Summary

Climate Change is considered the major present and future threat to the stability of cities, especially through the increase of related impacts. Out of all natural disasters, those related to hydrometeorological phenomena (e.g., coastal and pluvial-floods, storm surges, hurricanes/typhoons) have shown the fastest rate of increase in their frequency and intensity. Additionally, on a global level, flood events are the costliest natural hazards.

Changes in precipitation patterns and high levels of surface imperviousness result in increased runoff production in urban areas, increasing their sensitivity to flooding events. Particularly, coastal cities are facing significant compound floodings due to simultaneous rainfall runoff, storm surge and sea-level rise, all of which cause vast socio-economic and ecological impacts.

Various national and international climate change frameworks exist; however, these are vague, and have no practical effects on spatial planning tools. An urban climate adaptation strategy should address and include socioeconomic aspects in addition to the environmental ones to be effective and achieve benefits for all stakeholders. The concept of Nature-based Solutions (NBS) comes as the alternative that can act at several levels, being more than just an aesthetical improvement. NBS are considered the new planning tools for overcoming the boundaries of traditional ‘predict and prevent’ approaches, while playing a crucial role in addressing societal challenges and providing benefits through the supply of Ecosystem Services (ES). In this view, NBS impact simulation is considered a good practice to increase awareness about the solutions’ multiple co-benefits. Raising the willingness to accept NBS can be done by creating evidence on their effectiveness at an urban level. However, combining the benefits and costs of such solutions in thorough studies is challenging.

The objective of this research is to develop and utilize a spatial assessment framework to estimate the NBS impacts under climate scenarios. The intent of this to comprehensively evaluate the biophysical and economic effects of NBS, by estimating costs and benefits, in mitigating pluvial flood risk. This research is developed in two parts: first a flood risk assessment is conducted to assess the biophysical flood-mitigation performance of NBS in urban areas, then, a value transfer method is used to assess NBS implementation costs and flood mitigation benefits, resulting in a partial cost-benefit analysis (CBA) aimed at evaluating the economic impacts of such solutions. To achieve this, modelling tools (InVEST Urban Flood Risk Mitigation model) and economic valuation methods (value transfer methods) are employed; corresponding results are then combined and analysed using Geographic Information Systems (GIS). This theoretical framework is applied to the study of two Euro-pean coastal cities, namely the city of Aveiro (Portugal) and the city of Rapallo (Italy). NBS scenarios of green roofs and bioswales under current and future (mid-term) climate conditions are assessed and compared.

The main findings of this research show that green roofs scenarios generate economic benefits that offset between 32% (for Aveiro) and 65% (for Rapallo) of total flood damage expenses every year. On the other hand, when simulating bioswales scenarios, the difference between the two case study applications is smaller, with a 0.1% for Aveiro and 0.3% for Rapallo. Out of the two scenarios considered, results show that green roofs have the best performance. Furthermore, for both NBS scenarios, the economic performance improves under lower return period events, while the biophysical-economic performance is more promising under more extreme climate scenarios when compared to current climate. These results hold true when considering lower/higher NBS

implementation and maintenance costs, as well as when applying positive discount rates (sensitivity analysis).

These findings are highly valuable as input for the development of nature-based flood risk adaptation strategies in a context of changing climate. The perception of NBS benefits can be improved if other co-benefits of these solutions are considered. Indeed, the results of this study can be used to inform decision makers in the design of new policies to improve resilience to flooding events from both a biophysical and economic perspective. Thus, by estimating impacts, costs and benefits of NBS, this research shows the important role of quantitative assessments of ES to support climate change adaptation planning.