Project 3.2 Flood risk in dike-ring areas

Description of research

In order for a flood protection system to remain functional over time and to ensure the provision of the degree of safety that the respective society needs, appropriate investments in structural and non-structural flood control measures are necessary. Decisions regarding investments in flood protection are usually supported by means of cost-benefit analysis (CBA), whose objective is to indicate the optimal set of investments from an economic perspective. In the Netherlands an economically optimal solution is considered to be one that minimizes the total cost of the system over a certain time horizon. Nevertheless the application of a CBA and the interpretation of its results can be a complicated task.

Complications seem to occur when investments in measures with different functions need to be compared and optimized. Such is the case of investments in multi-layer safety systems, where measures for the mitigation of losses due to flooding need to co-exist and compliment the function of measures for prevention of flooding. In this case solutions that minimize the total cost prove not to comply with other economic criteria such as the optimization of return on investment. More complications occur when uncertainties over time are taken into account, such as climate change, economic and demographic growth or decline, innovation, risk aversion in society, deterioration of structural components etc, whose variations can have considerable effect on the result of a classical CBA.

The scope of this project is to investigate the reliability of decision analysis regarding the future of flood defence systems. In particular a comprehensive assessment of the currently used CBA approach is supposed to be performed and possible improvements to be suggested and analyzed. Those improvements should ensure that the distribution of investments in space and over time is realized in a way that fulfils the needs and preferences of the respective societies. Some needs that seem to be universal nowadays are that the system remains safe, is flexible enough to adapt to currently unpredictable future conditions in a reasonable cost, while at the same time unnecessary costs are avoided.

Research question

Taking into account the need for investments in multi-layer safety, and the need for incorporation of a future vision in flood risk management:

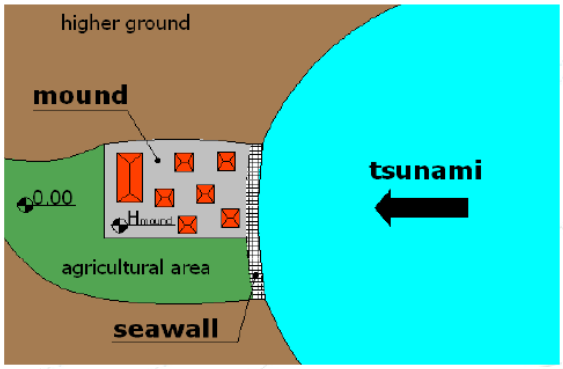
- How reliable is the currently used CBA approach for the economic assessment of investments in flood protection?
- Would it be viable to incorporate the concept of option value in order to improve its results?

Methodological approach

- Literature review on cost-benefit analysis, option value and the role of rationality and risk aversion.
- Elaboration of CBA for fictitious case studies, starting as simple as possible (i.e. one measure for prevention of flooding and stationary conditions), and making it gradually more complex by adding 1) flood control measures, 2) non-stationary conditions, 3) the prospect of learning and changing track over time.
- Comparison of results of different stages, explicit indication of special attributes of each stage, and conclusions about the most appropriate assumptions and economic optimization criteria used in CBA for flood protection investments.
- Enhancement of the analysis by describing the analyzed systems in terms of reliability engineering concepts.

Preliminary conclusions

A fictitious case of a simple multi-layer safety system in a tsunami-prone area is being elaborated, which resembles a village in Tohoku region in Japan that was devastated by the Great Eastern Japan Earthquake and Tsunami in 2011. In order to protect it against tsunamis the construction of a concrete seawall (layer 1) along the coastline and the construction of an artificial mound for increasing the elevation of the village (layer 2) are considered.



Rhine – Meuse estuary, Netherlands

Tohoku, Japan

Based on the results of a cost-optimization modeling the following preliminary conclusions have been derived.

- The combination of seawall height and mound height that minimizes the total cost of the project is not the one with the highest return on investment. The reasoning behind this observation needs to be investigated.
- The risk reduction due to the combined effect of seawall and mound seems to be greater than the summation of the risk reduction that each measure would contribute in the system if applied alone. This result brings the attention back to the nature of a multi-layer safety system in reliability engineering terms, which is not a serial system, not a parallel system, but some sort of “correlated parallel system”. Some research in this direction will follow.

Possible applications

The conclusions of the above analysis are going to be linked to real life applications. In particular cases in two different countries are going to be thoroughly investigated:

- In the area of Rhine-Meuse estuary in the Netherlands,
- In the tsunami-prone coast of Tohoku in Japan that was devastated by the tsunami of March 11, 2011.

More information

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