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Figure 1.
Cross section of Noordereiland: option flood protection by floodwall, small bench (image courtesy Peter van Veelen).



Figure 2.
Cross section of Noordereiland: option flood protection by new quay wall and sheet pile construction (image courtesy Peter van Veelen).



Figure 3.
Cross section of Noordereiland: option flood protection by large bench and boulevard (image courtesy Peter van Veelen).

Peter van Veelen

ADAPTIVE PLANNING FOR RESILIENT URBAN WATERFRONTS

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Dissertation title:
'Adaptive planning for resilient coastal waterfronts: Linking flood risk reduction with urban development in Rotterdam and New York City.'

PhD Supervisors:
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Many delta and coastal cities worldwide face increasing flood risk due to changing climate conditions and sea level rise. The question is how to adapt existing urban coastal areas to these slowly changing conditions?

A major challenge of adapting existing coastal urban areas is that it requires anticipating long-term trends and changes that easily exceeds periods of 50 to 100 years. This brings large uncertainties in the design and planning process. Dealing with uncertainty requires improving the ability to adapt. Adaptability can be both tactical-operational (designed) and strategic (planned). On a strategic level adaptability can be achieved by developing sequences of adaptation options (pathways) that keep options open in anticipation of future conditions. Additionally, key to successful adaptation of urban environments is the ability to use moments of change in urban development and management for low-cost adaptation and to yield additional benefits. This requires a better understanding of the opportunities to spatially and timely synchronize adaptation measures with spatial development, urban management and infrastructure maintenance projects, and finally, to create multi functional coastal landscapes. Therefor, the main research question of my research is twofold: "How can we adapt existing coastal urban waterfront areas to changing climatic circumstances and how can we take this adaptation process as an opportunity for creating added value?"

To answer the research question, this research applied a resilience based planning method (the Adaptive Pathways Method, see Figures 4 and 5) to develop and assess adaptation pathways at the level of neighbourhood development at two flood prone waterfront cases in Rotterdam and one in New York City. APM is a structured, iterative approach based on defining the conditions under which policy objectives are no longer attainable and adaptation is required, and the assessment of sequences of adaptation actions enabling policy makers to explore options for adapting and develop adaptive strategies. Although the APM has been successfully applied to large-scale strategic delta planning projects (e.g., the Thames Estuary 2100 project), it has not yet been applied to the level of urban development and local adaptation planning. Additionally, applying the method at the local level helps to better understand if incorporating adaptation pathways into urban development processes is an effective strategy to enhance the overall resilience of urban waterfronts.

There is a wide range of adaptation actions available ranging from small-scale building-to-building adaptation to large-scale flood protection infrastructures. This research concluded that, particularly under shallow, low-energy flood conditions as found in the Rotterdam unembanked areas and New York City's waterfronts, retrofitting flood resilience measures to buildings is effective in terms of flood risk reduction. However, because retrofitting flood resilience to buildings needs regular renovation and rebuilding projects to be cost-effective a building level adaptation strategy would require at least a period of 20-50 year, which would hardly surpass the expected increase in future flood risks. Additionally, due to policy regulations and economic restraints it is expected that only a small portion of the building stock will adapt incrementally. Consequently, one of the key findings of the case study research is that in high density urban conditions there is limited potential to build resilience from household redevelopment or renovation on the long run even when new complementary policies and regulative instruments that support building-level resilience would be developed. District-

Figure 4. Adaptive Pathways Method (APM) Dynamics.

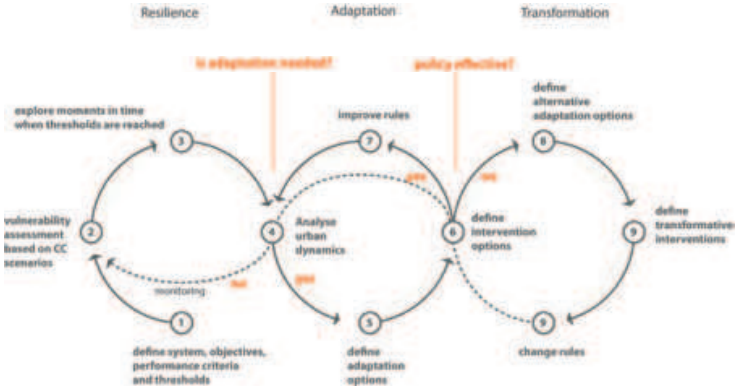
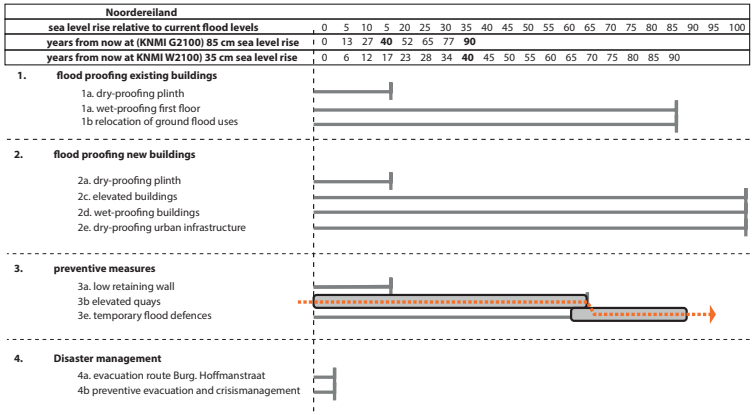


Figure 5. Adaptive Pathways Method (APM) applied to Rotterdam flood prone neighborhood Noordereiland.



wide flood protection is effective both in terms of flood risk and is economically beneficial, but requires large-scale transformations of the waterfront zone to seize opportunities to develop integrated protection at low costs. Additionally, a multipurpose flood protection strategy often needs financial arrangements to capture potential values and redistribute costs and benefits fairly among the stakeholders.

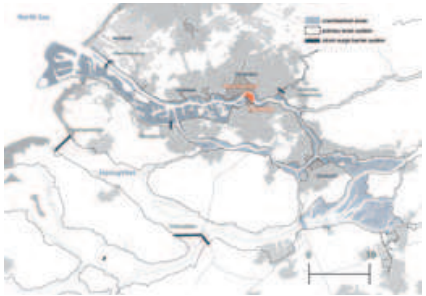
Another major challenge is that a change of strategy, for example between building level and district wide flood protection, runs a risk of a financial lock-in. Every single investment in building level resilience reduces the overall flood risks and hence the benefits accruing to a district-wide protection option making a 'transfer' to a district-wide solution less feasible from an economic point of view. This economic path dependency is a serious constraint for moving towards more resilient waterfronts, particularly for New York City where landlords and homeowners started to invest in property protection. However, co-benefits for urban development and added values arising from flood protection investments (e.g. increase in real estate value) may have a positive effect on reducing the transfer costs, although the effects strongly depend on local conditions. This means that it is necessary to decide early in the adaptation process on the long-term adaptation strategy and to support this strategy with short-cycle, low cost interventions aiming at 'buying time' to increase the opportunities for creating district-wide protection that offer additional opportunities for urban development.

Based on the case study research, this research concludes that the Adaptive Pathway Method is an effective tool to evaluate and select appropriate adaptation measures. Additionally, the method helps to better grasp the timing of adaptation and develop a wide portfolio of adaptation actions, which opens up opportunities to couple adaptation measures with other planned investments or to anticipate urban design to allow for easier adaptation in the future.

However, a fundamental shortcoming of the adaptive pathway method is that in reality – as clearly shown in the case studies— there is no smooth transfer between alternatives. In addition to this, the method ignores the dynamic aspect of urban development, renovation and change, and opportunities for adaptation that might arise from it. For example, retrofitting wet proofing measures to buildings is less expensive when it is part of a large-scale renovation. Arguably, understanding the dynamics of urban development, redevelopment and management of urban assets and the opportunities this brings for climate resilient urban design is essential in adaptation planning.

A more effective frame, introduced in this research (Figure 5), is to build pathways based on identifying adaptation intervention points, which are defined as the actual moments of change that may be used for adaptation, adaptation transitions that are defined as changes in legal, institutional and financial structures that improve or unlock the full potential of adaptation intervention points, and, finally, adaptation transformations that are fundamental changes in urban form, policies, institutional arrangements and norms that could create new adaptation opportunities. Applying this frame to the case study locations in Rotterdam and New York (see Figures 6 and 7 below and case study pp. 74-75) showed that it helps to identify key interventions (e.g., spatial, legal or financial) that are needed to unlock the potential of adaptation options. The method helps bridging the gap between adaptation planning and urban development and management.





Figures 6 and 7. Case study locations in New York City (Red Hook) and Rotterdam City (Noordereiland and Feijenoord).