

## **Approach to estimate monetary damages of riverine flooding under various future scenarios: A case study of the Neckar river basin (Germany)**

*Already today, riverine floods can cause costly damages to inundated assets along the river banks. The likelihood and magnitude of riverine floods are expected to change throughout the 21<sup>st</sup> century due to climate change, which is altering the precipitation patterns in many regions around the globe. Besides the flood hazard itself, flood damage potentials also depend on flood exposure and flood vulnerability, which are also subject to change due to socio-economic development. Due to these evolving damage-causing variables, practitioners in flood risk management need suitable methods to assess and predict future changes in flood damage potentials to plan, prepare and adapt to future flood risk. My thesis addresses this issue by providing an assessment framework, which can be used to estimate monetary damages due to potential riverine flooding under various future scenarios. The developed assessment framework was tested and validated in a case study of the Neckar river basin in southern Germany.*

The thesis shows which publicly available information can be used and how it can be processed to estimate flood damages in a particular region under today's and future conditions. The developed assessment framework is adaptable to different contexts and can be used by other researchers to assess flood damage potentials in different areas of interest. The comprehensive use of Europe-wide datasets in the developed assessment framework makes the case study results easily comparable to potential studies in other European river basins using the same assessment framework and data.

The results of the case study of the Neckar river basin suggest an increase in future flood damage potentials in this part of southern Germany. Under today's conditions, flood damages of 95.9 million EURO are expected along the Neckar river every year. The simulated increase in expected annual monetary flood damages ranges between 33% and 70% for the mid-century and between 80% and 83% for the end of the 21<sup>st</sup> century. The level of increase in flood damages along the Neckar river throughout the 21<sup>st</sup> century largely depends on the underlying future scenario conditions.

The projected increase is primarily related to expected changes in the exposure and vulnerability of the analysed assets along the river banks of the Neckar river and to a smaller extent due to changes in climate, which affect the flood hazard. In terms of climate change, the expected increase in future flood damages is higher for the applied business-as-usual scenario

than for the applied scenario of strong climate action. However, the differences in future flood potentials between the two applied future climate scenarios are merely significant for the study area.

The impact of climate change on future riverine flooding in the study area remains unclear due to ambiguity in the applied climate data and uncertainties in the applied methods to process this data. The study results highlight the interplay of the flood hazard, the exposure and the vulnerability of assets in the Neckar river basin, which can inform and facilitate the work of policymakers and specialists in flood risk management in southern Germany.

The developed flood damage assessment framework is based on the outcome of an initially performed scoping study. In this literature review, 48 peer-reviewed scientific articles on existing flood damage assessment approaches were systematically analysed. The findings of this literature review show that monetary flood damages are most commonly assessed based on flood extents and inundation depths, which allow for flood damage estimates for various assets under different flood inundation depths.

Informed by these findings, the developed assessment framework consists of a flood component and a damage component, which in combination can be used to estimate monetary flood damages for various flood scenarios under today's and future conditions. The developed assessment framework makes use of computer-based modelling and simulation software, including ArcGIS Desktop 10.5.1, HEC-RAS 5.0.7, HEC-GeoRAS 10.2 and MOLUSCE.

To account for uncertainties surrounding the simulation of riverine flood damages, a qualitative confidence estimation was used in the thesis project to reflect on the strength of knowledge underlying the framework-based flood damage assessment. Therefore, the strength of knowledge underlying 19 key variables in the assessment framework was evaluated on an ordinal scale from weak to strong in the case study. This confidence estimation is specifically tailored to the developed assessment framework and can be adapted to other study contexts alongside the assessment framework.

The main recommendation for similar future study projects is, to improve the integration and data wrangling of the used climate data, to improve the validity of future flood hazard projections. The performed case study revealed some weaknesses in the applied simulation approach of future flood discharges, which can be avoided by laying more focus on future rainfall shifts between the seasons. This could significantly increase the merit of the future flood damage projections considering different climate scenarios.