

Editorial

# Integrated Assessment of Climate Change Impacts and Urban Resilience: From Climate and Hydrological Hazards to Risk Analysis and Measures

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**Abstract:** This Special Issue brings together recent research findings related to urban resilience, in particular taking into account climate change impacts and hydrological hazards. Taking advantage of the work done in the H2020 RESCCUE project, 12 different papers dealing with several issues related to the resilience of urban areas have been published. Due to the complexity of cities, urban resilience management is one of the key challenges that our societies have to deal with in the near future. In addition, urban resilience is a transversal and multi-sectorial issue, affecting different urban services, several hazards, and all the steps of the risk management cycle. This is precisely why the papers contained in this Special Issue focus on varied subjects, such as impact assessments, urban resilience assessments, adaptation strategies, flood risk and urban services, always focusing on at least two of these topics.

**Keywords:** urban resilience; climate change; impact assessment; adaptation strategies; urban services

## 1. Introduction

We live in a world of cities, and that trend will continue in the future. Today, 54% of the world's population lives in urban areas, a proportion that is expected to increase to 66% by 2050 [1]. In addition, climate change is adding pressures and uncertainties that pose challenges to society, economy, and environment. In this case, focusing on the impacts to urban areas [2], climate change can affect basic urban services, such as water or energy supply, making the continuously functioning city capacity crucial for most parts of the world population. As the United Nations have stated, managing urban areas has become one of the most important development challenges of the 21st century [1].

According to UN-Habitat [3], urban resilience refers to the ability of human settlements to withstand and to recover quickly from any plausible hazards. Resilience against shocks and stresses not only refers to reducing risks and damage from disasters (i.e., loss of lives and assets), but also the ability to quickly bounce back to a stable state; the ability to adapt and transform towards sustainability. While typical risk reduction measures tend to focus on a specific hazard, leaving out risks and vulnerabilities due to other types of perils, resilience adopts a multiple hazards approach, considering all types of plausible climate-related threats.

Cities face a growing range of adversities and challenges in the 21st century, and increasing urban resilience is the only way to survive and adapt to the coming shocks and stresses that may occur [4]. Due to climate change, critical disruptions occur too often in cities around the world. On the other hand, urban areas are complex systems that cannot be understood by sectorial and disciplinary approaches alone [5]. In this context, the RESCCUE (RESilience to cope with Climate Change in Urban arEas—a multisectorial approach focusing on water) project aims to assess current and future resilience (related to future climate change scenarios) through a multisectorial approach, taking water sector as the focus. Climatic drivers and pressures affecting the urban water cycle, such as droughts or heavy rains, can produce critical direct impacts on strategic urban services (water supply, wastewater and stormwater drainage, wastewater treatment, solid waste, telecommunication, energy supply, transport, etc.), and cause cascading collateral impacts on other services. Given the interdependencies existent between the several city services, RESCCUE focuses on the cascading failures that involve several urban functions [6].

## 2. The RESCCUE Project

The RESCCUE project ([www.resccue.eu](http://www.resccue.eu)) aims to help cities around the world to become more resilient to physical, social, and economic challenges [7]. During the last four years, RESCCUE has generated models and tools to bring this objective to practice, make these tools available to be deployed to different types of cities, with different climate change pressures. RESCCUE has also supported cities preparing their resilience action plans (RAP) by developing guidance materials and plan templates. The consortium is led by Aquatec—SUEZ Advanced Solutions, and consists of a total of 17 partners with the three city councils of the research sites (Barcelona, Bristol and Lisbon), the United Nations agency UN-Habitat, several urban services companies, research centers, universities and SMEs (small and medium enterprises), all of them with a key role on resilience management in the three research sites.

### 2.1. RESCCUE Goals

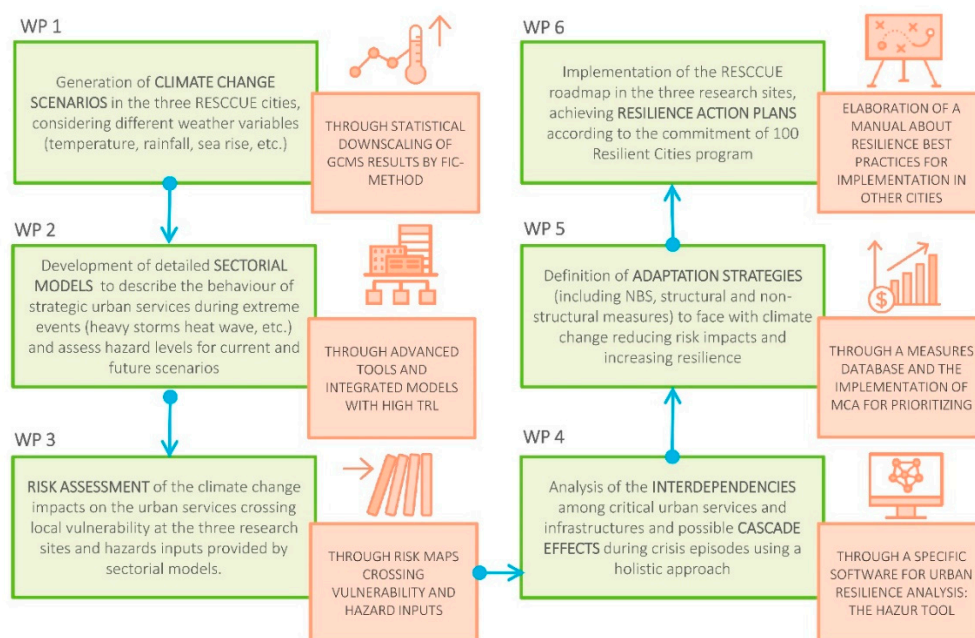
The main goal of RESCCUE is to help cities around the world to become more resilient. To achieve this overall goal, a set of specific objectives are pursued, including:

1. Compilation, generation, and analysis of different local climate simulations to set up future climate-related scenarios in a coherent way and suitable for users' needs.
2. Improve the understanding of the effects of selected climatic drivers on the urban water cycle in each research site, and identify vulnerabilities of each urban service that will lead to increased social security.
3. Assess the direct impacts of these drivers on all the urban services and the cascade collateral impacts on the ones connected to them for the current situation and future climate change scenarios. The impacts will be assessed in terms of hazard and risk for each analyzed urban service, for the whole set of selected scenarios at each research site.
4. Develop a methodology to assess urban resilience with respect to different climatic pressures, based on the interaction among different urban services. In addition, the improvements related to the operational performance of urban systems will be evaluated, as the urban resilience framework generated will be designed to be adapted to the operational platforms currently in use by urban operators.
5. Explore and assess the economic and societal impacts of multiple feasible mitigation and adaptation measures and technologies to reduce climate change effects on the urban services and their collateral impacts. Based on the impacts evaluated on key urban services and on the needs of end users enrolled in the RESCCUE project, an inventory of the most appropriate mitigation and adaptation options with a special focus on nature-based solutions will be established. The result will constitute a portfolio of validated and prioritized improving resilience strategies, based on

- multi-criteria analysis, integrating technological and non-technological alternatives, to better cope with challenges raised by climate change.
- Elaborate a RAP for each of the case study cities, considering the inputs of all local partners and stakeholders of each site, and led by the three involved local resilience offices. The civil protection and emergency sectorial plans will be analyzed to improve coordination during shocks and stresses, as these plans can benefit from RAPs inputs and vice versa.
  - Build a shared awareness and perception of challenges and opportunities, to guide actions and future collaborative approaches, by engaging leading universities and research centers, local governments, large companies, SMEs, non-governmental organizations and citizens from the three research sites.

## 2.2. RESCCUE Methodology

The RESCCUE project is being implemented through a set of eight WPs (work packages) described below (WP1 to WP6 is where the technical work is focused, whereas WP7 deals with communication and exploitation and WP8 is related to project management). Figure 1 depicts the project structure adopted by RESCCUE, specifying the relations among WPs and the main outputs.



**Figure 1.** Resilience to Cope with Climate Change in Urban Areas (RESCCUE) Project structure and technical details. Source: [7].

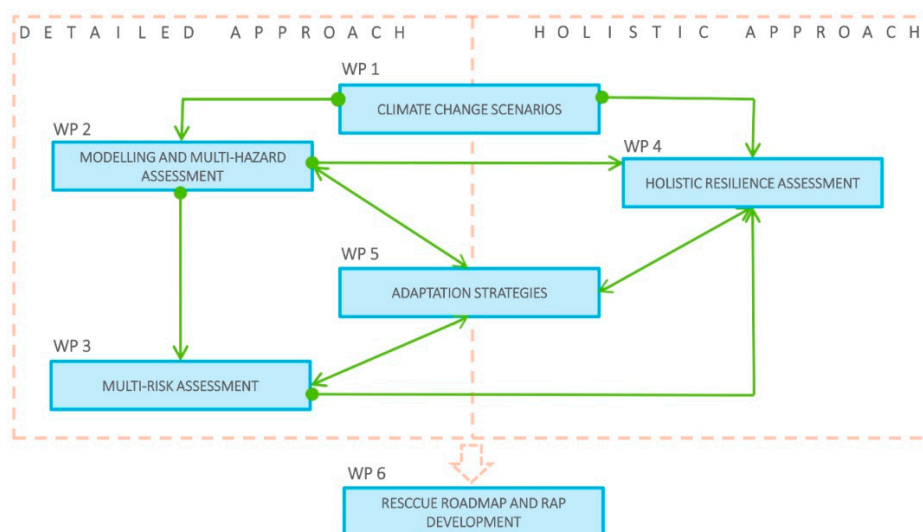
The use of detailed models and software tools is essential to analyze the behavior and the response of strategic services and critical infrastructures with respect to specific pressures and drivers related to climate change. Moreover, the outputs of these sectorial models will be used to assess hazard, vulnerability, and risk levels for current and future scenarios, where a large set of measures and strategies will be simulated and evaluated in terms of impacts reduction.

Once the detailed knowledge of each urban service has been acquired through available data, past experiences, and simulation results, then the interdependencies between them and the cascade effects due to failures or extreme climate events can be studied. Within RESCCUE, this is done with two different approaches characterized by a different level of detail (Figure 2):

- Detailed approach: advanced models and tools to describe specific cascading effects produced by extreme climate events on several urban services are developed. Then, the analysis of certain impact events could be achieved via the use of loosely coupled models and tools (integrated

models), using the outputs of one as inputs of the other, being able to simulate cascading effects in a detailed but simple way. In this case, adaptation strategies and measures will be proposed and prioritized based on hazard and risk reduction but, also, through multi-criteria analysis, providing an overview of other kinds of co-benefits

- Holistic approach: using a methodology for holistic resilience assessment, the relations and the cascading effects among the different urban services can be analyzed. In this case, adaptation measures and strategies will be focused on the recovery of the normal functioning of the city and, specifically, of its strategic urban services and infrastructures. This concept will be expressed by the concept of recovery time and the efficiency of the measures and strategies, in terms of decrease of recovery.



**Figure 2.** Summary of RESCCUE framework. Source: [7].

With the detailed approach, the analysis of hazard and risk produced by complex interactions and cascade effects involving different urban sectors is done. Then, as not all sectorial models are studied in detail and coupled with others, the whole spectrum of interdependencies and cascading effects is then covered by the holistic approach with a minor level of detail.

The two approaches presented before, coexist in the several different work packages studied in the RESCCUE project. Whereas some tasks are only part of the detailed approach, some others only focus on the holistic one, while there are a few that belong to both, linking the two and allowing to combine them.

The combination of both approaches allows to understand the functioning of the city as a whole, while focusing on some very detailed impacts that are crucial to understand how the several city services affect each other.

By having this detailed–holistic approach, the RESCCUE project has been able to deliver a very useful resilience roadmap for the cities in the form of a RAP, where the strategic lines in which the city must focus are also fed with concrete measures that will be applied to solve specific problems.

### 3. Special Issue

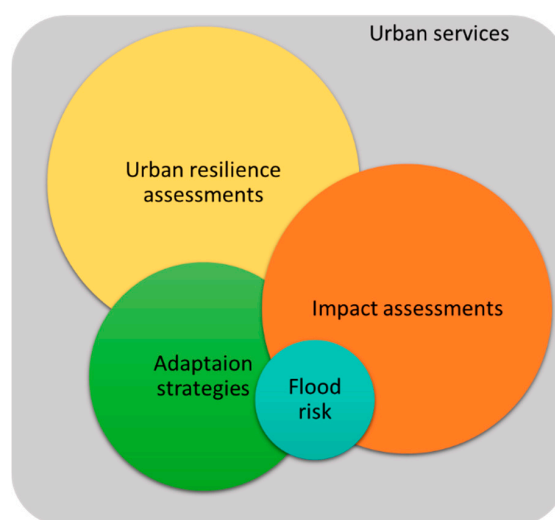
During the four years that the RESCCUE project has lasted, many outputs have been produced related to urban resilience. Obviously, during the first years of the project, the main results generated were related to climate change scenarios and modelling of climatic variables [8–10], hazard assessment for several specific urban services [11,12], impact assessment methodologies and implementations to specific sectors [13–15], and the preparation of the resilience assessment framework to be used in the project [16,17].

As the project advanced, some of the initial WPs finished, and thus, right now there are no new results related to climate change scenarios, for example. This is precisely why the current Special Issue has been mainly dealing with the topics of impact assessments, urban resilience assessments, adaptation strategies, flood risk and urban services.

Due to the complexity of cities, urban resilience is a transversal and multi-sectorial issue, affecting different urban services, several hazards and all the steps of the risk management cycle. This is precisely why the topics contained in this Special Issue overlap (Figure 3), which is why all the papers presented deal with at least two of these topics (Table 1).

**Table 1.** List of the papers published in this Special Issue, classified by the several topics addressed in them.

Title of the Paper	Flood Risk	Adaptation Strategies	Urban Resilience Assessments	Urban Services	Impact Assessment
Assessment of Urban Flood Resilience in Barcelona for Current and Future Scenarios. The RESCCUE Project	X		X		X
Flood Risk Assessment in an Underground Railway System under the Impact of Climate Change—A Case Study of the Barcelona Metro	X			X	X
Methodology to Prioritize Climate Adaptation Measures in Urban Areas. Barcelona and Bristol Case Studies		X			X
Socio-Economic Assessment of Green Infrastructure for Climate Change Adaptation in the Context of Urban Drainage Planning	X	X			
Interlinking Bristol Based Models to Build Resilience to Climate Change	X			X	X
Flood Depth-Damage Curves for Spanish Urban Areas	X				X
The Contribution of NBS to Urban Resilience in Stormwater Management and Control: A Framework with Stakeholder Validation	X	X			
RAF Resilience Assessment Framework—A Tool to Support Cities' Action Planning			X		
Investigating the Effects of Pluvial Flooding and Climate Change on Traffic Flows in Barcelona and Bristol	X			X	X
Urban Resilience to Flooding: Triangulation of Methods for Hazard Identification in Urban Areas	X	X			
Climate Change Implications for Water Availability: A Case Study of Barcelona City				X	X
Electrical Grid Risk Assessment Against Flooding in Barcelona and Bristol Cities	X				X



**Figure 3.** Main topics analyzed in the papers of this Special Issue.

#### 4. RESCCUE Toolkit

Throughout the project's lifetime, RESCCUE has placed much effort on dissemination tasks, aiming at allowing general and specialized audiences to access information about the project progress and its outcomes, as well as promoting the widest application of the RESCCUE outcomes in other cities.

In this regard, in addition to the scientific production generated by the project partners, such as this Special Issue, RESCCUE has also developed the RESCCUE toolkit, an interactive space where the main project's results are gathered, along with a set of guidelines outlining the steps to be taken to make your city resilient. In there, all the tools, datasets and methodologies developed within RESCCUE can be found, sorted by topic and by the three case studies: Barcelona, Lisbon and Bristol.

#### 5. Final Remarks from the RESCCUE Coordinator: Marc Velasco

During the last four years, the RESCCUE project has been my life. For quite a long time, I have been repeating over and over one of the mottos of the project: cities are complex systems of interconnected systems. The RESCCUE consortium, with a varied canvas of partners from different worlds, has been exactly like a city, a complex system of interconnected entities. Managing this has been a challenging but very satisfying task, as we jointly managed to overcome all the problems that appeared along the way.

As you will see while reading this Special Issue, RESCCUE has been a challenging and successful project, that has only been possible due to the hard work of all people involved. I would like to take this opportunity to acknowledge the work and support from all my colleagues who worked in the project. RESCCUE project has been quite a journey for all of us, and I hope that it can also become something special to you.

Along the 4 years of the project, we have learnt that the only way to make our cities stronger and more prepared is by working together in a holistic and transversal way. This is why I would like to tell decision makers and urban service operators that you are not alone in this. Therefore, take advantage of all the work that we have done, so you do not have to start from square one. If you have not done it yet, now is the time to check the RESCCUE Toolkit, where you will be able to find the key RESCCUE results to replicate the work in your city.

What we have started in RESCCUE is only the beginning. Now it is time to pass on the baton, so you can move forward to transform your city to be more and more prepared for the coming challenges.

**Author Contributions:** M.V., has been the Coordinator of the RESCCUE Project and the main contributor to this Editorial. B.R. and E.M.-G., Work Package leaders of RESCCUE and editors of this Special Issue, have mainly contributed to Section 3 of this editorial, presenting the work included in this Special Issue. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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