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CLIMATE CHANGE, RISK CONSTRUCTS AND COASTAL DEFENCE: PROBABILISTIC RISK ANALYSIS OF COASTAL DEFENSES

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Summary

An accelerated sea level-rise has a strong impact on the safety of the coastal zone. In order to quantify this impact the method of a probabilistic risk analysis is used. It comprises the calculation of the failure probability of existing coastal defence systems as well as the analysis of the consequences, i.e. flooding of the hinterland, in case of failure. A sea level-rise of 0.55 m, anticipated within the KRIM project until 2050, decreases the recurrence interval of failure by a factor of approx. 4. Besides that also the loss in case of failure, e.g. dike breach, increases. E.g. the loss approximately doubles as an investigation for the coast between the cities of Bremerhaven and Cuxhaven shows.

Aim of the research in the framework of KRIM

The probabilistic risk analysis is part of the scientific risk concept developed in KRIM (Schirmer et al. 2003). Within this study the typical coastal defence systems and their elements are analysed with respect to their failure modes and failure probabilities in case of storm surges. Besides that the hazard to hinterland is calculated assuming the failure of the coastal defence system. On the basis of these results on today's and future risk different response options are developed and associated with the four major strategies: defence, adaptation, retreat and advancement. The different options are worked out with respect to technical feasibility and costs as well as their efficiency in risk reduction. These are essential information to be integrated into the decision support system.

Completed and recent activities

So far the calculation of failure probabilities of the coastal defences of the Weser-Jade-region has been carried out employing the long-term statistics of water levels and wind and the statistics of waves derived by numerical modelling. The hinterland protected by coastal defences was analysed with respect to land use derived from digital landscape model and assets derived on the meso-scale from statistics of regional and national accounting. On this basis the effect of a failure of the coastal defence system was calculated using numerical simulations of the inundation of the hinterland. All calculations were carried out for today's and future (2050) climate conditions (Schirmer et al., 2003). The described steps of the probabilistic risk analysis were integrated and automated within a Geographic Information System (Weigel et al. 2002).

Comparing the results for both climate conditions the need for an improvement or a change in coastal defence becomes obvious. Possible response strategies are now under development.

Preliminary results

The probabilistic approach (on level III) revealed an annual failure probability of the existing coastal defences in the order of 1/1000 (Mai et al. 2003a). In the event of climate change the statistics of water levels, wind and waves change and therefore the probability of failure increases significantly to about 400 %. Although the failure probabilities of costal defences are more or less the same throughout the Weser-Jade region the possible impact in case of failure varies a lot. As expected, the largest concentration of (monetarily appraisable) assets within the hinterland is found in the cities. Therefore the loss is e.g. in the order of 250 Mio. € in case of a failure of the storm surge barrier in Bremerhaven, while a breach of a dike protecting rural areas, like Dorum north of Bremerhaven, results in a loss of approx. 30 Mio. € (Meyer et al. 2003). For this reason the risk as a product of failure probability and loss varies a lot along the coast. Assuming an increase in storm surge levels the loss will increase for Dorum by a factor of two and the hence the risk by a factor of eight (Mai et al. 2003b).

Further activities

On the basis of risk maps several response strategies will be introduced in the calculation scheme of the probabilistic risk analysis. In detail the following measures will be discussed:

- reinforcement of existing sea dikes
- installation of additional dikes within the hinterland (to reduce the flood plain)
- construction of storm surge barriers in the estuaries Jade and Weser
- installation of polders along the river Weser

Conclusions

The risk of the coastal zone with respect to storm surges increases significantly requiring the planning of adaptation measure already today. Due to the limited public budgets future coastal defence planning should focus especially on the high risk areas, i.e. the densely populated regions, in order to guarantee an optimal allocation with respect to annual construction and maintenance costs of the coastal defence system as well as the remaining risk (Mai et al. 2002).

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