construction or for modifying existing works are (i) to deal with effects of Sea Level Rise; (ii) to secure adequate fresh water supply in densely populated coastal regions; (iii) to reduce salinity

Hubert Savenije is Professor of Hydrology at the Delft University of Technology, where he is the head of the Water Resources Section. Prof. Savenije studied at the Delft University of Technology, in the Netherlands, where he obtained his MSc in 1977 in Hydrology. From 1985-1990 he worked as an international consultant mostly in Asia and Africa. He joined academia in 1990 to complete his PhD in 1992. In 1994 he was appointed Professor of Water Resources Management at the IHE-Delft and Professor of Hydrology at Delft University of Technology in 1998. He is Past President of the International Association for Hydrological Sciences (IAHS).

Jaap Kwadijk received his PhD from Utrecht University in 1993. Since 1997 he has been at Deltares (WL|delfthydraulics). His expertise is climate change, flood and water management and worked on these issues in Europe, Iran, Hong Kong, Mongolia, Bangladesh and Egypt, where he lived for two years. He was one of the founders of the Delft-FEWS forecasting system, one of the most widely used forecasting systems in the world. Currently he is Director of Science of Deltares. Since 2012 he is also part time professor Climate and water management at the Twente University.

Arthur Mynett (1950) is Emeritus Professor of Hydraulic Engineering and River Basin Development at UNESCO-IHE Institute for Water Education, and Emeritus Professor of Environmental Hydroinformatics at Delft University of Technology. He was director of strategic research at Delft Hydraulics and served as head of the water science & engineering department at UNESCO-IHE. He is past Vice-President of IAHR and was chair of the LOC of the 36th World Congress held in 2015 in Delft-The Hague, Netherlands. He is Honorary Professor at the Nanjing Hydraulic Research Institute (NHRI) working on ecohydraulics and flood risk management.

intrusion; and (iv) to enhance environmental quality. In recent times, reclaimed land is being used for harbour and port extension as well as for creating high value urban development and real estate, like the Marina Bay area in Singapore.

Nowadays over half of the world population is living in urban conglomerations that are often located in coastal areas where rivers meet the sea. As a consequence, the design and construction of coastal reservoirs is becoming increasingly important. However, in order to deal with uncertainties in the planning procedure due to (yet) unknown effects of climate change, population growth, economic development etc. it is extremely difficult to plan ahead for any prolonged period of time. This implies that flexibility is required in the planning process to deal with unknown and unforeseen circumstances.

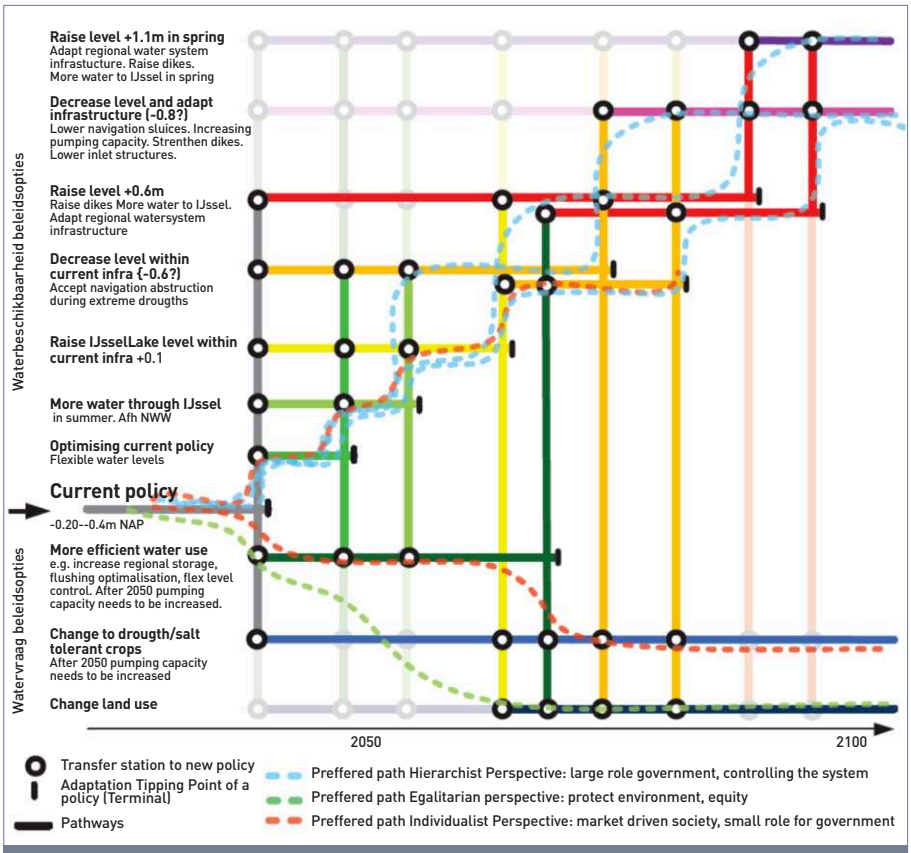

Figure 2. Adaptation pathway planning and tipping points

The Adaptive Pathway Planning approach identifies tipping points in decision tree analyses where proper decisions need to be made in order to secure adequate safety levels and other decision variables that government together with stakeholders have agreed to. Research efforts in this field include elements from Real Options Theory and Tipping Point Analysis, as well as innovations in climate change adaptation in combination with socio-economic considerations.

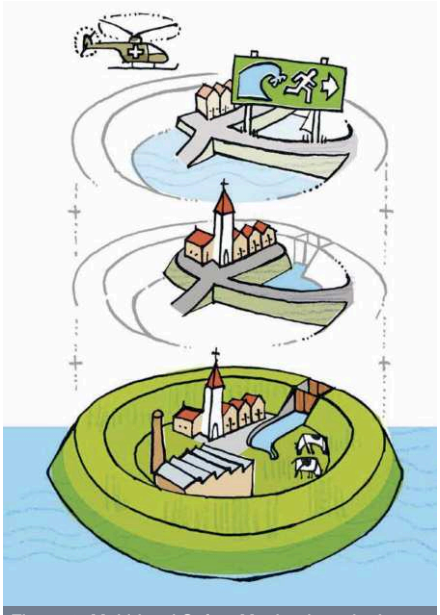

Figure 3. Multi-level Safety Mechanisms in the Netherlands

In the Netherlands considerable attention is being paid to securing sustainability of the various functions of coastal reservoirs. Rather than waiting for disasters to happen before responding by taking measures, the Dutch government has pro-actively initiated a second Delta Plan to anticipate effects of climate change and socio-economic development. Multiple defence mechanisms have been established against the risk of flooding: (i) primary safety from dikes, dunes, and storm surge barriers; (ii) adequate infrastructure for timely evacuation; (iii) early warning systems for proper planning and implementation.

In accordance with these measures, a Delta Fund has been secured by parliament to assure adequate funding for projects that are considered of national importance. A Delta Commissioner has been appointed at the ministerial level to assure proper planning and implementation of nationally agreed measures to be taken. All this and more to secure the sustainability of coastal reservoirs in the Netherlands. ■