European Commission

Climate change, river flooding and adaptation

Global warming and continued development in flood prone areas will progressively increase river flood risk in the future. Without climate mitigation and adaptation, direct damage from flooding could increase 6-fold from present by 2100. Mitigation can significantly reduce the impacts, which can be reduced even further with adequate adaptation strategies. In particular, reducing flood peaks using retention areas and implementing building-based damage reduction measures can lower impacts in a cost-efficient way in most EU countries. Restoring natural wetlands and floodplains to retain excess water also improves the state of water and ecosystems.

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Current effects of river flooding

River flooding is one of the costliest natural disasters in the EU+UK. River flooding currently causes damage of 7.8 €billion/year in the EU+UK. More than 170,000 people every year are exposed to river flooding.

		2100 - no adaptation			2100 - adaptation		
	Today	1.5°C	2°C	3°C	1.5°C	2°C	3°C
Damage (€ billion/year)	7.8	24	33	48	8.6	9.6	8.6
People exposed (1000/year)	172	252	338	482	92	100	90

Figure 1. Annual flood damage and population exposed to river flooding for EU+UK in the present and by 2100 for different levels of global warming, with and without adaptation respectively. The “no adaptation” scenario refers to present-day flood protection measures. The “adaptation” scenario is based on the implementation of retention areas to store excess flood water to a level of protection that maximises their economic benefit.

Future impacts of river flooding without adaptation

Global warming will progressively increase flood frequency and severity in most of Europe. At the same time, projected social and economic growth will further increase exposure to flood events. If no mitigation and adaptation measures are taken, economic losses will grow to nearly 50 €billion/year with 3°C global warming by 2100, or more than 6 times compared to present, while nearly 3 times as many people would be exposed to flooding. Limiting global warming to 1.5°C would halve the economic losses and population exposure to river flooding relative to unmitigated climate change (Figure 1).

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KEY MESSAGES

Mitigation and adaptation can significantly lower river flooding impacts

Economic losses to the EU+UK from river flooding will grow from around 8 €billion/year to nearly 50 €billion/year by 2100 without mitigation and adaptation. The population exposed annually to flooding will increase from around 170,000 to 480,000.

Mitigation halves both the losses and the exposed population.

Mitigation plus adaptation reduces the impacts further, to near present-day levels for economic losses, and below present-day levels for population exposure.

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About PESETA IV

The JRC PESETA IV project aims to better understand the biophysical and economic consequences of climate change. It does this by using projections of climate change for Europe from several climate models along with a set of climate change impact models. The project covers several sectors that are relevant to society and the natural environment, such as freshwater, agriculture, and coasts.

ec.europa.eu/jrc/en/peseta-iv

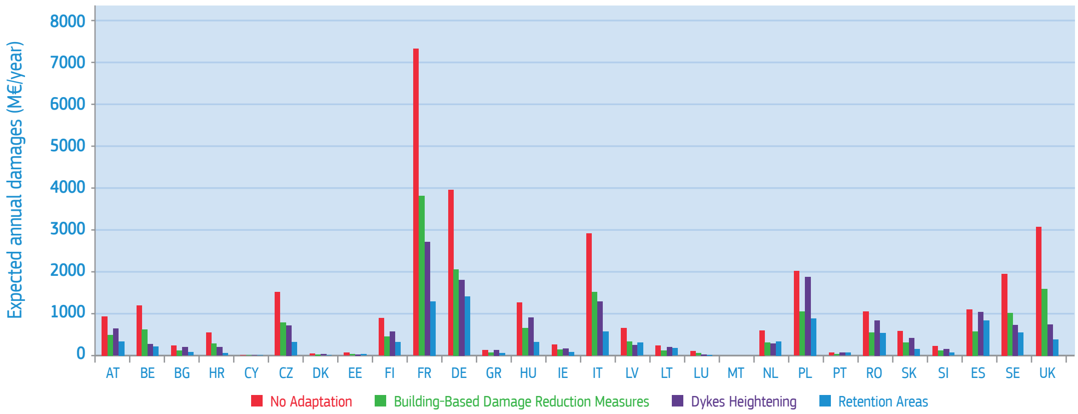

Figure 2. Comparison of expected annual damage in 2100 assuming no adaptation, and with the implementation of three different adaptation strategies. Results are calculated assuming a 2°C warming scenario.

Avoided impacts with adaptation

Adequate flood risk reduction strategies can substantially reduce the projected increase in flood risk with global warming. In particular, cost-benefit analysis shows that reducing flood peaks using retention areas has great potential to lower impacts in a cost-efficient way in most EU countries (Figure 2). Implementing this strategy at the EU level can reduce the economic damage and population exposed by 2100 by more than 70% compared to no adaptation (Figure 1). Retention areas have additional benefits, such as restoring the natural functioning of floodplain areas and improving ecosystem quality.

Strengthening existing dyke systems has lower but still favourable benefit-cost ratios (Figure 3), although this can transfer risk downstream. It also tends to stimulate further development behind flood barriers, which can result in catastrophic impacts in the case of failure. Building-based flood proofing measures can also significantly reduce flood damage, typically with limited implementation investments, but they do not prevent floods from happening and therefore can only partially avoid flood damage. Relocation is the least cost-effective adaptation measure as their implementation costs are subject to large variability and they may be less socially acceptable.

Strengthening of dyke systems
2€ to 2.9€ saved for each € invested
41% to 68% reduction in economic damage
41% to 65% reduction in population exposed

Building of retention areas to store flood water
2.9€ to 3.5€ saved for each € invested
64% to 82% reduction in economic damage
63% to 81% reduction in population exposed

Damage reduction measures for buildings
5.2€ saved for each € invested
Up to 50% reduction in economic damage
No reduction in population exposed

Relocation to flood-safe areas
1.2€ saved for each € invested
17% reduction in economic damage
16% reduction in population exposed

Figure 3. Cost-benefit analysis of four adaptation strategies considered in PESETA IV. Results are averaged at the EU level and calculated considering future socioeconomic conditions (2100) under 1.5°C, 2°C and 3°C warming scenarios.

Approach

Contact information: Francesco Dottori, JRC Disaster Risk Management Unit.

PESETA IV simulated river flows using the LISFLOOD hydrological model, analysed the occurrence and intensity of flooding processes, and estimated the impacts on economy and people across Europe. Future climate scenarios corresponding to an increase in global average temperature of 1.5°C, 2°C and 3°C above preindustrial temperature were combined with socioeconomic projections according to the ECFIN 2015 Ageing Report.

Four possible adaptation measures were considered in the analysis: strengthening of existing dyke systems, implementing flood damage reduction measures for buildings, building of retention areas to store flood waters, and relocation of people and buildings from flood-prone to flood-safe areas. Each measure was considered independently. However, a combination of different measures working in synergy, and optimised at the level of river basins, is the best strategy to locally maximise benefits and minimise drawbacks of each measure.

The evaluation of each adaptation strategy was achieved using a cost-benefit analysis that optimises the overall costs of implementation and avoided economic damage over the lifetime of the measure (up to 2100). The costs were calculated as the sum of capital investment costs to implement the measure and maintenance costs. The benefits are the damage avoided by implementing the measure, calculated as the difference between future damage with and without adaptation respectively. The analysis facilitates comparison of costs and effectiveness of river flood adaptation measures under future scenarios but it is not designed to replace detailed analyses at local and regional scale, which are necessary for an effective and reliable design and implementation of adaptation measures.

Flood losses, costs and benefits are presented undiscounted in general, but in the cost-benefit analysis of adaptation, the future costs and benefits were discounted. The benefit-to-cost ratio, which is the ratio of total benefits to total costs, is also based on discounted values. The cost-benefit analysis does not include social, environmental and cultural aspects.

For all PESETA IV publications - https://ec.europa.eu/jrc/en/peseta-iv