FLOOD RISK IN LIEGE AREA: A TRANSNATIONAL PERSPECTIVE

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Liege is located at the heart of the Meuse basin, which covers parts of France, Belgium, Germany and the Netherlands. Considering explicitly this transnational context when conducting flood risk analysis in the area of Liege sheds light on specific features and management opportunities which might otherwise be overlooked. Within a basin-wide collaborative approach, future flood risk was estimated along the course of the Meuse and adaptation measures were evaluated, particularly for the protection of the city of Liege.

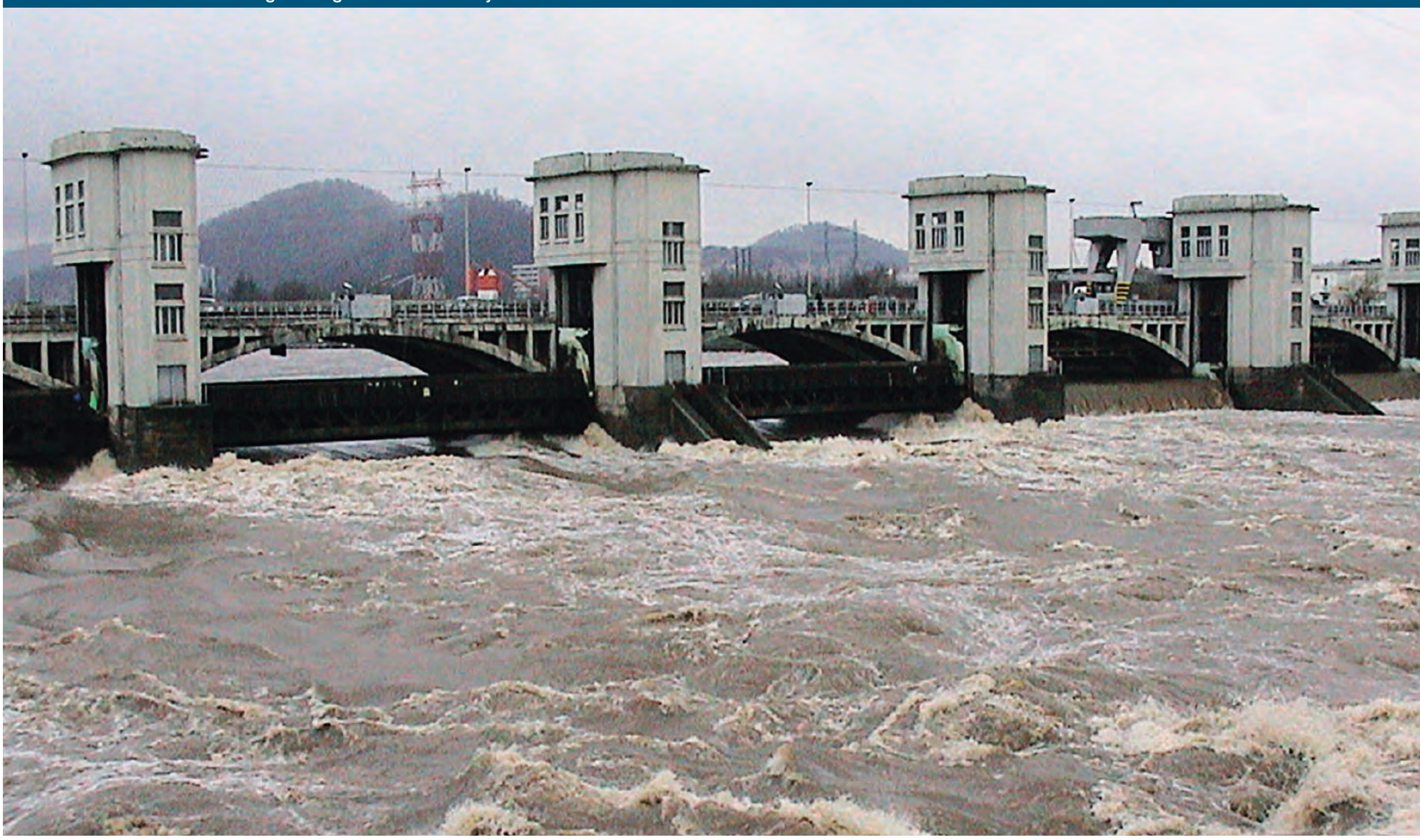
Liege is characterized by a complex setting of rivers and artificial waterways, involving the Meuse, its main tributary river Ourthe, a major derivation channel, as well as the Albert canal connecting the Meuse to the harbour of Antwerp. The main structure controlling the flow is Monsin dam (see photograph) situated downstream of the city.

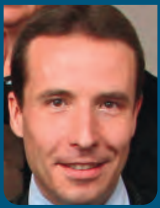
In the context of the European project AMICE, a basin-wide approach has been developed for flood risk analysis. As the focus of the project was primarily on impact analysis of climate change, transnational climate scenarios were derived for two time horizons (2050 and 2100) and, by means of hydrological modelling, they were translated into hydrological scenarios (Dewals et al. 2013). From this early stage of the research, the main stakeholders (e.g., water authorities) were involved and shared their views on the modelling approach.

> **"Liege shows a significant flood risk for the time horizon 2100"**

Next, existing models were coupled to perform the first coordinated hydraulic modelling from the headwaters to the mouth of the river Meuse. Compared to the development of a new basin-wide harmonized hydraulic model, this approach lead to a higher acceptance by the water authorities, as the results rely on tools they have been familiar with for many years. For a "wet" climate scenario, the computations revealed increases in flood levels significantly

Monsin dam downstream of Liege during floods in February 2002





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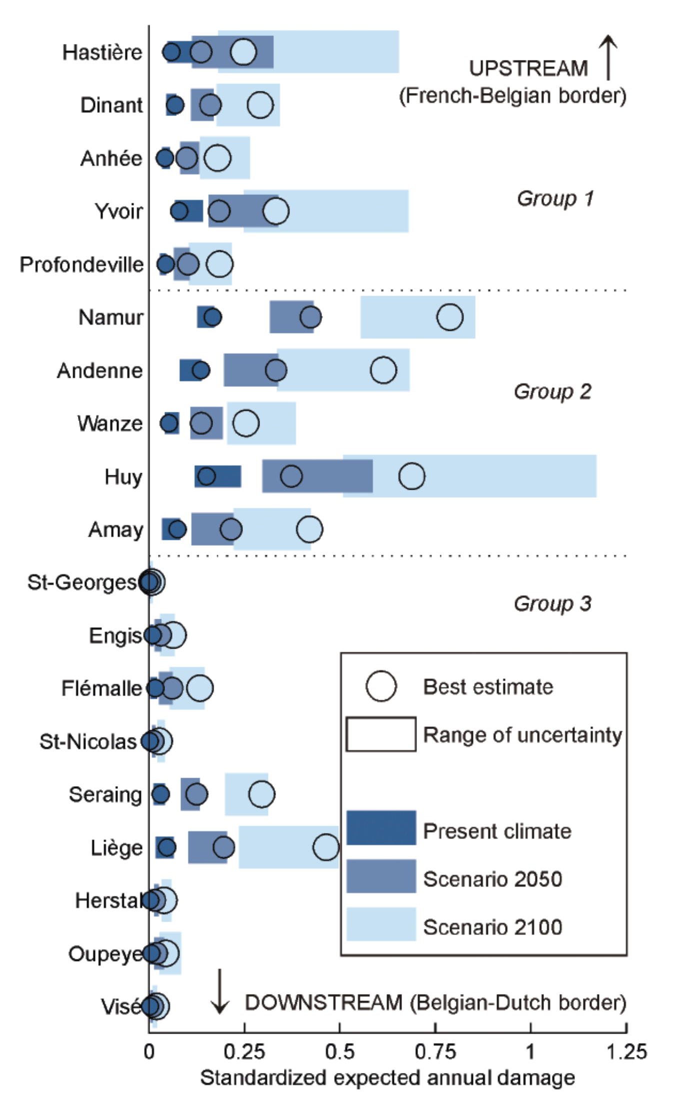


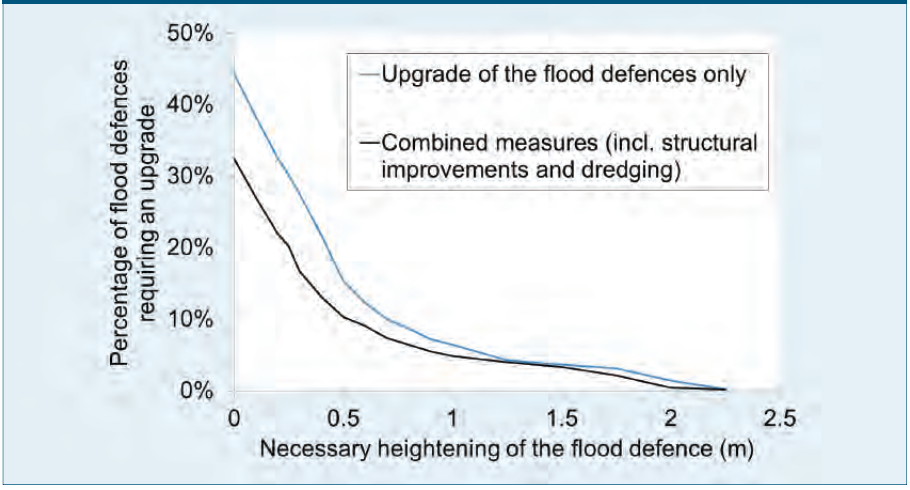
Figure 1 - Expected annual damage per municipality along the river Meuse in Belgium for the "wet" climate scenario. Values at the municipality level were standardized with respect to the total damage in the present climate. Adapted from Detrembleur et al. (2015)

higher in the central part of the Meuse basin compared to the upper and lower parts. This results from the narrower shape of the valley as the river crosses the Ardennes massif close to the French-Belgian border and in most of the Belgian part of the Meuse.

The hydraulic modelling results were subsequently used for damage estimation and computation of flood risk (e.g., Ernst et al., 2010). The distribution of flood risk across all the municipalities along the river Meuse in Belgium is displayed in Figure 1 (Detrembleur et al. 2015). Flood risk is generally higher in the upstream municipalities (groups 1 and 2), in which the protection levels are relatively lower and inundations are more frequent. Nonetheless, Liege shows a significant flood risk for the time horizon 2100 ("wet" climate scenario), due to (i) the high values of future flood discharges (about 30 % higher than in the present climate) and (ii) the very high water depths in the floodplains in case of flood protections overtopping, as a result of mining subsidence.

Flood risk analysis is inherently affected by a substantial level of uncertainty. A distributed uncertainty analysis conducted at the level of the municipalities along the Meuse reveals that both the magnitude of the uncertainty and its main origin vary significantly in space and in time (Figure 1). In most locations, damage estimation and flood frequency analysis were the main sources of uncertainty, while inundation modelling contributed less to the overall uncertainty (Detrembleur et al. 2015). Different adaptation measures were analysed for flood risk management in the city of Liege. An adaptation of the existing flood defences appears technically feasible to preserve the current protection standard of the city under the future "wet" climate projected for 2100. Indeed, only 45 % of the defences need some upgrade, among which only 10 % require a heightening exceeding 70 cm (Figure 2). Dredging of the main riverbed and structural improvements to increase the hydraulic efficiency of Monsin dam (see photograph) constitute useful complementary measures but are not sufficient on their own to protect the city of Liege (Figure 2). Computations also showed that dynamic storage upstream of the city is not a realistic option as the storage capacity of the floodplains is far too low. Similarly, large dams situated further upstream in the basin were shown to have a vanishing effect in Liege (Bruwier et al. 2015). Spatial planning may also play a vital role in reducing flood risk, but mostly in less densely urbanized municipalities, in which new developments may account for up to one half of the estimated future flood damage (Beckers et al. 2013).

Figure 2 - Portion of the overall flood defences in Liege which require an upgrade exceeding a given heightening to preserve the current protection standard of the city under the future "wet" climate



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