Flood risk assessment as an integral part of urban planning

Löwe, Roland; Urich, Christian; Sto Domingo, Nina; Mark, Ole; Deletic, A.; Arnbjerg-Nielsen, Karsten

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
flood risk assessment as an integral part of urban planning

* Dept. of Environmental Engineering, Technical University of Denmark (DTU), Denmark
† Ecofys, the Netherlands
** Department of Civil Engineering, Monash University, Australia
*** DHI Water Environment Health, Denmark
* CRCWSC for Water Sensitive Cities, Australia

INTRODUCTION

This poster presents a software framework that integrates flood risk assessment using the 1D-2D hydraulic model MIKE FLOOD and urban development modelling using the DanCE4Water platform. This framework allows for the systematic evaluation of flood adaptation strategies given a variety of future scenarios for urban development and climate change. Adaptation strategies can thus be tested with respect to their robustness towards different futures.

The framework aims to bridge the gaps between different professions involved in the urban planning process and therefore allows for the consideration of traditional flood adaptation strategies focusing on modifications of the urban water infrastructure such as pipes or dikes, just as well as decentralised water management and urban planning policies aimed towards a water sensitive city development. Reductions in flood risk are evaluated in a cost-benefit assessment which permits to compare investment cost against reductions in flood risk as well as added benefits such as reductions in drinking water consumption.

METHODS

We tested various combinations of flood adaptation strategies for different scenarios, manifested in varying drivers of flood risk, such as population growth or climate change.

A combination of a certain adaptation strategy and a specific scenario is called a pathway.

In a 300 ha case study catchment in Melbourne, Australia, we evaluated strategies over a planning horizon of 50 years. Urban development was modelled as an interaction between the key actors city council, developers and households. City council defines different zones for development (white, green and orange in subfigure A), developers split parcels of sufficient size and erect new buildings on these depending on housing demand and household size, and new buildings appear as a result of population growth and move into new buildings.

The new building set is then transferred into the hydraulic model (subfigure D) to assess flood risk.

Cost benefit assessment: We compared accumulated investment and operation expenses over the planning horizon against benefits from reduced flood risk and smaller drinking water consumption. As flood risk is not stationary, reduced flood risk must be derived by comparing against a reference without adaptation for the exact same scenario and net present value (NPV) must be computed separately for each scenario [2].

RESULTS

A total of 32 potential combinations of adaptation options was simulated for 9 scenarios each, leading to a total of 288 pathways. Along each pathway, flood risk was assessed every 10 years, by considering 7 design rain storms with return periods from 1 to 100 years, leading to a total of 12,096 1D-2D hydraulic simulations in MIKE FLOOD. Figure 4 highlights flood risk for selected strategies, while Table 2 illustrates net present values derived for different adaptation options.

DISCUSSION

Uncertainty: Our simulation setup provides a means to test the robustness of flood adaptation towards a variety of futures and thus goes one step further than traditional, projection-based planning approaches. However, it is limited to the consideration of futures we are not aware of or that we cannot quantify [3]. In addition, the simulation setup as such is subject to a number of uncertainties such as assumptions on flood damages for buildings or an assumed ongoing evolution of the city through parcel splitting.

CONCLUSIONS

We have successfully applied a simulation setup coupling the urban development modelling platform DanCE4Water and the 1D-2D hydraulic modelling package MIKE FLOOD to systematically test flood adaptation options for a variety of climate and urban development scenarios.

We draw the following conclusions:

• flood risk is very much subject to changes in climate and urban development, an urban planning policy proved to be the most efficient flood adaptation strategy, because reductions in flood risk could be obtained as a side-effect of urban planning without additional investment cost, the efficiency of flood adaptation strategies depends on which climate and urban development scenarios are considered and which other strategies are implemented, flood adaptation strategies should be designed in a way in which they can be flexibly adapted in the future.

Figure 4 – Development of flood risk expressed as expected annual damage over the planning horizon for selected adaptation strategies.

Table 2 – Net present value (NPV) in 10^6 AUD for selected combinations of flood adaptation options. Shown are the mean and maximum values over the 9 considered scenarios.

Figure 4 suggests that flood risk in the catchment is very much increased by changing rain intensities and population growth. Master planning was the most efficient strategy to mitigate changes in flood risk, because it did not require additional investment cost. Flood zoning reduced flood risk, but was applied to too large an area and was too costly as a result. Several strategies scored clearly positive NPVs in some scenarios, while being inefficient on average over all scenarios. Increasing pipe capacity to handle a fixed design event would, for example, not be robust towards a variety of futures.

REFERENCES


ACKNOWLEDGEMENT

This research has been financially supported by the Australian Government through the CRC for Water Sensitive Cities. The catchment data were kindly provided by Melbourne Water and the City of Monash.

Figure 4 – Development of flood risk expressed as expected annual damage over the planning horizon for selected adaptation strategies.

Table 2 – Net present value (NPV) in 10^6 AUD for selected combinations of flood adaptation options. Shown are the mean and maximum values over the 9 considered scenarios.

Figure 4 suggests that flood risk in the catchment is very much increased by changing rain intensities and population growth. Master planning was the most efficient strategy to mitigate changes in flood risk, because it did not require additional investment cost. Flood zoning reduced flood risk, but was applied to too large an area and was too costly as a result. Several strategies scored clearly positive NPVs in some scenarios, while being inefficient on average over all scenarios. Increasing pipe capacity to handle a fixed design event would, for example, not be robust towards a variety of futures.

REFERENCES


ACKNOWLEDGEMENT

This research has been financially supported by the Australian Government through the CRC for Water Sensitive Cities. The catchment data were kindly provided by Melbourne Water and the City of Monash.

Figure 4 – Development of flood risk expressed as expected annual damage over the planning horizon for selected adaptation strategies.

Table 2 – Net present value (NPV) in 10^6 AUD for selected combinations of flood adaptation options. Shown are the mean and maximum values over the 9 considered scenarios.

Figure 4 suggests that flood risk in the catchment is very much increased by changing rain intensities and population growth. Master planning was the most efficient strategy to mitigate changes in flood risk, because it did not require additional investment cost. Flood zoning reduced flood risk, but was applied to too large an area and was too costly as a result. Several strategies scored clearly positive NPVs in some scenarios, while being inefficient on average over all scenarios. Increasing pipe capacity to handle a fixed design event would, for example, not be robust towards a variety of futures.

REFERENCES


ACKNOWLEDGEMENT

This research has been financially supported by the Australian Government through the CRC for Water Sensitive Cities. The catchment data were kindly provided by Melbourne Water and the City of Monash.

Figure 4 – Development of flood risk expressed as expected annual damage over the planning horizon for selected adaptation strategies.

Table 2 – Net present value (NPV) in 10^6 AUD for selected combinations of flood adaptation options. Shown are the mean and maximum values over the 9 considered scenarios.

Figure 4 suggests that flood risk in the catchment is very much increased by changing rain intensities and population growth. Master planning was the most efficient strategy to mitigate changes in flood risk, because it did not require additional investment cost. Flood zoning reduced flood risk, but was applied to too large an area and was too costly as a result. Several strategies scored clearly positive NPVs in some scenarios, while being inefficient on average over all scenarios. Increasing pipe capacity to handle a fixed design event would, for example, not be robust towards a variety of futures.

REFERENCES


ACKNOWLEDGEMENT

This research has been financially supported by the Australian Government through the CRC for Water Sensitive Cities. The catchment data were kindly provided by Melbourne Water and the City of Monash.