Appraising projects - An application to inland and coastal flood risk management

Key Messages

- Adaptation to climate change receives little if any attention during the phase of planning and appraisal of investments into infrastructure at the Member State and European level. Recently, efforts have been made to assist project planners with incorporating considerations of adaptation into their workflow, but no guidelines yet address adaptation projects in their own right.
- The sensitivity analysis in the Prague case study showed that the critical factor in the Cost-benefit assessment is the selection of a discount rate. Discount rates in the range up to 3% still enable that the adaptation option generates positive Net Present Value. However, if discount rate is set at 4% and above, the project is no longer efficient.
- In Bilbao, the use of several economic measures of uncertainties in infrastructure investments (i.e. expected damages through stochastic modelling, value at risk and expected shortfall and real-option analysis) provided different types of information to decision-making. The main advantage of the methodologies presented is the capacity to consider and integrate multiple sources of uncertainties in the assessment, to inform not only decision on whether or not to invest, but also on the optimal timing for investment.

Introduction

The following presents an illustration of the application of the policy-led framework to inland flood protection for the city of Prague (Czech Republic), and and to coastal flood protection in Bilbao (Spain). The application of the policy-led framework focuses on the use of climate information with risk data to prioritise adaptation options and the treatment of uncertainties.

Define the adaptation problem

The Czech study carried out an ex-post appraisal of adaptation of flood risk protection built from 1999 to 2014, for which the corresponding investments and social benefits were included in a cost-benefit analysis. The Spanish study carried out an appraisal of an infrastructural measure that is currently planned, which consists in the conversion of an urban peninsula into an island, so as to reduce flood risk from the combination of river and coastal flooding.

Assessing the context and materiality

The step consisted in synthesising knowledge on the geo-morphological and hydrographic features, the climate, and the hazard proneness of the cases' area. The boundaries of the cases were defined, identifying which people and activities are exposed to climate-related risk.

The Czech case study focused on Prague, located in the Lower Vltava river basin district, one of two river basin districts in the Vltava river basin that are both managed by the Povodí Vltavy, state enterprise. Prague is the absolutely dominant economic unit in the river basin, and the floodplain area encompasses residential areas as well as several important industrial areas, recreational zones such as urban parks and also agricultural areas in the south of Prague.

The Spanish case study focused on an district of Bilbao, situated in a flood prone area of the estuary. The area had been shaped by the requirements of the manufacturing industry accompanied by a fast growing population in the mid 20th century.

Climate and risk information

In the Prague case, different combinations of compatible climate and socio-economic scenarios were selected. Climate data were included from a wide range of climate models, and thus adequately sampled the inter-model uncertainty. For the Bilbao case, results of only one climate model were used, after ensuring that the dataset was representative of the multiple models' ensemble mean.

Furthermore, in the Prague case, conditions were however only simulated at present and at the end of the century. Simulating multiple future time slices greatly improves the appraisal of future benefits of adaptation, but requires more computational power. In Bilbao, the study makes use of climate forcing data from the downscaling of a suite of state-of-the-art Regional Climate Models. New definitions of flood hazard probabilities were created under the new IPCC emission scenarios, RCPs 4.5 and 8.5.

For both cases flood maps for floods of multiple return periods were produced, which allowed addressing floods as stochastic events. For the Prague case, simplified relationships and data interpolation were used to obtain flood extents from maximum precipitation. Exposure datasets were intersected with flood maps, using vulnerability curves. Country-specific vulnerability curves (i.e., depth-damage curves) were applied.

In the Bilbao case, floods of different magnitude were treated as discrete possibilities, thus likely underestimating the expected annual damage resulting from their joint probabilities. Exposure datasets were obtained using land use maps, which were retrieved with very high spatial detail. The following factors were considered: population, economic activity, and areas of environmental interest potentially affected. Impacts included also intangible and non-monetary metrics, such as health, and disruption of traffic.

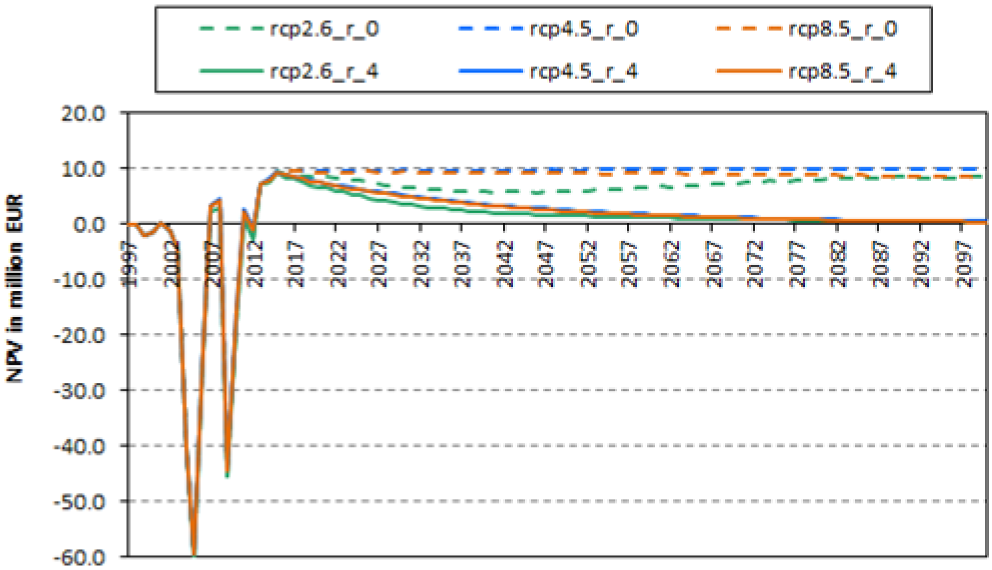
Option identification, sequencing and prioritisation

In the Prague case, adaptation measures to increased inland flood risk consisted of line measures (e.g. fixed anti-flood earth dikes, reinforced concrete walls, mobile barriers) and barriers in the wastewater system (e.g. backflow preventers). In the Bilbao case study, the main adaptation measure to coastal flooding was the opening of the Deusto channel, turning the area under examination from a peninsula to an island. An additional measure to be implemented in Zorrotzaurre is the elevation of the urban area developed along the Deusto channel.

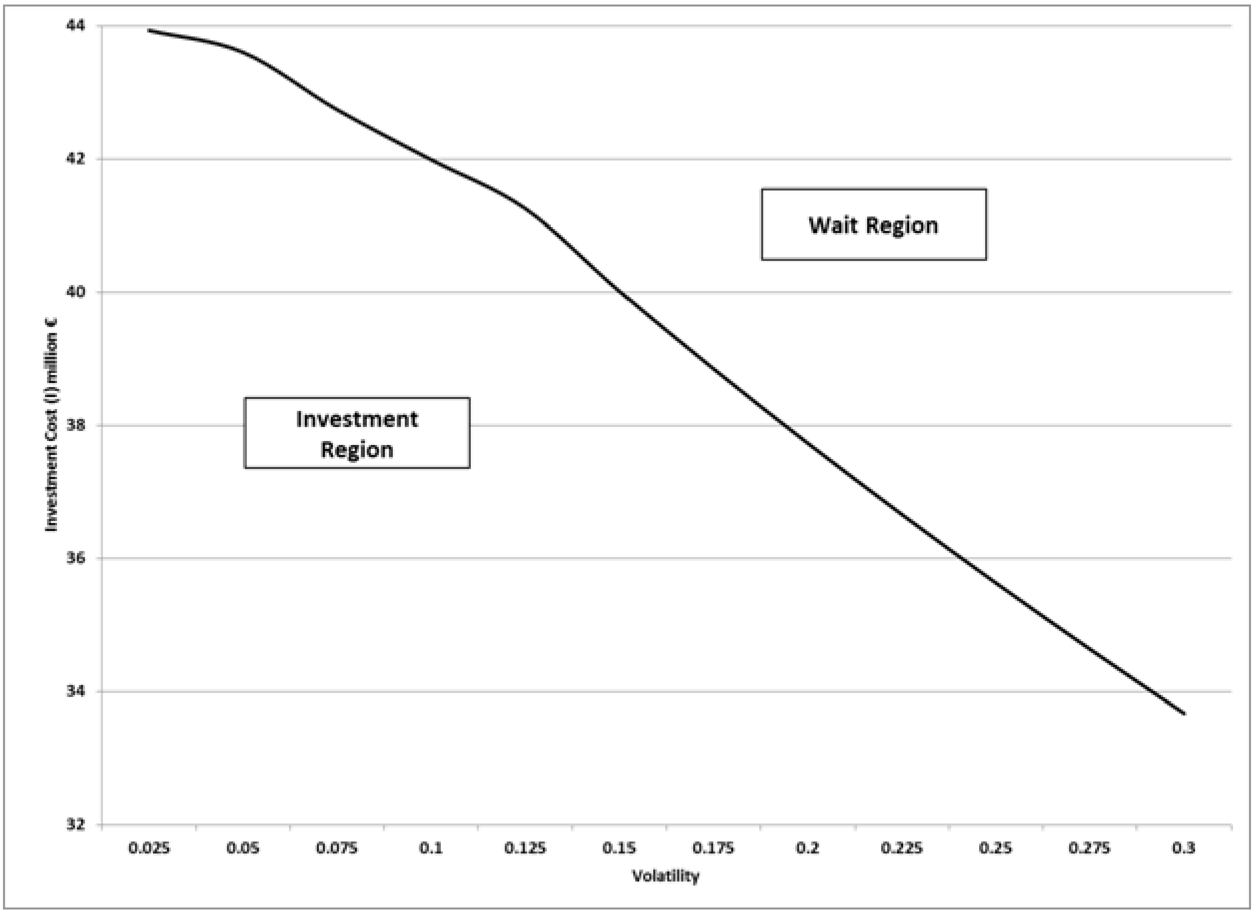
Two methodologies were applied in the economic appraisal:

- For the Prague case study, cost-benefit analysis was used, implemented with an extensive sensitivity analysis: on climate scenarios and model-uncertainty, economic growth, discount rates, infrastructure cost variables and depth-damage functions;
- For the Bilbao case study, three approaches were combined: stochastic modelling, estimation of two risk measures (Value-at-Risk and Expected Shortfall) and real-option analysis. The Value-a--Risk (VaR) is a standard measurement and well recognised by international financial regulatory bodies. The VaR of damage resulting from river flooding in the case study expressed the losses that could occur with a given confidence level α of 95%, for a time interval of 85 years. Expected Shortfall, ES, represented the average damage of the 5% worst cases. ES is, therefore, a better measure of risk for low probability but high damage events.

The graph below displays the annual ENPV of flood protection measures in Prague according to different climate conditions (represented by RCP scenarios) and discount rates. The dashed lines represent a discount rate of 0%, while the solid lines are discounted at 4%. The average value of ENPV for all RCP scenarios is € 626 million, if we assume 0% discount rate. The differentiation between RCPs will have a moderate impact on ENPV, the RCP2.6 scenario will decrease the value by 30%, RCP4.5 will increase ENPV by 6% and RCP8.5 decreases by 4%. The investments are thus efficient across scenarios of changing future climate. However, when considering 4% discount rate, then the effect of RCPs on ENPV is larger, the change is -107%, 14% and -7% for RCP2.6, RCP4.5 and RCP8.5, respectively. Using a discount rate above 4% meant that the project was not longer efficient.



In Bilbao, results showed a range of 266-330 M€ for VaR (95%) and 371-445 M€ for ES (95%) in the baseline. The opening of the canal is expected to reduce not only the expected damage but also the level of risk, that is, the damages that would occur in the worst 5% of the cases. Average expected damages would be reduced by 41 to 58 M€, while ES decreases with the opening of the canal by 174-205 M€ during the period under assessment. The final step was to evaluate the economic impact of different investment timing using real-option analysis. The figure shows the results that determine the boundary value of investment cost between the “investment region” and the “wait region” for a limited time period. The graph shows that the greater the volatility, and therefore in uncertainty, reduces the investment boundary. In other words, greater volatility makes potential investors more demanding and they invest only when the cost is lower.



Econadapt insights

Appraisal of adaptation to river flood at the Vltava river, Prague

Appraisal of adaptation to river and coastal flood in Bilbao

Treatment of future learning: Acceptable Risks Analysis

Treatment of future learning: Real Options Analysis

Uncertainties and causes of uncertainties in climate change adaptation

Uncertainties and risk analysis in climate change adaption

Sourcing and using climate information for economic assessments of adaptation