ARCH

Resilience Pathway Handbook
ARCH D.6.4

savingculturalheritage.eu

Advancing Resilience of historic areas against Climate-related and other Hazards

Deliverable D6.4. Work Package WP6
his document has been prepared in the framework of the European project ARCH – Advancing Resilience of historic areas against Climate-related and other Hazards. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 820999.

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Actual submission date: 2023-03-06
Revision: 2.0
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Updates in version 2.0 from March 2023
This second version of the Resilience Pathway Handbook was produced after the final review of the project in November 2022 upon request of the reviewers and it further describes the critical role of heritage and culture in the pathway approach (subsection 1.1.5) and adds explanations and examples to better incorporate the heritage perspective in the different steps of the approach (1.1, 1.2, 1.4, 2.2, 3.1, 3.3...). Finally, it highlights in chapter 4 how heritage values are considered in setting the objectives.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 820999.

About ARCH

ARCH was a European-funded research project (2019-2022) that aimed to better preserve areas of cultural heritage from hazards and risks. The ARCH team, along with the cities of Bratislava, Camerino, Hamburg and Valencia, has co-created tools that will help cities save cultural heritage from the effects of climate change.

The impacts of climate change are global in scope and unprecedented in scale. Cities will face frequent extreme events in future and the risk to cultural heritage and historic urban centres from climate change will also increase.

ARCH has developed an integrated climate change adaptation and disaster risk management framework for assessing and improving the resilience of historic areas to climate change and natural hazards. Tools and methodologies have been designed for local authorities and practitioners, the urban population, and national and international expert communities. The project produced various models, methods, tools and datasets to support decision-making.

To complement these results in line with the project aims, ARCH has also produced the Resilience Pathway Handbook and the Resilience Pathway Visualization Tool (RPVT), a web-based tool to assist on the graphical display of pathways. The Resilience Pathway Handbook has been developed to guide in the pathway approach, and introduce concepts and steps, since this approach is a novel methodology to support planning.

The Resilience Pathway Handbook aims to:

- Introduce the concept of adaptation and pathways and its context
- Address the advances in resilience pathway methodology
- Communicate in an educational way the steps to build resilience pathways with a special focus on historic areas
- Help with the use of the RPVT
- Describe the co-creation activities carried out as part of the ARCH project.

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Table of Abbreviations

Acronym	Explanation
AF	Administrative Functional urban area
BS	British Standard
BMZ	Bundesministerium Für Wirtschaftliche Zusammenarbeit (German Federal Ministry for Economic Development Cooperation)
BCA	Benefit Cost Analysis
BCR	Benefit Cost Ratio
CCA	Climate Change Adaptation
CCI	Canadian Conservation Institute
CEA	Cost effectiveness analysis
DAFNE	Donors and Foundations Networks in Europe
DAP	Dynamic Adaptive Policymaking
DRM	Disaster Risk Management
DTS	Draft Technical Specification
EBRD	European Bank for Reconstruction and Development
ECB	European Central Bank
ECN	EU Crowdfunding Network
EEA	European Environment Agency

EIB	European Investment Bank
GPS	Global Positioning System
HA	Historic Areas
ICCROM	International Centre for the Study of the Preservation and Restoration of Cultural Property
IPCC	The Intergovernmental Panel on Climate Change
ISO	International Standardisation Organization
IVAVIA	Impact and Vulnerability Analysis of Vital Infrastructures and Built-Up Areas
MC(D)A	Multi-Criteria (Decision) Analysis
NbS	Nature Based Solutions
NGO	Non-Governmental Organizations
PET	Physiological Equivalent Temperature
PPP	Public Private Partnerships
RAM	Risk Assessment Module
RMI	Resilience Measure Inventory
RSQ	Risk Systemicity Questionnaire
RPVT	Resilience Pathway Visualization Tool
SECAP	Sustainable Energy and Climate Action Plan
SSDSS	Shelter Strategic Decision Support System
SWOT	Strength Weakness Opportunities Threats
TRL	Technology Readiness Level
UNESCO	United Nations Educational, Scientific and Cultural Organization

01 Introduction

1.1 About this Handbook

1.1.1 What are Resilience Pathways?

A Resilience Pathway is a decision-making strategy closely related to urban planning, that addresses both slow-onset climate change and natural disaster risk management and displays a sequence of potential resilience-boosting measures that can be implemented progressively as conditions evolve.

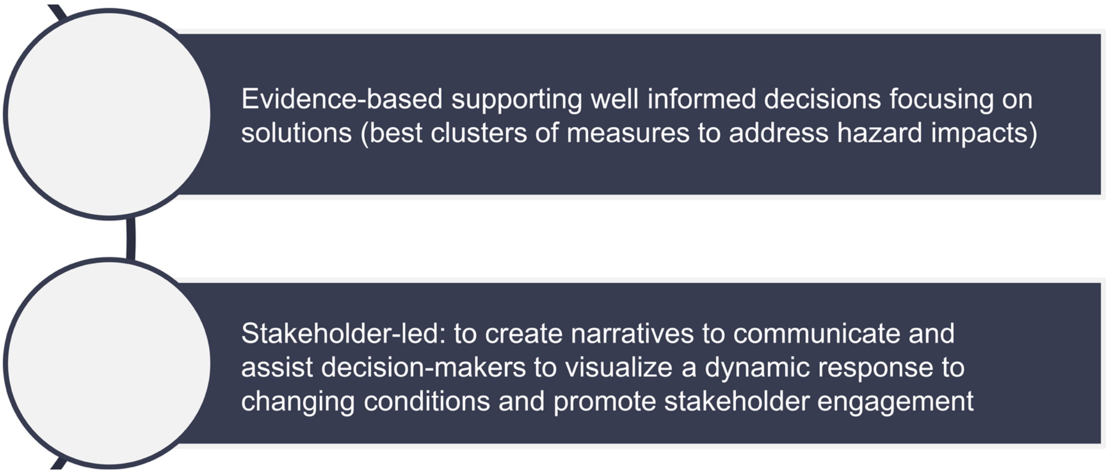
1.1.2 Why do we need to advance towards Resilience Pathways?

The pathway approach promotes flexible management: Not all decisions must be made immediately, rather they are deployed progressively as needed based on latest knowledge. In regard to resilience, a pathway approach has the following strengths:

- It encourages a holistic approach, by considering a mix of resilience measures both from adaptation to climate change and disaster risk management perspectives. This helps to have a better understanding and coordination among stakeholders to address risks.
- It accounts for uncertainty about the future and promotes flexible responses to a given problem. It allows planning for vulnerability and risk reduction while providing flexibility on the implementation of measures to better consider forthcoming knowledge and changing contexts. This will help to avoid an inappropriate use of resources by acting too early or too late.
- It encourages co-creation and, thus, the integration of various views and interests, which may be at times conflicting interests.
- It assists with the sequencing of measures, including identification of priorities through benchmarking to increase resilience.
- It can be translated into visual aids, similar to 'route maps' that support communication with stakeholders (see Chapter 3: Resilience Pathway Visualisation Tool).

Resilience Pathways can be built either based on scientific evidence or models or on stakeholder non-scientific knowledge as presented in Figure 1. These two approaches can be complementary.

Figure 1 – Working approaches for Resilience Pathways which determine their use



1.1.3 The use of Resilience Pathways in the context of Heritage

Cultural heritage is recognised as both a universal value and a factor of economic growth, as it often is a key driver for sustainable and resilient economic, social, and environmental development. Because cultural heritage places hold special value for communities, their protection is central to resilience. For this reason, the Resilience Pathway Handbook pays special attention to historic areas, though it can be used in a broader sense.

1.1.4 Who is this handbook for?

This handbook is an educational tool, targeted to city and regional stakeholders, to support cities, regions and their historic areas in the definition of pathways towards successful resilience building*****. Therefore, the handbook provides guidelines and advice to local and regional administrations and their relevant stakeholders in order to help their historic areas and, thus, cities or regions become more resilient and sustainable.

Audiences also include stakeholders concerned with adaptation to climate change, resilience****** or sustainability and historic areas, to support end-users in the definition of Resilience Pathways for historic or urban areas. These stakeholders can be either decision makers or technicians working at local or regional administrations as well as practitioners and consultants supporting historic areas and municipalities.

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* To prepare historic areas against potential damages, to safeguard the historic areas (with technical, social and governance approaches) once evidence of potential damages emerges, to plan and carry out conservation and management works taking into account future climate projections into account, to tackle proper response & recovery strategies, once the damages have occurred

** The sustained ability of a historic area as a social-ecological system (including its social, cultural, political, economic, natural and environmental dimensions) to cope with hazardous events by responding and adapting in socially just ways that maintain the historic area's functions and heritage significance (including identity, integrity and, authenticity)"

1.4 Structure of this handbook

Following this introduction, the report is divided into 4 Chapters as seen in Figure 2, plus the Glossary (Annex A) and Further readings (Annex B).

Chapter 1

Resilience pathways: How did it come about?

This chapter offers information

- An overview of the origin, concept and purpose of adaptation pathways
- Describing the conceptual difference between adaptation and resilience

Chapter 2

Step-by-step methodology to develop a resilience pathway

This chapter provides

- A replicable methodology to develop resilience pathways in an educational way
- Concrete examples of tools that can support the different steps of the methodology
- Practical considerations for the application of resilience pathways in historic areas

Figure 2 – Structure and content of the handbook chapters

Chapter 3

Resilience Pathway Visualization Tool in the context of the Handbook

This chapter offers

- An overview of the Resilience Pathway Visualization Tool
- A guide on how it can assist on the development of some of the given steps from Chapter 2, with special attention to historic areas
- A summary of the content of the tool

Chapter 4

ARCH Co-creating and testing activities

This chapter provides

- The description of the co-creation activities in relation to adaptation carried out within ARCH Project in Valencia case study
- Lessons learned and practical considerations of the implementation of the pathway approach in Bratislava, Camerino, Hamburg and Valencia case studies

02 Chapter 1
Resilience Pathways: How did they come about?

1.1 Adaptation Pathways

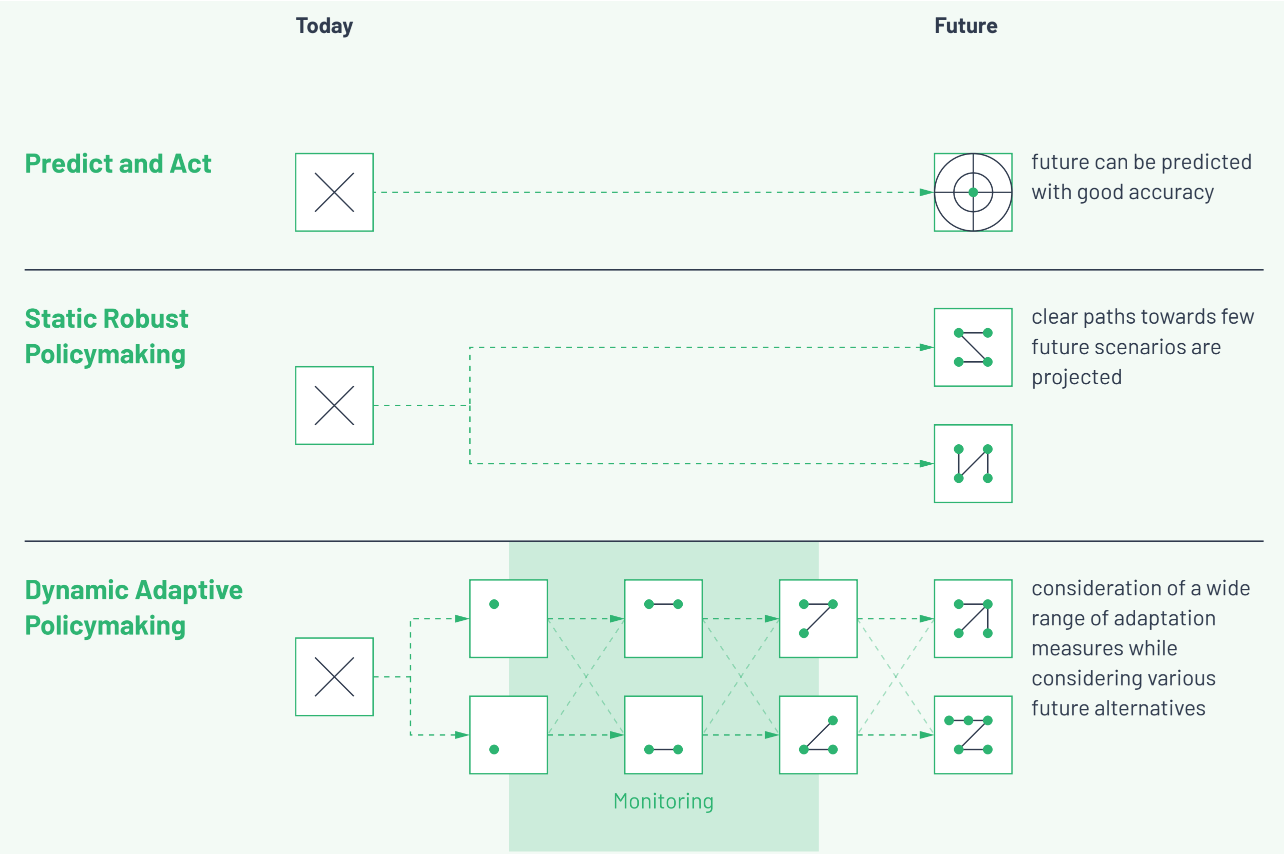
Climate change is increasing the frequency and intensity of climate-related hazards. Their effects will have huge economic, environmental and social impacts on European cities, for which we have to be prepared. However, the uncertainty associated with climate change makes it difficult to plan — especially for the needed adaptation actions to protect our urban and historic areas.

Furthermore, urban and historic areas are embedded in complex systems (socio-ecological systems) that require great efforts to be modelled, analysed, understood, managed and governed (1–3). These systems, which may vary depending upon culture, economy, environment etc., involve a multitude of strongly intertwined components (4).

The quest for better cities and historic areas, in the context of climate change, has led to the search for better planning and decision-making solutions. Nowadays improved planning strategies (Figure 3) considering future scenarios have been put into place, such as:

- "Predict and act", when it is believed that the future can be predicted with good accuracy
- Static Robust Policymaking, when clear paths towards few future scenarios are projected

Figure 3 – Approaches that policy makers apply regarding uncertainty of future scen arios. Source: Adapted from (5)



But, are these strategies adequate when planning urban adaptation to climate change? Probably not, due in large part to the fact that climate change introduces a significant amount of uncertainty, and the nature of cities is complex. Additional uncertainties arise when one also considers cascading effects. Despite this, decision-makers have to act with cost-effective and flexible approaches that allow sustainable policy implementation over time, while considering political uncertainty alongside other environmental, societal and economic changes.

In the light of climate uncertainty and the (urban) system complexity, Flexible Adaptation Pathways, as part of Dynamic Adaptive Policymaking* (DAP), have emerged as decision-focussed approach to support climate change adaptation planning. Adaptation pathways ensure the consideration of a wide range of adaptation measures while considering various future alternatives. Depending on the evolution of the problem, the alternative is reinforced with another set measures, modify or even delayed. In other words, in Adaptation Pathways, measures and actions are planned well ahead to prepare for envisioned climate change impacts, while their deployment is initiated once certain conditions occur.

* Dynamic Adaptive Policymaking lie under the assumption that future cannot be predicted

1.1.1. The context of Adaptation Pathways

Academia started to use the term 'deep uncertainty' in the early 2000s to respond to the need to address and name many different, yet plausible, future alternatives under climate change(6). This term was often associated with complex systems (7) and decision-making frameworks related to climate change (8). Soon, academics realized the need to assist decision makers with new approaches and tools to support planning when many plausible futures are possible. Consequently, DAP was developed. These approaches are based on assumption planning and explore a wide range of future scenarios, as seen in Figure 3. These approaches are based on the implementation of an initial plan, despite the fact that uncertainties are not yet solved, with the plan being deployed over time as new knowledge is obtained e.g. through monitoring of the evolution of conditions.

Yet, the concept of Dynamic or Flexible Adaptation Pathways was devised to address the challenges of climate change uncertainty around 2010 and firstly applied to coastal adaptation as a result of sea level rise scenarios (9). This approach considers the timing of actions explicitly and it develops an overview of alternative routes into the future. Since more than 200 studies on Adaptation Pathways have been published.

1.1.2. What is an Adaptation Pathway?

Adaptation pathways assist local governments and communities***** in making decisions about adaptation to climate change in an ongoing, flexible and dynamic way. Their development and implementation, as is the case with adaptation, is an iterative process. Flexible Adaptation Pathways allow for monitoring and evaluating the outcomes of specific adaptation measures and adjusting the roadmap as appropriate. This flexibility allows stakeholders to assess and identify the most effective ways to minimise the impacts observed for a given context or expected for the future impacts of climate change. They also allow for a change of course if „maladaptations", i.e., unintended negative consequences of adaptation, occur.

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* A group of people with an arrangement of responsibilities, activities, relationships and with common interests e.g. climate change. A community can also be a body of persons of common and especially professional interests

There are different definitions of Adaptation Pathways depending on which component is considered by the authors to be more relevant, as presented in Table 1.

In practice, Adaptation Pathways may combine evidence-based information (e.g., modelling, observations) with expert opinion to suit the Adaptation Pathway approach to the local context. As the complexities of dealing with multiple future possibilities and local contexts, as well as aims and commitments towards adaptation cannot be modelled, the Adaptation Pathway approach does not provide a single, optimal plan. Rather, it provides policymakers support in considering a wide range of actions, identifying opportunities and prioritizing them over time.

Table 1 – Definition of Adaptation Pathways

Source	Definition
CoastAdapt (10)	An Adaptation Pathway is a decision-making strategy that is made up of a sequence of manageable steps or decision-points over time
IPCC (11)	A series of adaptation choices involving trade-offs between short-term and long-term goals and values. These are processes of deliberation to identify solutions that are meaningful to people in the context of their daily lives and to avoid potential maladaptation
BS 8631:2021 (12)	Sequences of potential actions that can be implemented as conditions evolve in response to climate change risks and opportunities
Barnett et al. (2014) (13)	A sequence of linked strategies that are triggered by a change in environmental conditions, and in which initial decisions can have low regrets and preserve options for future generations
Werners et al. (2021) (14)	Sequences of actions, which can be implemented progressively, depending on future dynamics (on how the future unfolds and the development of knowledge)

1.1.3. What are Adaptation Pathways suitable for?

Adaptation pathways may have goals with different levels of hierarchical importance towards a system adaptation or transformation as described in the British Standard BS 8631:2021 Adaptation to climate change. Using Adaptation Pathways for decision making. Guide (12). This may depend on how Adaptation Pathways are understood, as well as on the available resources (e.g., climate knowledge and its impacts, technical, economic) and socio-political commitment (Table 2) which will determine its final scope. Thus, Adaptation Pathways can be used to:

- Achieve short, medium, or long-term adaptation goals
- Facilitate adaptation planning by considering a broad range of adaptation measures and actions
- Promote awareness, learning, collaboration, and capacity building

Table 2 – A summary of the goals of the Adaptation Pathway, needed resources and expected adaptation outcomes

a The required political commitment
b economic and technical needs
c How holistic the approach is
d Public and private stakeholders needed to achieve the adaptation goals

Vision of the Adaptation Pathway	What for	Political commitment [a]	Resources [b]	Knowledge [c]	Adaptation outcomes [d]
A sequence of measures to achieve a well-defined adaptation objective	Develop a flexible medium long-term action plan	High	○○○	○○○	○○○○○
	Guidance documents that provide a methodology on how adaptation measures can be deployed over time and help incorporate them in future action plans	Medium	○○	○○○	○○○○
A roadmap of measures with various alternatives to promote a change towards a strategic aim	Support the consideration of a wide range of adaptation measures and the order in which they could be deployed (Quantitative analysis)	Low-Medium	○○	○○○	○○○
	Support the consideration of a wide range of adaptation measures and the order in which they could be deployed (Qualitative analysis)	Low	○	○○	○○
A tool to support adaptation to climate change while considering uncertainty	Awareness raising (e.g. adaptation measures) to achieve adaptation goals	Low	○	○○	○○
	To engage and build a collective vision on adaptation	Low-Medium	○○	○○	○

1.1.4. Which advantages do Adaptation Pathways have in the context of Adaptation Planning?

Adaptation Pathways provide several benefits compared to traditional planning instruments. The three fundamental ones are:

- They can reflect different (planning) future scenarios that promote flexibility in terms of the deployment of adaptation to climate change.
- They are based on the performance of the solutions; thus, planning is supported by evidence*****.
- They are an approach that encourage consideration of a wide range of actions and the sequence in which they could be implemented to address a challenge or risk.
- They reduce uncertainty in adaptation planning as the triggers for decision points are scaled against events, and not time. The deployment of measures is initiated once certain climate-related occurrences have been observed to get worse.
- They buy time to plan and reduces the pressure of making decisions now. As previously mentioned, the Adaptation Pathway is deployed over time when monitoring of conditions identifies triggering conditions, at which further decisions or measures deployment will need to be undertaken.

1.1.5. Gaps in Adaptation Pathways: Heritage

Based on literature, there is a notable lack of attention given to heritage and cultural-led approaches in the design of pathways. Despite the benefits of cultural-led approaches based on local knowledge, many planners tend to overlook them in favour of scientific knowledge-based approaches to reduce climate risks.
At the time of writing this Handbook, it appears that Adaptation Pathways have only been applied once (15) for the climate adaptation for Aboriginal and cultural heritage. This work focused on the management of heritage, and it was the result of a stakeholder-led approach using a risk matrix as in Figure 13. This highlights both:

1. that this topic is not common knowledge, for example, among heritage managers Thus, there is a need to further explore and communicate the pathway approach with heritage-related stakeholders and

2. that there appears to be a preference for more standardised and universal strategies that can be easily implemented across different contexts, rather than context-specific solutions that draw on the knowledge and experiences of local communities. As a result, the potential contributions of heritage and culture to climate change adaptation, community resilience and sustainable development goals are often not fully recognized or utilized in the pathway design.

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* Stakeholder-led pathways are also an option to build narratives to communicate and assist decision-makers to visualize a dynamic response to changing conditions and promote stakeholder engagement

1.1.6 Gaps in Adaptation Pathways: Disaster Risk Management

Adaptation pathways, as previously mentioned, have been conceptualized to address the challenges of climate change adaptation. This is often related to slow-onset hazards like glacier melt, sea level rise, or the spread of invasive species. Thus, flexible Adaptation Pathways address long-term, gradual and progressive risks. However, as a result of climate change, the frequency and intensity of weather extremes is also intensifying. Disaster risk management has traditionally addressed these sudden extreme weather events and their related impacts, as well as geophysical extremes (earthquakes, volcanic eruptions etc.). Thus, there is a gap in the application of the pathway concept, as disaster risk management and adaptation are also naturally intertwined from a climate change perspective. Similarly, it has not been designed to address, for example, the resilience of historic areas to geophysical hazards. To bridge this gap, the ARCH Project has advanced the conceptualization of Resilience Pathways.

1.2 Resilience Pathways
What are the conceptual differences between an Adaptation and Resilience pathways?

While Adaptation Pathways deal only with slow-onset risks, Resilience Pathways integrate them and allow stakeholders to address and plan for sudden hazard extremes – that is, disasters. Resilience pathways are aligned with the ARCH Resilience Management Framework (Figure 4,(16)), which integrates both the management cycle of climate change adaptation (17) planning and the disaster risk management cycle (18). The normal operating phase within the ARCH Resilience Management Framework encompasses both the planning of slow-onset risks as well as the prevention, preparedness and protection activities that would take place during possible future disasters. Meanwhile, the emergency operating phase (i.e. the during and post-disaster recovery activities) is triggered once a disaster occurs. Thus, Resilience Pathways approach mirrors the cycle by addressing the identification, assessment, prioritization and sequencing of resilience measures during normal and emergency operating phases of the ARCH Resilience Management Framework.

Therefore, the authors of this report adopt the following definition for Resilience Pathways:

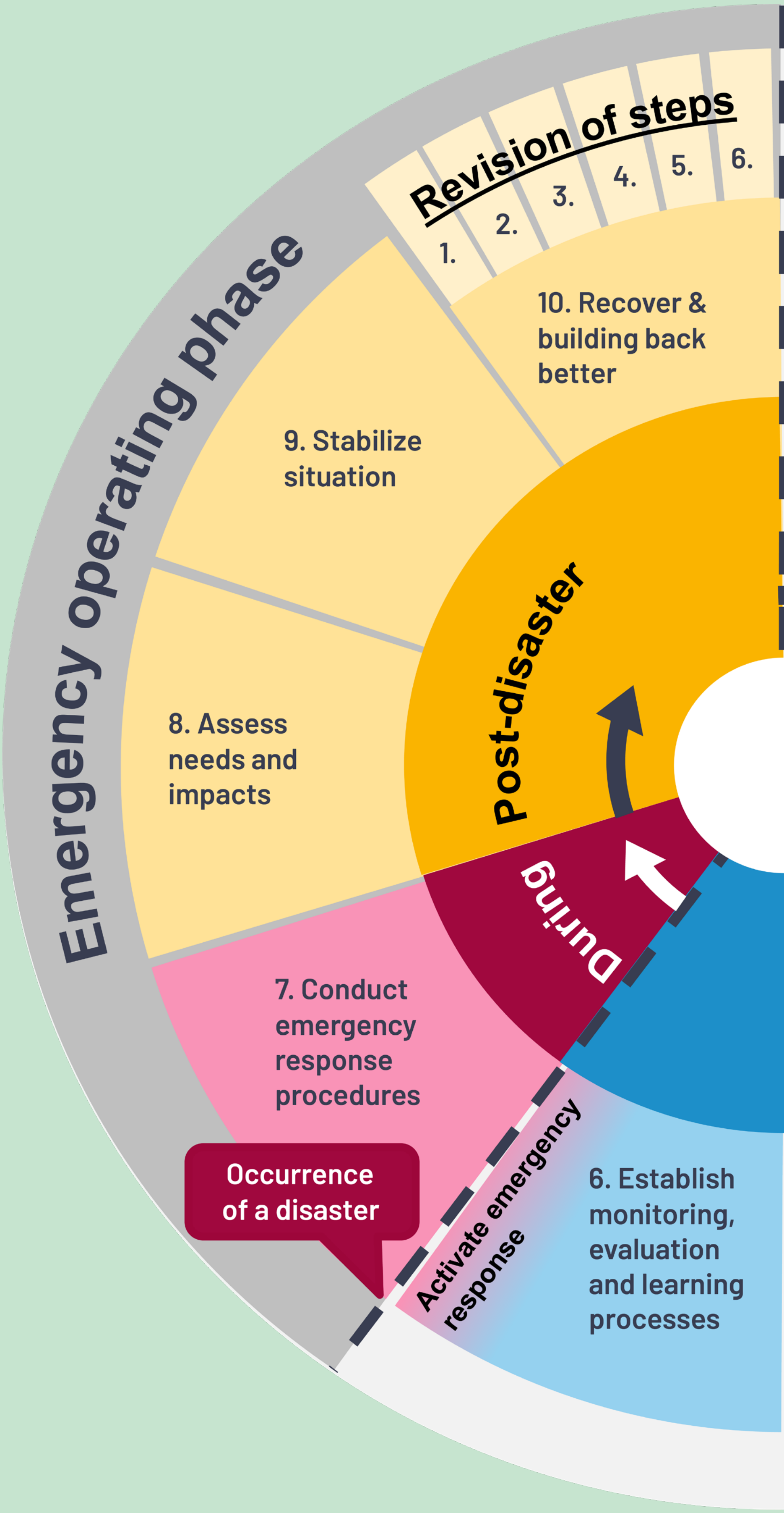
> A Resilience Pathway is a decision-making strategy, closely related to planning, that addresses both slow-onset climate change and natural disaster management, and sequences potential measures that can be implemented progressively as conditions evolve (depending on how conditions change over time, as well as how knowledge develops further).

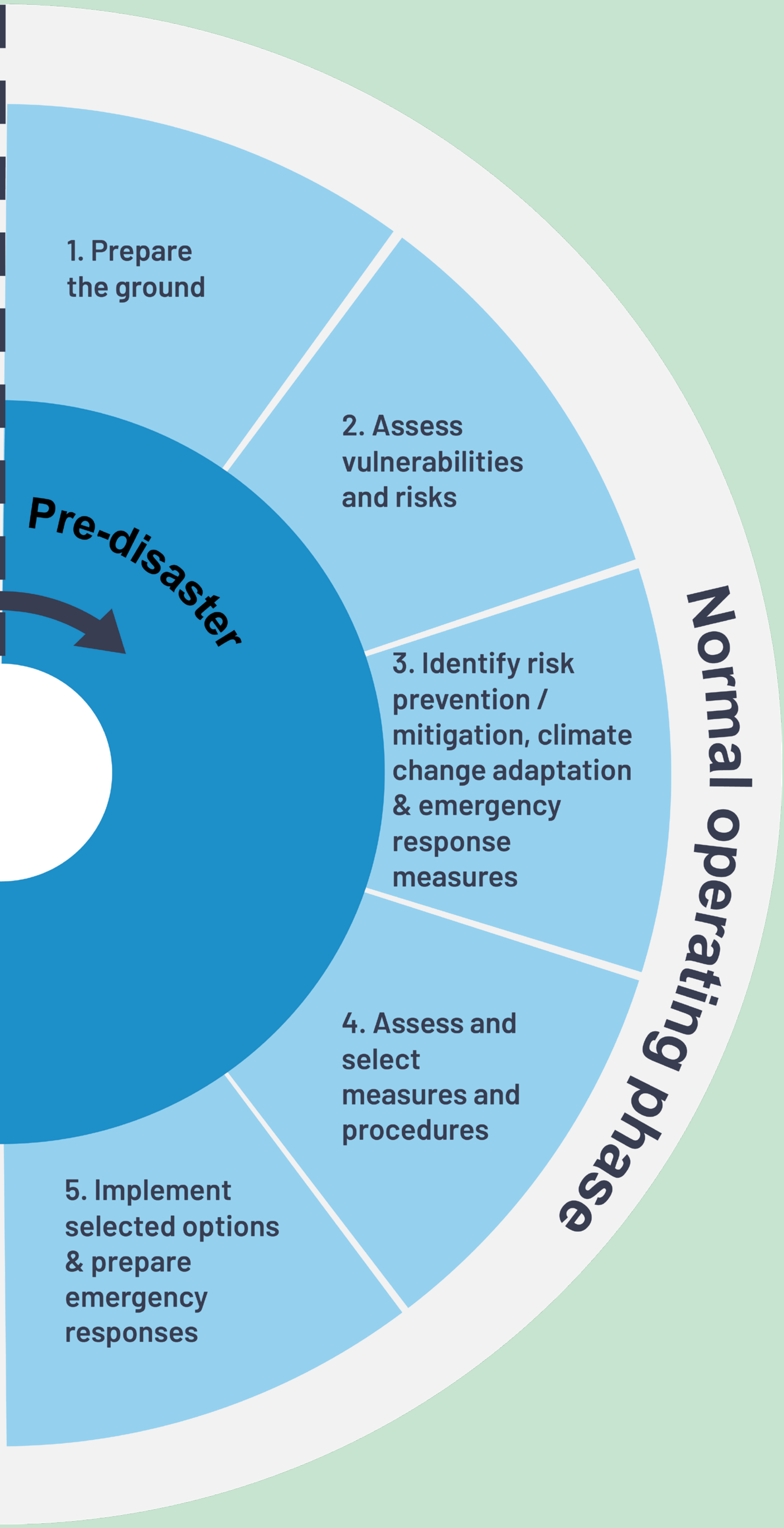
The main differences between adaptation and Resilience Pathways are presented in Table 3, while methodologically specific differences are covered in Chapter 2. Step-by-step methodology to develop a Resilience Pathway.

Table 3 – Differences between adaptation and resilience approach

Pathway approach	Addressed hazard	Examples of hazards	Addressed disaster risk management phase	Considered solutions
Adaptation	Slow-onset	Slow sea level rise, average monthly or annual temperature increase	Pre-disaster	From the adaptation to climate change perspective: • Measures to prepare areas against potential damages (Preparedness) • Measures for conservation & management, taking future climate projections into account (Prevention) • Measures to safeguard the sites once evidence of potential damages emerges (Protection)
	Sudden weather extremes	Pluvial and fluvial foods	Pre-disaster	Measures to prepare areas against potential damages (Preparedness)
Resilience	Slow-onset	Slow sea level rise, average monthly or annual temperature increase	Pre-disaster	From the adaptation and prevention of a disaster perspective: • Measures to prepare areas against potential damages (Preparedness) • Measures for conservation & management, taking future climate projections into account (Prevention) • Measures to safeguard the sites once evidence of potential damages emerges (Protection)
	Sudden weather extremes	Pluvial and fluvial foods, explosive cyclogenesis	Pre-during-post disaster	• Pre-disaster measures & • Emergency response measures • Restoration, recovery and building back better measures
	Sudden geophysical extremes	Earthquakes, volcanic eruptions, tsunamis		

Figure 4 – ARCH Resilience Management Framework




Pre-disaster
1. Prepare the ground
2. Assess vulnerabilities and risks
3. Identify risk prevention / mitigation, climate change adaptation & emergency response measures
4. Assess and select measures and procedures
5. Implement selected options & prepare emergency responses
Normal operating phase

03 Chapter 2
Step—by—step methodology to develop a Resilience Pathway

Both Adaptation and Resilience Pathways are aligned or embedded in the climate change adaptation cycle (17, 19) and the ARCH Resilience Management Framework (Figure 4), (20). Once the target system's vulnerabilities, risks and impacts have been evaluated, Resilience Pathways address mainly the identification, assessment and selection of the resilience measures using a specific methodology. This allows to prepare an action plan to adapt, safeguard and mitigate impacts from climate change and/or other natural hazards.

What are the unique features of pathways in the identification and selection of resilience measures?

- They are problem-solving roadmaps. They not only work towards the identification and selection of resilience measures, but also towards the sequencing of these measures
- They reflect on clusters of resilience measures at the same time: Aggregation of the resilience measures which are often called 'Resilience Pathway alternatives'
- They consider the performance of the resilience measures. Though not all pathway approaches may be data driven, their effectiveness is normally assessed by means of environmental or economic performance (e.g. modelling or literature based) but can also be addressed by stakeholder vision co-development or/and experts' judgment.

ARCH Resilience Pathway methodology, and proposed resources, responds mainly to the following purposes (Figure 6), which are considered data-driven approaches:

- To achieve short, medium, or long-term adaptation/ resilience goals
- To facilitate resilience planning by considering a broad range of resilience measures and actions

However, when there is a gap in knowledge the methodology may be adapted (e.g. without explicitly considering thresholds (step 1.3) or effectiveness (step 3.2) of each pathway alternative) to promote awareness, learning, collaboration, and capacity building among various local stakeholders and/or create resilience narratives. This may be also very relevant as a starting point especially in those systems where resilience management is at a preparatory phase, the management of the system is complex due to the involvement of numerous stakeholders with various responsibilities, lack of data to perform an evidence-based pathway and/or a capacity building of the stakeholders' work is sought.

The proposed methodological sequence is composed of four main steps (Figure 5), which are not necessarily linear, may be iterative and can be adjusted according to the strategic objectives, local needs, and resources of each municipality. As seen in the image, the three first steps are composed of three sub-steps, each. The British Standard BS 8631:2021 (12), on the other hand, divides the process in 9 similar steps.

This chapter provides step-by-step guidance on how to develop a Resilience Pathway, explains key concepts that may be new to the reader, as well as practical consideration and tools to assist local government and communities on their development.

Step 1

Preparing the ground and setting objectives

- Preparation and context analysis
- Long term vision & objectives
- Definition of threshold

Step 2

Selecting resilience measures

- Creation of resilience measure portfolio
- Characterisation of resilience measures
- Spatial plannification of resilience measures

Figure 5 – Methodological sequence of the Resilience Pathway approach

Step 3

Developing pathway alternatives

- Aggregation of different resilience pathways into the pathway alternatives
- Performance assessment of the pathway alternatives
- Sequencing of the resilience measures over time

Step 4

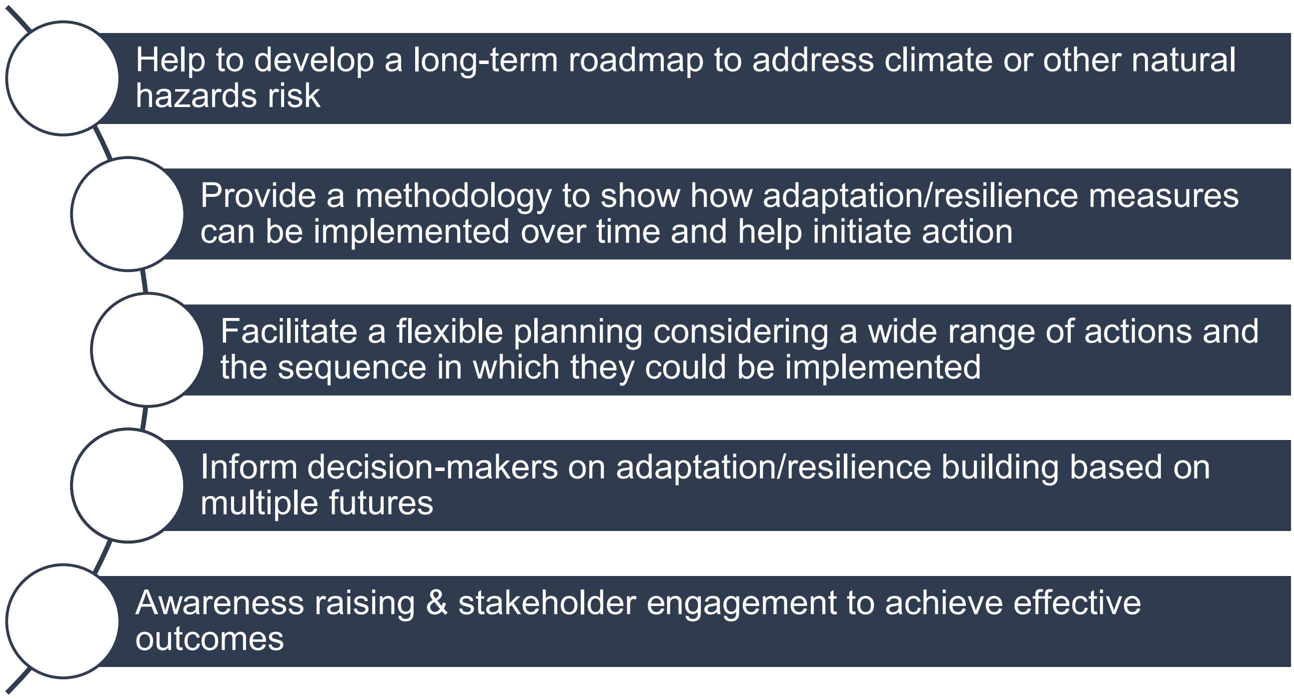
Selecting a pathway

- Decision regarding the optimal pathway choice, or
- Ranking of pathway choices
- Communication of the outputs of the resilience pathway develoment

Step 1
Preparing the ground and setting objectives

This step is vital to ensure the successful development and implementation of a Resilience Pathway. It aims at organizing and coordinating a working group, and finding the best ways to use its knowledge and the local/regional government's resources, all while reaching consensus on an integrated vision for resilience. This step is transversal and benefits from a multidisciplinary view in preparing for adaptation to climate change or other natural hazards.

Figure 6 – A non-exhaustive list of potential Resilience Pathway purposes in the context of the historic area or municipality based on the BS 8631:2021 (12)



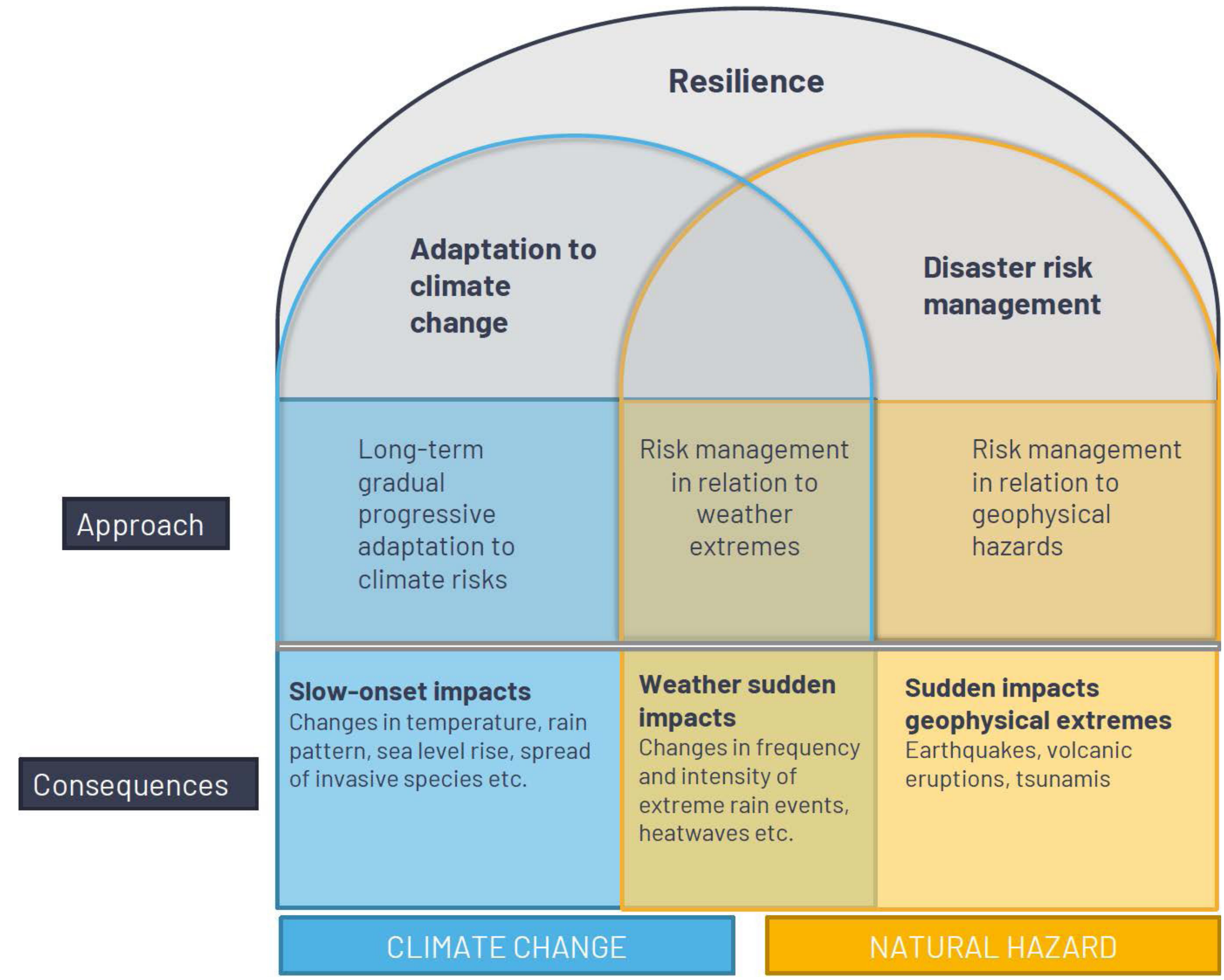
Step 1.1
Setting the purpose of the Resilience Pathway approach

Objectives

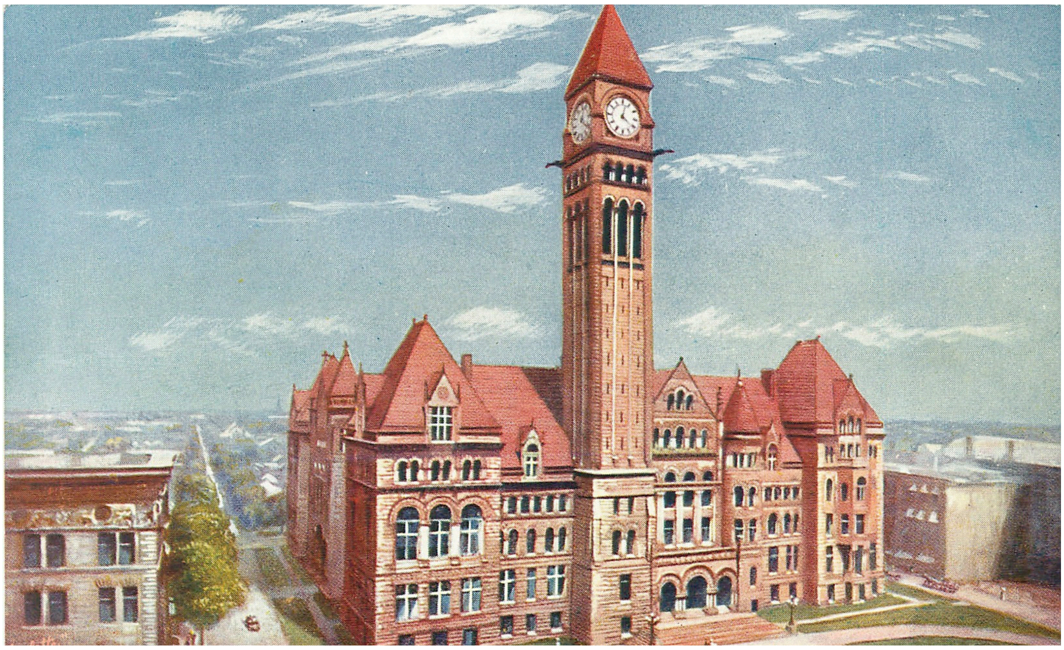
- Clarify the purpose of the adaptation or resilience pathway, i.e to answer *What do we want to use the pathway for?*
- To align resources to the scope of the pathway
- To identify the best decision making framework to the scope of the pathway

Before starting to prepare the framework and structure needed to develop a Resilience Pathway, the actors and stakeholders driving the initiative must determine the purpose of the pathway approach. This will determine, among other things, the number of resources (financial, human, technical) needed, and the time needed to develop the pathway (see also Table 5). Figure 6 presents some examples of the possible purposes of the pathway, which will also determine its final impact on preparing, safeguarding and managing historic areas. The stakeholder engagement and political commitment may also determine the scope of the Resilience Pathway.

Figure 7 – Intersection between disaster risk management and adaptation to climate change. Adapted from (21).



A second relevant question to address is whether the pathway should follow an adaptation or resilience approach. In Chapter 1. Resilience Pathways: How did it come about? The main differences between an Adaptation and Resilience Pathways were described from a theoretical point of view, which are also represented in Figure 7. In summary, Resilience Pathways address both adaptation to climate change and disaster risk management of extreme events or disasters. Adaptation pathways only address long-term gradual adaptation to climate change and prepare for, but do not manage, impacts from weather events such as flooding.



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However, there are other practical considerations when deciding for the final approach (summarized in Table 4), which may determine the pathway methodology selected. This might include the type of heritage assets in question, capacity to engage with stakeholders or whether the full cycle of Disaster Risk Management (DRM) needs to be considered.

Table 4 – Characteristics of the different pathway approaches and methodology. *See Figure 8 on the "tip box" for clarification

Pathway methodology	Data/ knowledge	Heritage type	Characteristic	Adaptation	Resilience
Evidence based / performance oriented	High dependence on scientific knowledge	Tangible	Nature of measures*	Structural	Structural, Social, Institutional
			DRM phase covered	Pre-disaster	Pre, during and post-disaster
			Performance indicator	Environmental and economic	Economic
Stakeholder-led based on non-scientific knowledge	High dependence on stakeholder participation and knowledge	Tangible & intangible	Nature of measures*	Structural, Social, Institutional	Structural, Social, Institutional
			DRM phase covered	Pre-disaster	Pre, during and post-disaster
			Performance indicator	Multistakeholder knowledge	Multistakeholder knowledge

Tip 1

What is a structural, social and institutional adaptation or resilience measure?

Figure 8 – Categorisation of adaptation/resilience measures based on their nature

Structural	• This category gathers measures with clear outputs and outcomes and that are well defined in scope, space and time • They include structural and engineering solutions (e.g. coastal protection, building reinforcement), the application of technologies (e.g. sensors for structural stability, early warning system), the use of ecosystem based solutions (e.g. ecological restoration, shade trees) and the delivery of services (e.g. enhanced emergency medical services)
Social	• This category aims at improving informational strategies (e.g. vulnerability map, definition of emergency storage facilities for movable heritage), favouring behavioural measures (e.g. changing cropping practices, household preparation and evacuation planning) and providing educational services (e.g. awareness raising, sharing local and traditional knowledge) • It especially focuses on reducing social vulnerability and increasing the knowledge of elements like cultural heritage, in order to facilitate its safeguarding, management and protection against hazards
Institutional	• This category targets institutional measures that foster adaptation/ resilience • They include economic actions (e.g. financial incentives for adaptation, catastrophe bonds), laws and regulations (e.g. regulation for effective citizens' evacuation, zoning and statutory planning regulations for historic areas) and government policies and programs (e.g. integrated coastal zone management, integrated strategic planning for urban heritage conservation management)

Step 1.2
Preparing the ground

Objectives

- Ensure a high level of support within different fields (adaptation, heritage, civil protection, planning, funding etc.)
- Minimise the risk of inadequate coordination
- Clarify roles and responsibilities (internally and externally)
- Minimise the risk that the involved people do not understand the importance of considering and planning both climate change adaptation and disaster risk management at the same time
- Securing funding or minimising the risk of running out of funding in the without it in the implementation, with the consequences that this entails.

While there is no one exclusive way of approaching these pathways, there are some logical tasks to set the context of the historic area/municipality in terms of climate change and natural disasters. This preparatory step has a transversal nature and, while framed as an initial phase, should be integrated throughout the different steps of the pathway approach.

The proposed working sequence

- Setup of the internal working team responsible for the resilience process in all its phases. This team should be responsible for coordinating and leading the pathway development, securing funding, clarifying roles and responsibilities, conducting stakeholder engagement and setting a continuous communication process.

- Development of a map of stakeholders and institutions linked to climate change adaptation, disaster risk reduction and heritage. This map can be revised during the pathway development [See Toolbox 1]. For this purpose, it may be useful to have gathered information that gives relevant context to the status quo of the municipality's actions in this area: For example, data about observed impacts on heritage sites that may be associated to climate change, previous initiatives, etc.

Tip 2

A multidisciplinary working team is especially important when addressing historic areas as stakeholders working on climate change or civil protection traditionally do not have technical/ social knowledge on heritage or its management. Similarly, heritage managers or conservation officers can lack certain knowledge on how climate change or other natural hazards will affect the historic areas or what type of work can be done to preserve the historic sites in light of climate impacts.

- Involvement of stakeholders (public, private, associations, etc.) which could contribute or have interest in making the historic area more resilient. The involvement of stakeholders often depends on the governance culture, resources of the local government, and on the political commitment of authorities. However, involving stakeholders with local, traditional knowledge and those from the cultural and creative sector is particularly important when designing resilience pathways with a focus on heritage.

  These stakeholders possess a wealth of knowledge about local heritage, cultural practices, and traditional ecological knowledge that can inform the design of pathways that are context-specific, grounded in local cultural values and foster community resilience. Additionally, their involvement can help ensure that heritage is not only preserved but also leveraged for the social, economic, and environmental well-being of local communities. Table 5 shows the type of decision-making framework in terms of stakeholder engagement with their advantages and disadvantages.

- Funding and resources. Definition of the human and economic resources to develop the Resilience Pathway and the financing mechanism to ensure appropriate economic resources are sought for the implementation of the resilience measures (further information can be found in Step 1.6 Financing the flexible Resilience Pathway)

- Internal and external communication and citizen participation. Enabling and use (or, where appropriate, creation) of communication mechanisms and spaces for citizen participation. Using the cultural and creative sector can be a powerful way to communicate complex ideas and engage diverse audiences, by using arts, music, storytelling, and other cultural expressions to convey messages and foster meaningful dialogue.

Table 5 – Decision making framework based on the involved stakeholders

DECISION MAKING	STAKEHOLDERS	CONS	PROS
Centralized	City Council (Tactical expertise- the Resilience Pathway initiative is led by an individual)	Reactivity from other stakeholders, poor, not validated	Fast and cheap process
Hierarchical	City Council (Operational competences- the Resilience Pathway initiative is launched by various municipal stakeholders)	Reactivity from other stakeholders, poor, not validated	Fast and cheap process
Hierarchical with scientific knowledge	City Council (Operational competences), Expert Support	Reactivity from other stakeholders, not validated and poor form the citizens point of view	Fast process
Hierarchical with limited participation	City Council (Operational competences), Expert Support, Organizations (NGOs and local)	No representation of the citizenship	Relatively fast process
Participatory	City Council (Operational competences), Expert Support, Private Sector, Organizations (NGOs and local)	Resources invested (time and budget)	Higher level of heritage protection
Co-Design	City Council (Operational competences), Expert Support, Private Sector, Organizations (NGOs and local), Citizens	Resources invested (time and budget)	Community sense of belonging better considered from the citizens. 360-degree vision

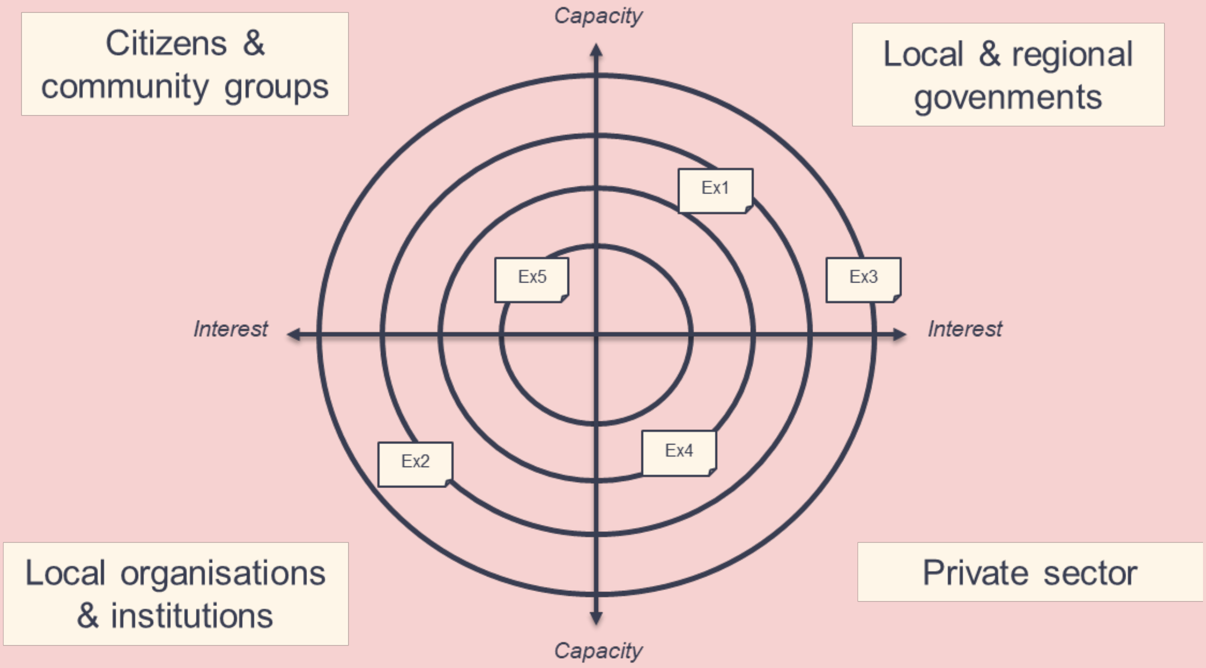
Toolbox 1

There are different methodologies and tools to identify stakeholders. The stakeholder ecosystem map allows to identify stakeholders based on their typology and on their interest and capacity (technical, economic, political...).

Relevant stakeholders may be among others:

- decision makers on district
- municipal, or national level related to historic areas
- resilience or adaptation to climate change
- disaster risk managers
- heritage managers (including managers of museums and collections)
- public administrators
- sustainability and resilience officers
- critical infrastructure managers
- service providers
- emergency service providers
- civil society associations (including the cultural and creative sector)
- non-governmental organisations
- academic and research institutions

Stakeholder ecosystem map



Step 1.3
Context analysis

Objectives

- Make appropriate and optimal use of existing information
- Access suitable methodologies and select those that are most appropriate for our municipality /historic area
- Improve knowledge about possible impacts and effects of climate change & other natural hazards in the municipality, both negative and positive if any
- Assess vulnerability and potential risks
- Define those impacts that transcend the territorial or jurisdictional scope of our municipality competence of our municipality
- Enable sufficient coordination between agents and institutions

Apart from stablishing a resilience team structure it is also important to identify the resilience needs of the historic area in question. In other words, stakeholders might ask of themselves:

- *We are aware of geophysical hazards in our area, and that climate change is a reality, but how does it affect this particular historic area?*
- *Which areas and activities will be most affected, and which are most vulnerable?*
- *What is our collective (or individual) capacity to react?*
- *What are the places, traditions, events, etc., that hold inherent significance for local communities, beyond those officially listed as heritage assets?*

In the process of resilience building, proposing effective measures depends on the availability and awareness of information regarding the current situation of the historic area, and of local realities when it comes to climate impacts and other hazards. It is important to quantify climate trends and their impacts, the factors that determine vulnerability to climate change or geophysical hazards, as well as the potential risks the historic area or municipality faces.

The main elements to be addressed during this step:

Compilation of available information on the defined historic area/ municipality.
Often municipalities, regions and their stakeholders possess a valuable, but scattered knowledge on the local context, as well as the status of a given historic area. The integration of the knowledge from different stakeholders allows a broader picture not only of the observed changes in climatology and its impacts (e.g., changes in the beginning of flowering, new pests), but of the needs and challenges that the historic area faces.

Furthermore, the compilation of information in a historic area should take into account not only the historic value but also the values ascribed to the elements by the local community. This can provide a comprehensive understanding of the cultural significance of the area and serve as a basis for designing pathways that are sensitive to local needs and aspirations.

ARCH D3.3 City baseline report and the Irish Climate Change Sectoral Adaptation report provide examples of risk profiling in heritage sites and historic areas, which can aid in identifying and characterising observed changes associated with natural hazards and climate change.

Compilation of available information on climate change, geophysical hazards and/or extreme events, including historical events.
This task aims at answering questions regarding the magnitude of projected climate impacts and changes, the ability to predict such changes, and the ability to anticipate hazards. To gain clarity in these areas, first the (climatic) variables and scenarios need to be decided upon (e.g. using business-as-usual climate projections), as well as the timeline for action.

Preliminary identification of potential future local impacts of climate change/ geophysical hazards.
The existence of a climate hazard does not necessarily imply that a municipality (or its historic areas) will suffer its effects or impacts, as this varies widely depending on its context (specific historic areas, sectors of activity, infrastructure, population, ecosystems, etc.). To this end, the exposure of an area must be determined, in order to know which hazards are of the highest concern.

Exposure refers to the presence of people, livelihoods, species or ecosystems, environmental services, resources, infrastructure, or economic assets, social or cultural assets, in locations that could be adversely affected or impacted by an event or adversely affected or impacted by a climate event or trend. In order to determine what is exposed to particular hazards and to what degree or order of magnitude an impact may occur, it is often necessary to undertake local studies called impact modelling.

This involves carrying out studies of various kinds to gain a more accurate understanding of the potential extent of impacts arising from changes in climate variables or patterns, or other geophysical hazards. Examples of impact modelling include flooding studies, mapping of the heat island effect, epidemiology studies of certain diseases, seismic damage models, ecological niche displacement analysis, etc.

Due to the diversity of biophysical and socio-economic situations, the impacts of climate change for similar hazards vary from region to region, affecting different sectors, actors, and decision-makers in very different ways. This strengthens the case for carrying out these local studies. In addition, effects in one geographical area or sector may have consequences in other sectors or areas, resulting in so-called cascading effects or highlighting other interdependencies. Identifying and prioritising these direct and indirect impacts of climate change, as well as existing interdependencies, is key to define resilience measures appropriate for a given municipality or historic area.

Vulnerability and risk assessment of the historic area, municipality and/or relevant sectors.
One of the key concepts and steps in climate change adaptation and resilience building is the vulnerability analysis (22), which refers to the propensity or predisposition of a system to be affected by a hazard. Vulnerability can be assessed generally using indicators or by expert judgment, preferably through a predefined rating scale. Normally, socio-economic or environmental indicators available in the municipality are used, such as population data, level of education, family income, age and types of buildings, classification of economic activities, unemployment rates, green space per area or inhabitant, access to services, etc. The selected indicators will be available at a certain level of disaggregation of the data. This will condition what our basic unit of analysis will be (buildings, census tract, neighbourhood, district, urban planning areas, etc.).

In any case, it is important to link with the previous step (exposure) and therefore to overlay the exposure to climate hazards with the vulnerability assessment. In order to carry out such an exercise, it is advisable to identify relevant impact chains* for our system. The formulation of an impact chain consists of pairing a climate hazard with a receptor, usually a subsystem or element of the municipality. For example, we may define that heat waves can affect health, or that floods can affect infrastructure or economic activity. In case there are multiple impact chains of interest, there are different methodologies, as shown in e.g ARCH HUB to prioritise them. For each impact chain,
we select the appropriate indicators that can be used to develop a risk assessment [Toolbox 2]. This involves selecting key data and information from previous stages regarding hazards, exposure and vulnerability.

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* Impact chains can be used to identify and describe relevant cause-effect relationships as a basis for further risk and impact analysis

Tip 3

The IVAVIA methodology guides a risk-based vulnerability assessment, helping to map, analyse and communicate the impact of climate trends and weather events on key elements of a community's physical, social and economic fabric. IVAVIA provides guidance on how to prepare, gather, and structure data for a risk-based vulnerability assessment, to quantify and combine vulnerability indicators, to assess risk and to present outcomes.

As for vulnerability assessments, there are different qualitative and quantitative approaches to risk analysis, which can be combined. Irrespective of the approach or methodology adopted (quantitative and/or qualitative), it is important to consider the uncertainty* associated with the quality of the data or the methods (23) used and how to communicate it (24). The risk estimation often implies the comparison and prioritisation of the results of the risk analysis. These results can often be ranked according to a nominal scale (high, medium, medium, low) or ordinal scale (e.g a scale of 1 to 5). Once the risks have been analysed and their importance has been prioritised, the next step is to assess the need for action, including where and when it is needed. This assessment is likely to depend on how the risk is linked to other priorities of the municipality, the legal and jurisdictional framework, or the resources available for resilience-building actions.

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* A state of incomplete knowledge that can result from a lack of information or disagreement about what is known or even knowable. It can have many types of origins, from imprecise data to ambiguous concepts or terminology, or uncertain projections of human behaviour. Uncertainty can therefore be represented by quantitative measures or by qualitative statements (e.g., reflecting the judgement of a group of experts).

Toolbox 2

1. The Risk Assessment Module (RAM), developed by the European Research Project Shelter, is an online tool (Figure 9) that calculates the risk score of the heritage asset using indicators related to the applicable hazard. It targets city technical practitioners and researchers.

2. The Risk Systemicity Questionnaire (RSQ), developed in a web and excel format by the European research project Smart Mature Resilience, can be used to identify and prioritise risk scenarios, where interdependencies between risks are shown to lead to networks of risks, including so-called "vicious cycles," and to review and prioritize mitigation and adaptation actions for various scenarios of risk interdependencies (Figure 10).

3. Shelter Strategic Decision Support System (SSDSS) is a web-based application that implements and links the multiscale iterative vulnerability and resilience assessment methodology.

Figure 9 – Shelter Risk Assessment Module. https://shelter-gis.azurewebsites.net/

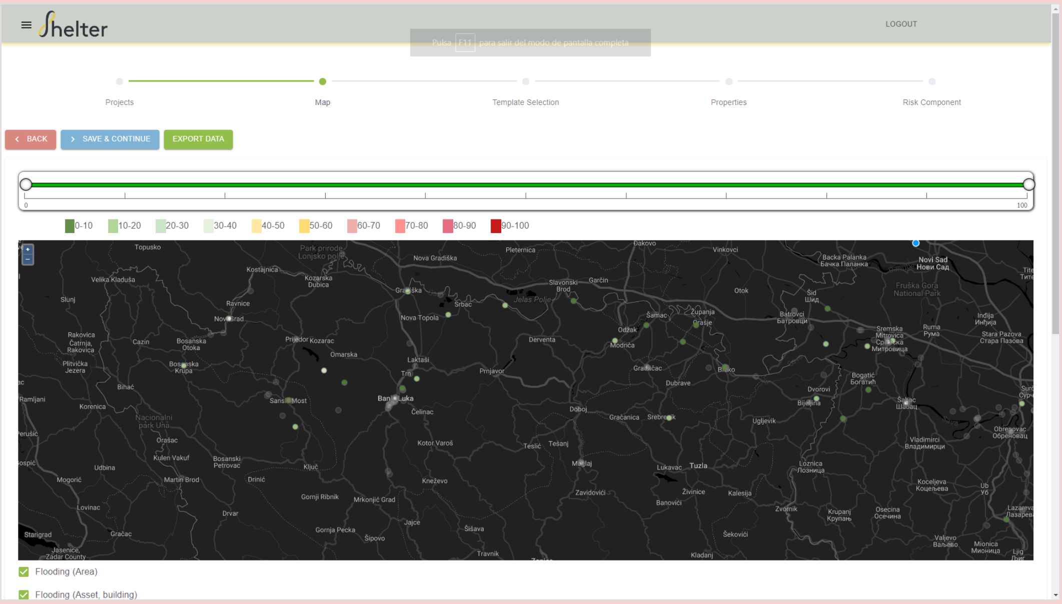


Figure 10 – Topics that the RSQ includes which fall under three broad themes: social dynamics, climate change, and critical infrastructure. Source: https://smr-project.eu/tools/risk-systemicity-questionnaire/

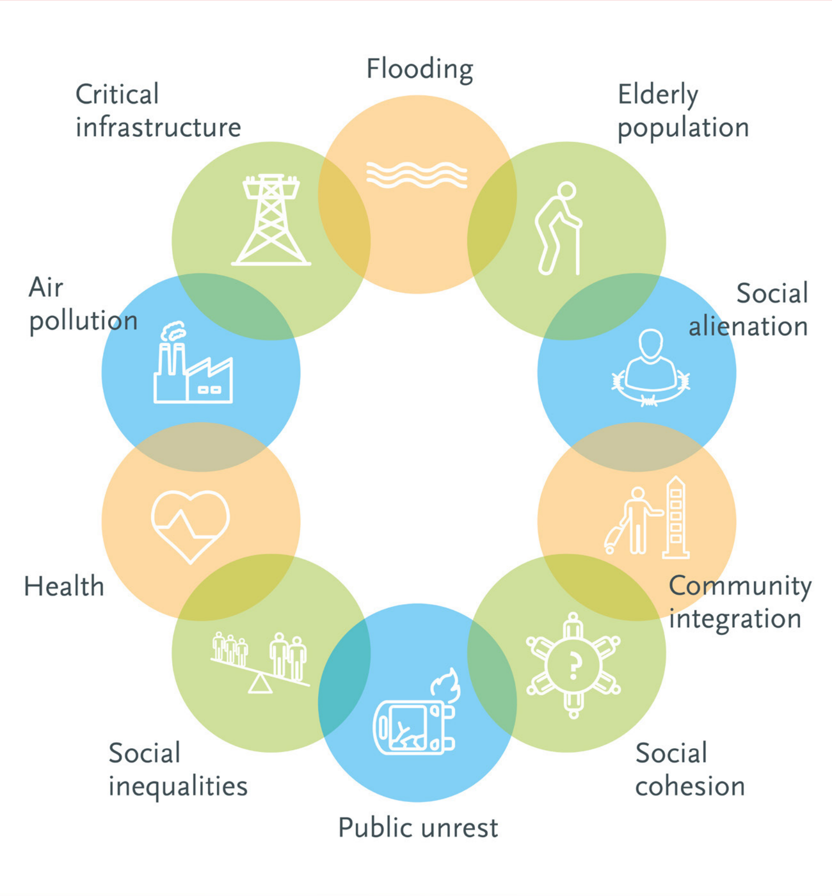
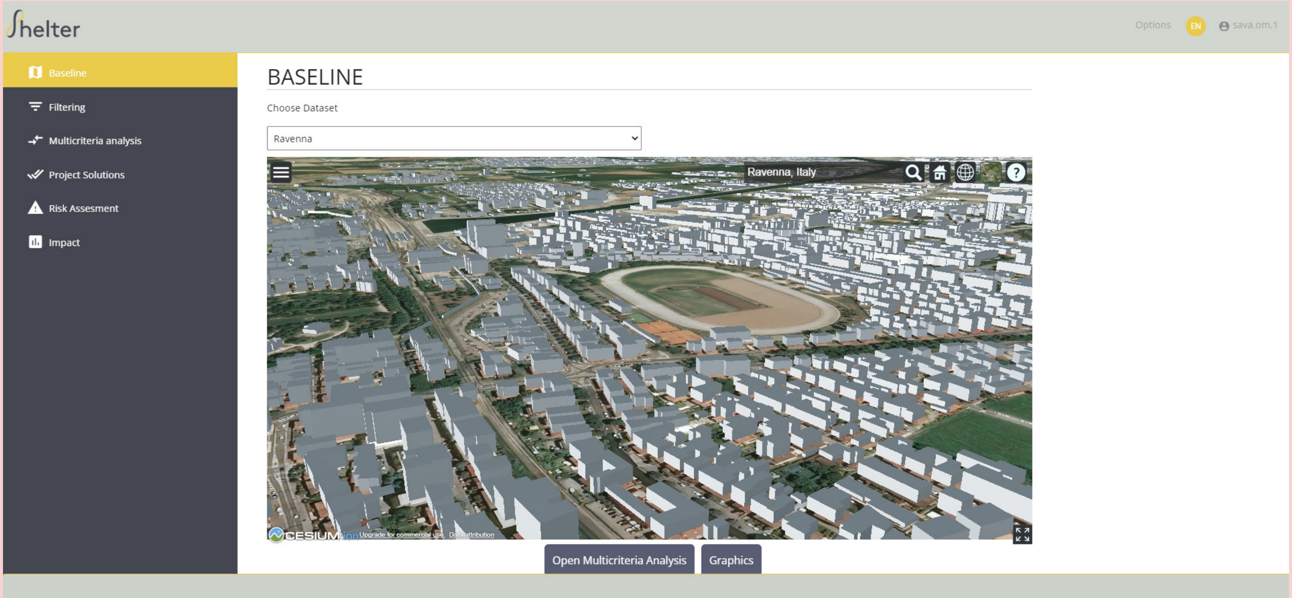


Figure 11 – Shelter Strategic Decision Support System*

* https://shelter-gis.azurewebsites.net/



Tip 4

Climate data processing, geophysical scenarios, impacts, vulnerability, and risk assessment often require expert assistance. However, when that is not possible due to lack of resources or lack of data, screening methods (Figure 12) or conventional risk matrices (Figure 13) can be used, informed by local knowledge.

Figure 12 – Extract of the screening template on risk identification. Source: CoastAdapt Australia. https://coastadapt.com.au/tools/decision-support-templates-create-risk-register

Risk assessment template

Fill in your project details	Organisation			
	Project			
	Date			
Scope your assessment	What is the objective of this risk screening?			
	What is your planning horizon or time frame of this risk screening?		Briefly document the reason for selecting this time frame	
	Which climate change scenario/s will you include in this risk screening (i.e. high RCP8.5, medium RCP4.5, low RCP2.6 scenario)		Briefly document the reason for selecting your scenario/s	

Screen potential coastal climate risks in your coastal zone

	Potential hazards in the coastal zone	Have these occurred in the past in your area of interest?	Do you have any existing risk management strategy in place to tackle this hazard?	Do you have any residual (existing) risk from this hazard? (i.e. if you have a record of past occurrence of a hazard, and you do not have in place an adequate risk management strategy to address it, then you have a residual risk)	What is the likely future direction of the hazard? (based on your selected time frame and climate change scenario)	Does this hazard have the potential to become problematic for you in future? (based on future climate change and sea level rise)	Which geographical area/sector/assets/ecosystems can be impacted
Coastal hazards around open coast beaches and estuaries	Storm related beach erosion in your area (short-term erosion)	☐ Yes ☐ No ☐ Not Relevant	☐ Yes ☐ No ☐ Not Relevant	☐ Yes ☐ No ☐ Not Relevant	☐ Decrease ☐ Increase ☐ No change	☐ Yes ☐ No ☐ Not Relevant	
	Long-term shoreline recession around open coast beaches	☐ Yes ☐ No ☐ Not Relevant	☐ Yes ☐ No ☐ Not Relevant	☐ Yes ☐ No ☐ Not Relevant	☐ Decrease ☐ Increase ☐ No change	☐ Yes ☐ No ☐ Not Relevant	
	Storm surge inundation of beach and surrounding areas	☐ Yes ☐ No ☐ Not Relevant	☐ Yes ☐ No ☐ Not Relevant	☐ Yes ☐ No ☐ Not Relevant	☐ Decrease ☐ Increase ☐ No change	☐ Yes ☐ No ☐ Not Relevant	
	Storm surge inundation of estuaries and surrounding areas	☐ Yes ☐ No ☐ Not Relevant	☐ Yes ☐ No ☐ Not Relevant	☐ Yes ☐ No ☐ Not Relevant	☐ Decrease ☐ Increase ☐ No change	☐ Yes ☐ No ☐ Not Relevant	
	Coastal lake or watercourse entrance instability	☐ Yes ☐ No ☐ Not Relevant	☐ Yes ☐ No ☐ Not Relevant	☐ Yes ☐ No ☐ Not Relevant	☐ Decrease ☐ Increase ☐ No change	☐ Yes ☐ No ☐ Not Relevant	
	Tidal inundation of beach	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Decrease ☐ Increase	☐ Yes ☐ No	

Figure 13 – A conventional risk matrix.
Source: Adapted from (17)

RISK RATING KEY	LOW 0-ACCEPTABLE -------------------- OK TO PROCEED	MEDIUM 1- GENERALLY MANAGEBLE -------------------- TAKE MITIGATION EFFORTS	HIGH 2- UNACCEPTABLE -------------------- SEEK SUPPORT	EXTREME 3-INTOLERABLE -------------------- PLACE EVENT ON HOLD
	SEVERITY			
	ACCEPTABLE LITTLE TO NO EFFECT	TOLERABLE EFFECTS ARE FELT, BUT NOT CRITICAL	UNDESIRABLE SERIOUS IMPACTS	INTOLERABLE COULD RESULT IN A DISASTER
LIKELIHOOD				
IMPROBABLE RISK IS UNLIKELY TO OCCUR	LOW -1-	MEDIUM -4-	MEDIUM -6-	HIGH -10-
POSSIBLE RISK WILL LIKELY OCCUR	LOW -2-	MEDIUM -5-	HIGH -8-	EXTREME -11-
PROBABLE RISK WILL OCCUR	MEDIUM -3-	HIGH -7-	HIGH -9-	EXTREME -12-

Heritage Tip 1

CCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property) and the Canadian Conservation Institute (CCI) published a Guide to Risk Management of Cultural heritage in 2016, which provides a specific list of common risks that heritage faces, based on real lived experiences (Figure 14). However, the guide is focused on achieving effective protection from risks, some of which are climate change related.

Figure 14 – Identification template for the specific risks that affect heritage asset in its own context

	Rare events	Common events	Cumulative processes
Physical forces			
Criminals			
Fire			Generally not applicable
Water			
Pests			
Pollutants			
Light and UV	Generally not applicable		
Incorrect T			
Incorret RH			

Step 1.4
Define resilience threshold or objectives

Objectives

- Define the objectives of the resilience or adaptation pathway based on the context analysis
- Help to identify 'acceptable' losses based on thresholds and thus identify when new resilience measures should be deployed to avoid non-acceptable losses
- Make sure that the scope of the resilience or adaptation pathway is adjusted to the available resources

´Threshold* analysis is an approach to prioritize where and when action will be needed by understanding the points at which a system is deemed to be no longer effective (economically, socially, technologically or environmentally) as a result of changes in the average or extreme climatic conditions´ (25). Figure 15 presents a graphical representation of a threshold analysis and concept. The threshold analysis responds to the classical top-down approach, "What if climate changes according to scenario x?". However, threshold values are not always feasible or easy to determine for all type of hazards. In those cases, the Resilience Pathway approach can also focus on the ability to cope with climate change or other local hazards.

This makes the method less dependent on climate scenarios and focuses more on resilience. In these cases, it is desirable to set specific objectives for resilience. Resilience objectives may be clear after analysing the context and resilience needs derived from vulnerability, impact and/or risk assessment. However, in cases where the targeted system or historic area is complex, there is high uncertainty on the gathered information, or there remain big gaps in knowledge, practical tools to trigger and support socio-institutional co-creation are available [Toolbox 3].

In any case, regardless of the approach, objectives or thresholds should be documented including how they were determined and the reason behind the assumptions made, if any.

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* A climate threshold is a critical limit where a climate system responds drastically when exposed to an external forcing, resulting in the system changing into a different stable state

Tip 5

What is an adaptation tipping point?

The point at which a series of small changes become significant enough that their impacts render a system no longer effective. An adaptation tipping point determines a point in time when the threshold is reached (see Figure 15 for an example of a tipping point) and new adaptation or pre-disaster measures are needed to safeguard a system.

What is a resilience tipping point?

The point at which a significant incident or disaster modifies the system resulting to be no longer effective (the crisis stage in a process, when a significant change takes place). A resilience tipping point determines a point where the disaster occurs and during- and post-disaster measures (Emergency operating phase, see Figure 4) need to be deployed.

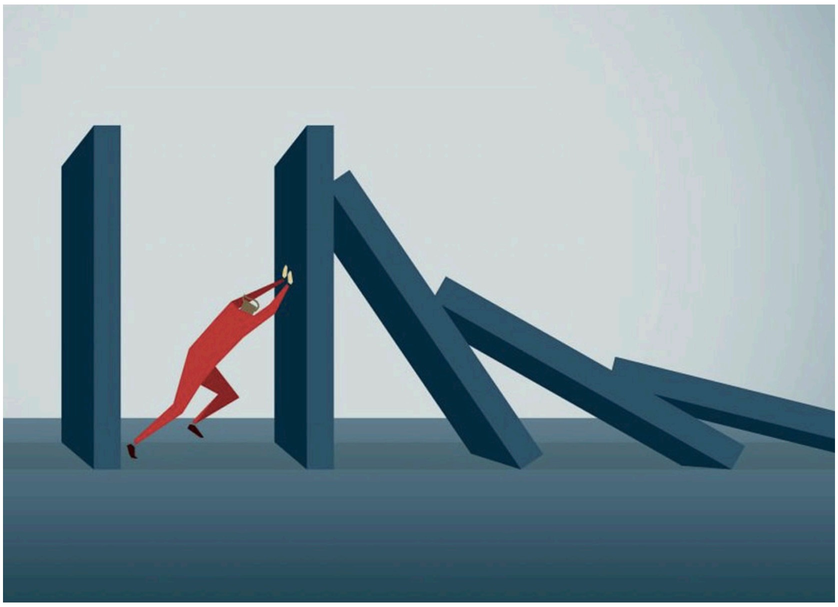
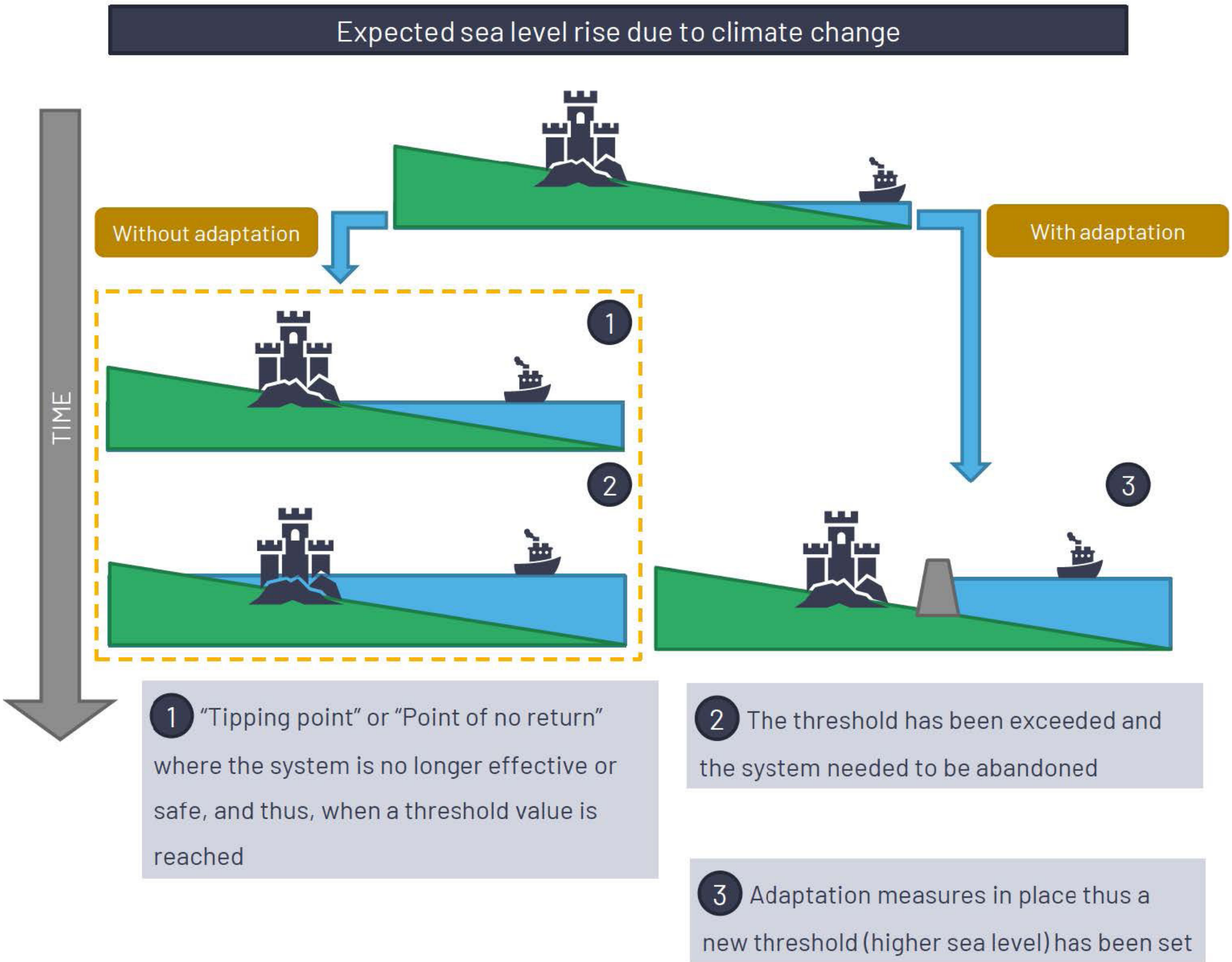


Figure 15 – Tipping point and threshold concept graphical representation for sea level rise



Toolbox 3a

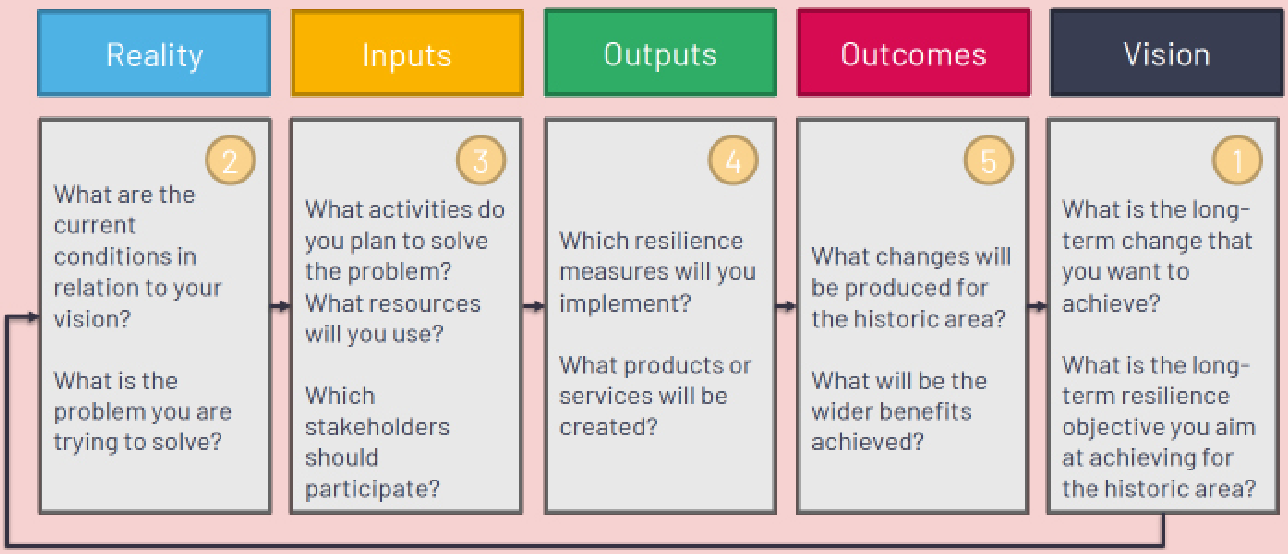
Theory of change aims at deeply understanding how change actually occurs

The Theory of change process was conceptualized as the mini-steps that allow a system to achieve long-term goals while setting assumptions and connections between the activities that need to be in place and the outcomes that occur at each step. It is especially focused on identifying the pre-conditions needed to achieve the long-term goals, that is, understanding what the activities do (outputs) and how these lead to the desired goals (outcomes). Then it works back from these to identify all the conditions that must be in place for the goals to occur. Source: The Center for Theory of Change (26)

As shown in Figure 16, the Theory of Change begins by determining the desired long-term changes in, for example, the historic area in relation to the resilience objectives (vision). Then, the identification of the existing conditions and envisioned or actual climate/geophysical problems is carried out. This is followed by the determination of necessary inputs and outputs to achieve short-term as well as intermediate outcomes, which themselves lead to the desired long-term impact (vision). Furthermore, assumptions are identified and linked to a specific pathway risk to attempt to manage these by identifying what conditions must hold true for change to occur.

An example of its application to heritage can be found in the Climate Heritage Network Action Plan where Theory of Change has been applied to define its goals.

Figure 16 – Schematic steps involved in the theory of change methodology



Toolbox 3b

Setting SMART objectives (26)

Five criteria (Specific, Measurable, Achievable, Relevant and Time-bound (i.e. , S.M.A.R.T') have traditionally been used to ensure quality objectives or determine the criteria for monitoring and evaluating the results of an implemented policy. In the Resilience Pathway approach, the *time-bound* criterion would be replaced by *scenario-bound* to account for the uncertainty related to climate change (e.g greenhouse gasses emission scenarios, climate model uncertainty etc.)

What are SMART objectives?

Specific

Objectives should be precise and concrete enough not to be open to varying interpretations by different people.

Measurable

Objectives should define a desired future state in measurable terms, to allow verification of their achievement. Such objectives are either quantified or based on a combination of description and scoring scales.

Achievable

Policy aims should be set at a level which is ambitious but at the same time realistically achievable.

Relevant

The objectives should be directly linked to the problem and its root causes.

Time-bound (Scenario-bound)

Objectives should be related to a scenario of change (or scenario of resilience measure implementation) to allow an evaluation of the pathway's achievement to reduce the risk per scenario.

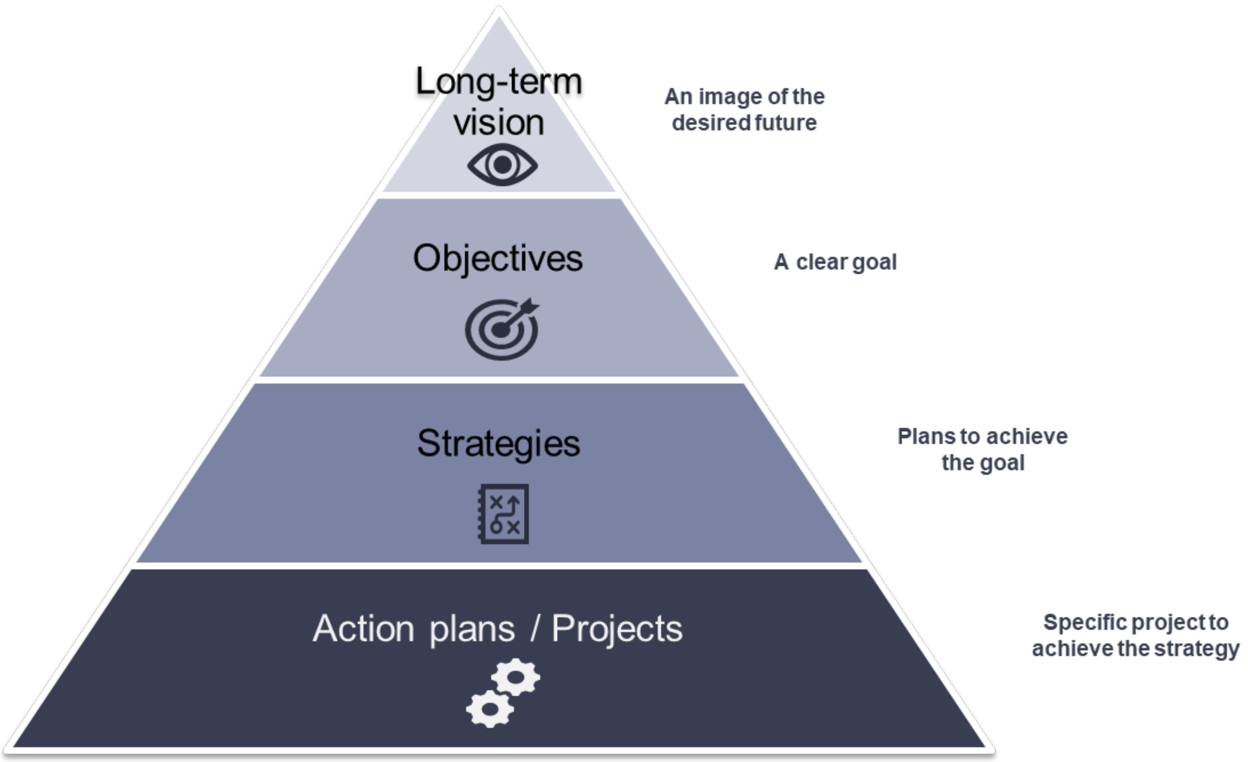
Step 1.5
Alignment of the Resilience Pathway with long-term vision of the system

Objectives

- Make sure that the resilience objectives are aligned with the municipalities or historic area's long term-vision
- Understand that the flexible resilience pathway will be the planning toot to deployed the resilience objectives, similarly to conventional sectorial or transversal strategic plan
- Revise the involved stakeholders to ensure that the resilience pathway will not encounter implementation risks

This step aims to ensure that the objectives set for the Resilience Pathway are not in conflict with other municipal policies. Figure 17 shows the different planning levels to be revised within this step. It may also help to identify synergies with existing plans and promote the cooperation with the leading stakeholders, if they are not already part of the working team dedicated to the Resilience Pathway development. It is important to document the deadlines, specific objectives and the specific plan's timeframe to align the outputs of the Resilience Pathway with ongoing projects. It is also vital at this stage to revise the stakeholder ecosystem map. This will also promote more efficient and sustainable funding and management of the different plans or projects targeting the same or similar objectives within different sectors.

Figure 17 – Framework for planning and decision-making based on the set long-term vision



Step 1.6
Financing the flexible Resilience Pathway

Objectives

- Make sure that the financing of the potential resilience measures is considered from the beginning to secure funding or minimising the risk of running out of funding at implementation, with the consequences that this entails.
- Understand available funding opportunities and select the most appropriate one for each resilience measure typology and our municipality /historic area

Despite challenges to funding and financing in sustainable urban development (as reported by local authorities) (27), local action on climate change adaptation, disaster risk reduction or resilience building in general is an opportunity. Not only because it anticipates potential problems or opportunities, but because it can position municipalities to access new sources of funding, programmes and initiatives that are being carried out in Europe (LIFE+, Horizon 2020, Interreg, among others).
It is therefore essential to consider from the outset what sources of funding are available and to understand what characteristics apply to each funding programme. In order to do this, it is important to have a methodology to help identify the best funding programme for each type of resilience measure.

Tip 6

The ARCH Methodology followed three main steps to identify and select the most appropriate funding opportunities.

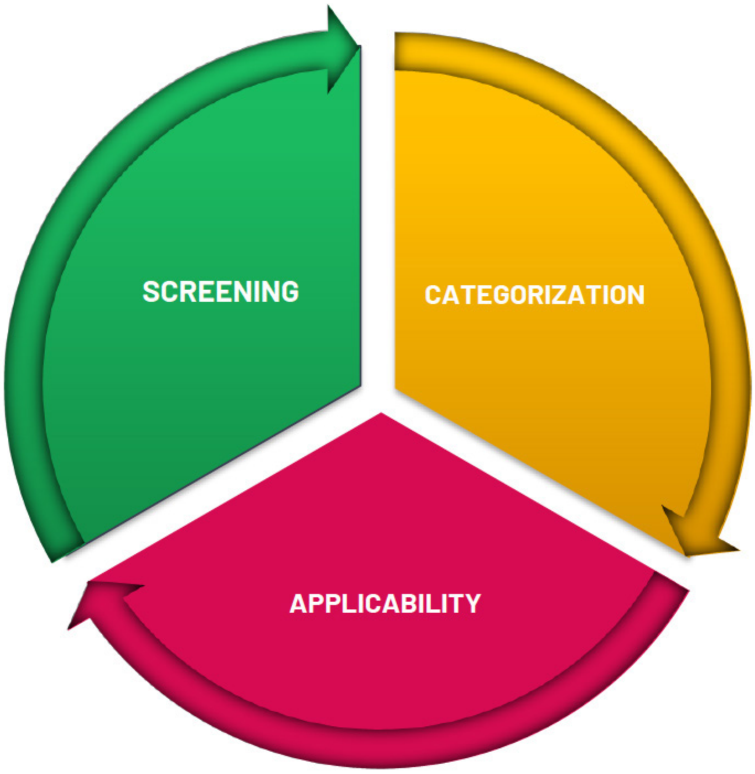
The **(1) screening**, **(2) categorisation and (3) applicability** of funding measures is a crucial part of the pathway development for improving the resilience of historic areas to climate change-related and other hazards as it supports decision-making at appropriate stages of the management of resilience measures.

The initial **screening** of the funding measures is conducted to analyse all the possible funding opportunities for the identified resilience measures and narrow down the choice to a given number of possible funding sources.

The **categorization** of funding measures is performed by performing a "Strengths, Weaknesses, Opportunities and Threat" (SWOT) analysis of the identified funding measures for selected resilience options and analysing the city's structure based on a set of indicators: social, technical, economical, institutional and organizational.

Finally, the **applicability** of the identified funding measures to the cities structure is represented with a "crossing" SWOT table that matches the SWOT analysis of the funding measures with the city's structure leading to a final result score table of the most suitable funding measures.

Figure 18 – The methodology adopted to analyse the financing of the resilience measures in the case of ARCH pilot cities.



1. Screening

ARCH Example

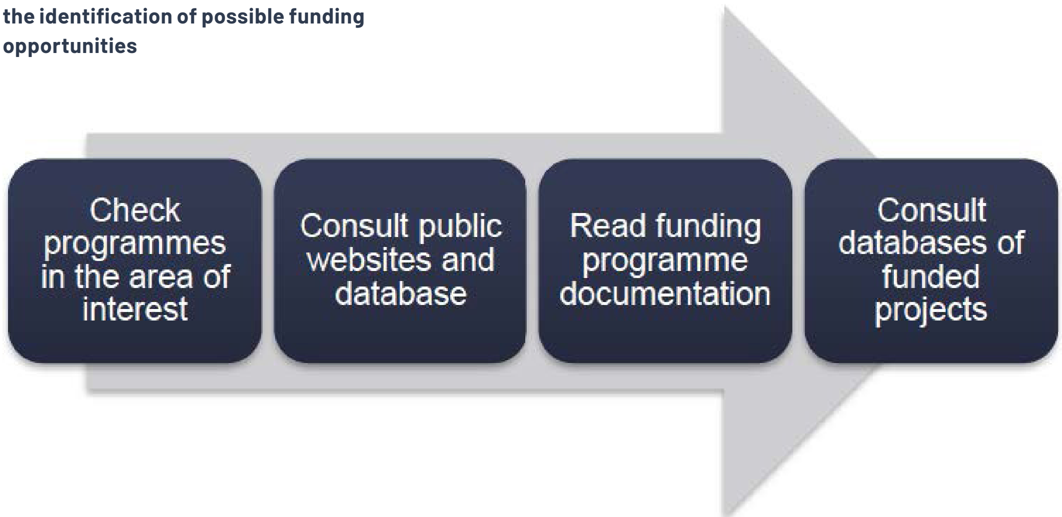
Once the resilience measures are identified, an initial **"screening"** of possible funding measures should be performed. These range from EU funds to non-traditional financing sources like crowdfunding and funding through Public-Private Partnerships (PPP). Various solutions apply and can contribute to funding resilience measures in historic areas. These should be selected paying special attention to the intersections across the fields of cultural heritage conservation, disaster risk management and adaptation to climate change.

The screening activity can be conducted by way of literature review, including research of grey and scientific literature and EU and international projects' websites. Other sources like articles and scientific publications should be consulted.

Moreover, possible funding sources to consider are bank foundations, private foundations, donors and foundations networks (e.g. for Europe DAFNE, ENEL Foundation, Fondazione TIM, BOCELLI Foundation, Rockefeller Foundation, Fashion sector etc.), EU institutions (ECB, EIB, EBRD, EEA), International Organisations (UNESCO, Global Heritage Fund, ICCROM, World Bank) and other sources like the EU Crowdfunding Network, and IKOSOM platform for civic Crowdfunding.

To narrow down the search for the most suitable financing solutions for the selected resilience measures, the following steps (Figure 19) for the identification of possible funding opportunities should be followed when, for example, the EU funds are investigated.

Figure 19 – Four step methodology for the identification of possible funding opportunities



The first step is to check EU Programmes in the area of interest. In order to be financed, the identified resilience measure must meet the selection criteria and investment priorities of the regional programme. At the EU or regional/local level, strategic priorities are normally identified, and for the financing of the selected resilience measure, these must be aligned with the financing programme's priorities.

The second step is to consult public websites and databases for available funding instruments. Examples of EU funds database are:

- https://ec.europa.eu/info/overview-funding-programmes_en
- https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/home
- https://www.funds-navigator.eu/en
- https://euro-access.eu
- www.welcomeurope.com/programs
- www.eucalls.net

The third step is reading funding program documentation. This is essential to understand the strategy behind the funding instrument. The EU, for example, sets annual or even long-term goals in so-called „work programs" that are to be achieved within a certain period. Through calls for tenders, the EU then looks for service providers who can help to translate these EU work program goals from theory into practice through the implementation of very specific projects. The programmes funded under the Multiannual Financial Framework (MFF) are grouped into various headings or expenditure categories of the EU budget, each one dedicated to a specific policy area. For resilience measures, for example, these could fall into the policy area "cohesion, resilience and values" or "natural resources and environment". Once the policy area is identified, the "programme guide" should be carefully analysed together with all the call documents, financial guidelines and other available documentation.

A fourth step is consulting the database of funded projects to check whether the resilience measure to be financed has been already financed or could be connected with previously financed projects.

The scheme below (Figure 20) illustrates a summary of the guiding criteria that could be applied to select the most suitable funds, once a preliminary analysis of the resilience measures and the structure of the city has been performed.

Figure 20 – Guiding criteria for the funding selection

2. Categorisation

Once the screening of the available funding measures has been conducted, in order to narrow down the choice of the most suitable financing measures for the selected resilience measure to be implemented in a given context (city), the following steps of **categorization** should be followed:

- SWOT***** analysis for identified funding measures
- Analysis of the city structure based on a set of indicators: social, technical, economic, institutional and organizational

The parameters to carry out the SWOT analysis can be the following:

1. Programme budget
2. Project budget
3. Frequency
4. Partnership
5. Project TRL (technology readiness level)
6. Complexity of project preparation
7. Success rate
8. Necessity of co-financing
9. Project innovation rate
10. Project social acceptability
11. Combination with other financial instruments
12. "Brain or bricks" focus
13. Support rate of public or private entities
14. Project reporting complexity
15. Intellectual property issues
16. Need for fundraising web platforms
17. Territorial availability
18. Project duration
19. Communication campaign requirements
20. Private stakeholder involvement

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* **Strengths**
These are things that enable securing the necessary funding;

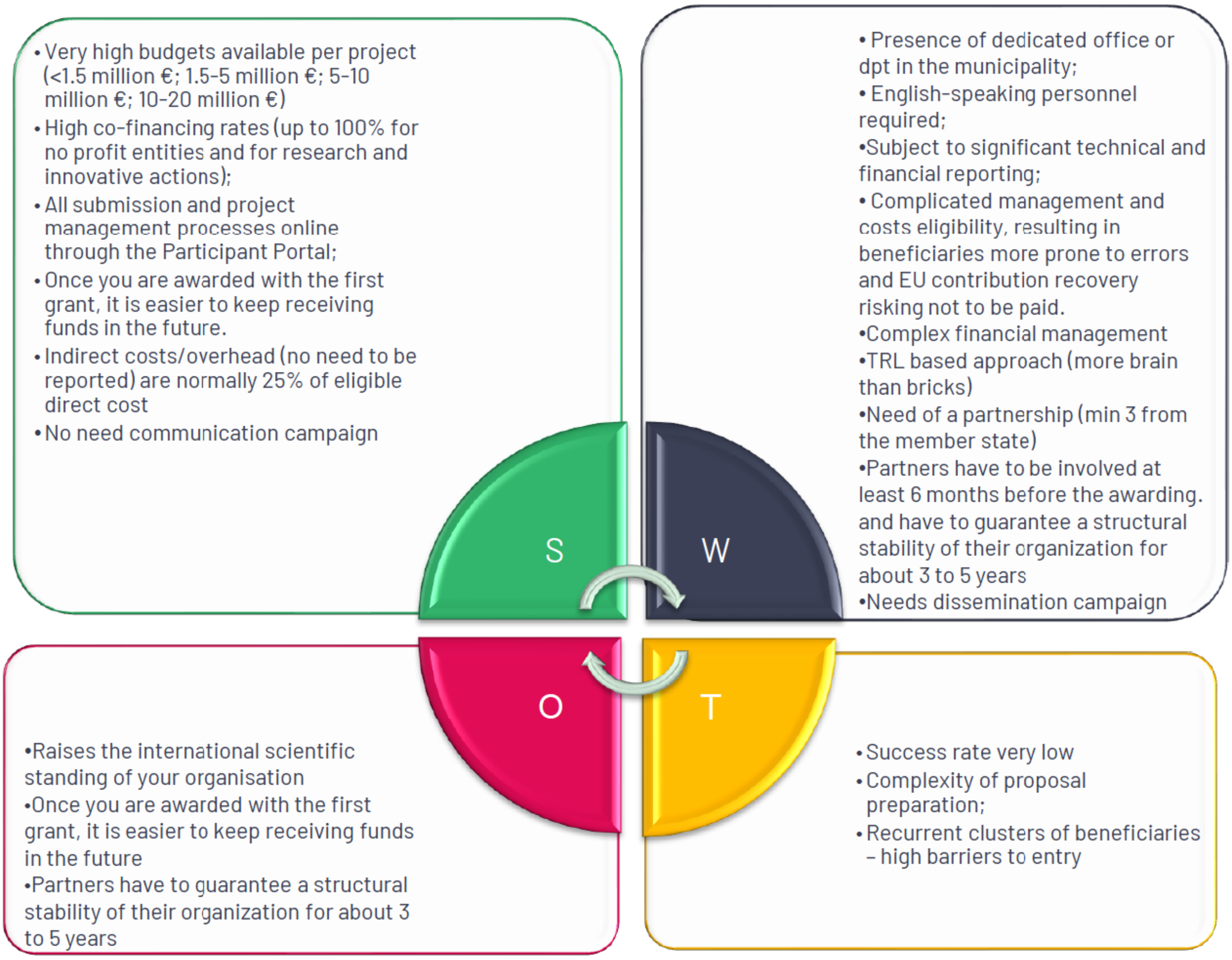
Weaknesses
These are things that hinder the application to resources or increase the effort needed to be eligible;

Opportunities
These are things which could benefit the entity applying, but do not currently;

Treats
These are things which could discourage the application to that specific funding.

For example, the SWOT analysis of the Horizon Europe programme is reported in Figure 21.

Figure 21 – SWOT analysis of the Horizon Europe programme



An analysis of the local (or regional) government structure should be carried out in order to assess the applicability of the selected financing measures, keeping in mind the characteristics of the funding measures and financing mechanisms. This helps to assess the capacity of the local or regional government to access the funds based on technological, economic, institutional and organisational criteria. Figure 23 presents the indicators used to analyse the ARCH pilot cities' structures.

Figure 22 – Indicators used to analyse the ARCH pilot cities structures

3. Applicability

The **applicability** of opportunities is assessed by the stakeholder, supported by the administrative/technical staff of a local government based on technological, economic, social, institutional and organisational criteria. These criteria should be employed to evaluate the benefits of funding measures in terms of effectiveness, value creation and minimised risk.

The result of the analysed funding measures as applied to the specific case of each city will be described and illustrated with a "crossing" SWOT analysis that will take into account the SWOT analysis of the funding measure (see above).

The applicability will therefore derive from both the SWOT analysis of the funding measure and the characteristics of the cities, as well as the specific type of resilience measure analysed.

The crossing SWOT can appear quite similar to the SWOT analysis performed for the funds in the categorization phase when resilience measures chosen are not executive detailed projects with identified costs and the information about the city's structures collected are not so crucial to take the priority on the characteristics of the fund itself. However, the SWOT analysis crossing tables are essential to create the final score tables related to each city case.

The SWOT below (Table 6) represents the crossing SWOT analysis of the Horizon Europe programme for financing infrastructure structural monitoring of stability in ARCH pilot city Camerino, i.e. technologies to provide information on the performance and condition of the infrastructure such as Global Positioning System (GPS) systems through sensors.

Table 6 – SWOT analysis of the Horizon Europe Programme for financing infrastructure structural monitoring of stability

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• High co-financing rates (up to 100% for no profit entities and for research and innovative actions) • All submission and project management processes online through the Participant Portal • Indirect costs/ overhead (no need to be reported) are normally 25% of eligible direct cost • No need of communication campaign to apply	• Lack of EU project dedicated office in the municipality • Limited number of English-speaking personnel • Project implementation subject to significant technical and financial reporting • Complicated management and costs eligibility, resulting in beneficiaries more prone to errors and EU contribution recovery risking not to be paid • Complex financial management • TRL based approach (more brain than bricks), chosen resilience action not so adapt • Partners have to be involved at least 6 months before the awarding and have to guarantee a structural stability of their organization for about 3 to 5 years • Needs dissemination campaign during the project	• Raises the international scientific standing of your organisation • Once the partnership is awarded with the first grant, it is easier to keep receiving funds in the future • Opportunity to exploit an existing partnership • Opportunity to involve external consultants paid by the project	• Success rate very low • Complexity of proposal preparation; • Very high budgets available per project (<1.5 million EUR; 1.5-5 million EUR; 5-10 million EUR; 10-20 million EUR) hence large structured project needed

As seen in Table 7, the results of the analysis are valued with a score from 1 to 5 (1= lowest applicability, 5= highest applicability) and represented by a traffic light in which the green light represents the solution with which it seems to be possible to proceed smoothly, the yellow light represents a solution to adopt with a more cautious approach and the red light means that, for the specific case, it is worth re-evaluating whether the fund can be effectively applied or not.

1 = lowest applicability
5 = highest applicability

Table 7 – The results of the analysis performed for Camerino case study

CAMERINO	LIFE Climate Change	Interreg	Private Public Partnership	NRRP	Invest EU Fund	Match Funding	Horizon Europe
Building Back Better				5 (green)	2 (red)	4 (green)	
Monitoring System	3 (yellow)			5 (green)			3 (yellow)
Awareness raising	2 (red)	3 (yellow)	4 (green)				

As illustrated above, the EU programmes are focused on clear individual themes and specialist sectors. Therefore, once the project idea is established, there is normally one main funding instrument per thematic sector to investigate. However, there is also the possibility to present cross-sectoral projects with potential synergy effects.

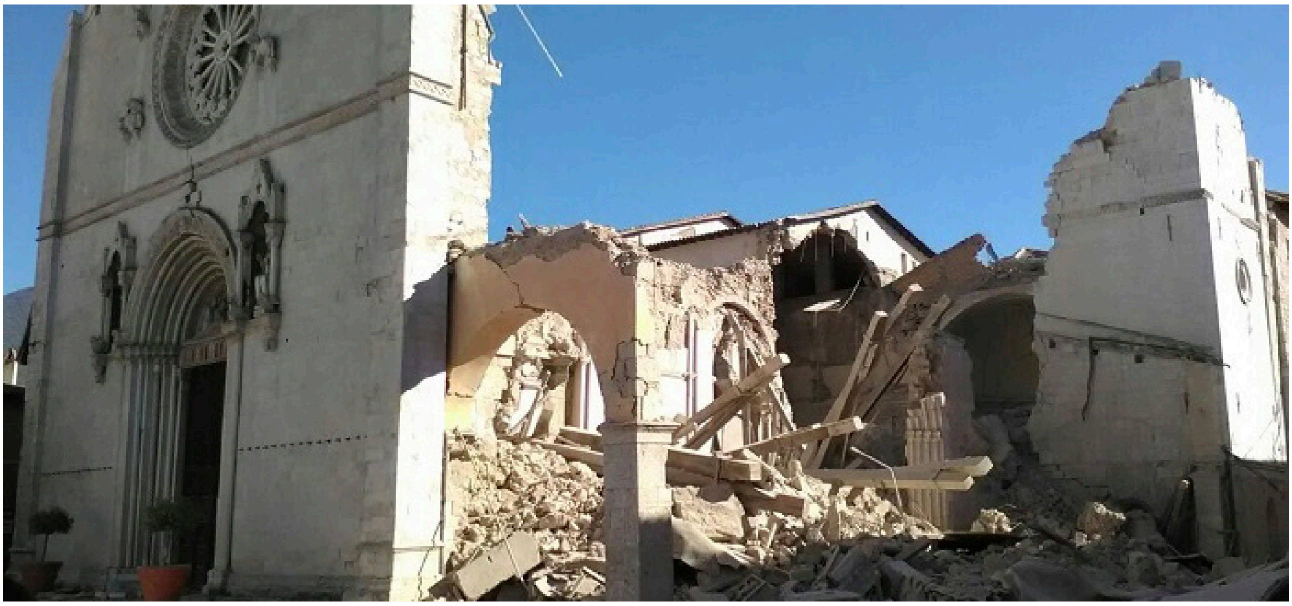
It is important to bear in mind that, as a general rule, it is not allowed to apply for two different funding sources for one project at the same time. However, different types of funding can be grouped, for example, private and public funds.

For financing the selected resilience measures for local authorities, the best solution could most likely be that of combining funding sources. For example, a crowd funding campaign, therefore private funds, could be anticipated by a publicly funded awareness raising campaign financed through EU grants.

Step 2
Selecting resilience measures

The possible responses and solutions associated with the impacts and effects of climate change or geophysical hazards may be familiar, even obvious, if these effects are related to an aggravation of problems already experienced by or familiar to a given place (floods, heat waves, thermal oscillation etc.). If, on the other hand, the potential impacts are new (infectious vectors, new pests, change in species productivity, etc.), they may be less obvious, and more effort will be needed to identify responses. In this phase, alternatives and possibilities for responding to the risks, challenges or opportunities must be identified, from which the best suitable measures can be selected depending on the socio-institutional context and the nature of the hazards that affect the historic or territorial context.

A wide range of resilience measures are available to reduce the negative impacts of climate change and other hazards. However, when it comes to heritage, due to its authenticity and heritage significance, the measures applicable to the specific area may be significantly reduced. This is especially true for structural measures (see Figure 8 for the definition) that may have a visual, physical and/or spatial impact and which may not be reversible. For example, in a historic area that has been designated as a sacred site by a local community, the community's perception of the heritage may determine whether certain measures, such as flood walls, are deemed appropriate or not. This may be related on how historic areas and their associated values are receptive to change based on their different qualities.



Step 2.1
Identification of resilience measures

Objectives

- Build a portfolio of resilience measures that are relevant and appropriate to the specific challenges or opportunities of the historic area and its specific characteristics
- Optimise the use of existing resilience assets
- Learn from good practices and „maladaptation" examples if available

A first step in this process is to identify the sources of information which may be relevant. The information to build a preliminary portfolio of resilience measures may come from catalogues of adaptation, risk reduction or resilience measures, good practices and reference cases in other historic areas or municipalities.
A few catalogues dedicated to general adaptation to climate change are available and to resilience of heritage [See Heritage Toolbox 1]:

- RESIN Adaptation Option Library* includes over 100 adaptation measures mainly for urban environments and addressing climate risks including heat; pluvial, fluvial and coastal floods; and drought
- Climateapp** provides urban designers, engineers or others insight in feasible measures for a project with a specific climate adaptation goal
- Urban Green-Blue Grids*** for resilient cities is focused on Nature-based Solutions (NbS) and provides not only general information about each NbS typology but examples of projects.

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* https://resin-aol.tecnalia.com/apps/adaptation/v4/#!/app/summary

** https://www.climateapp.nl/

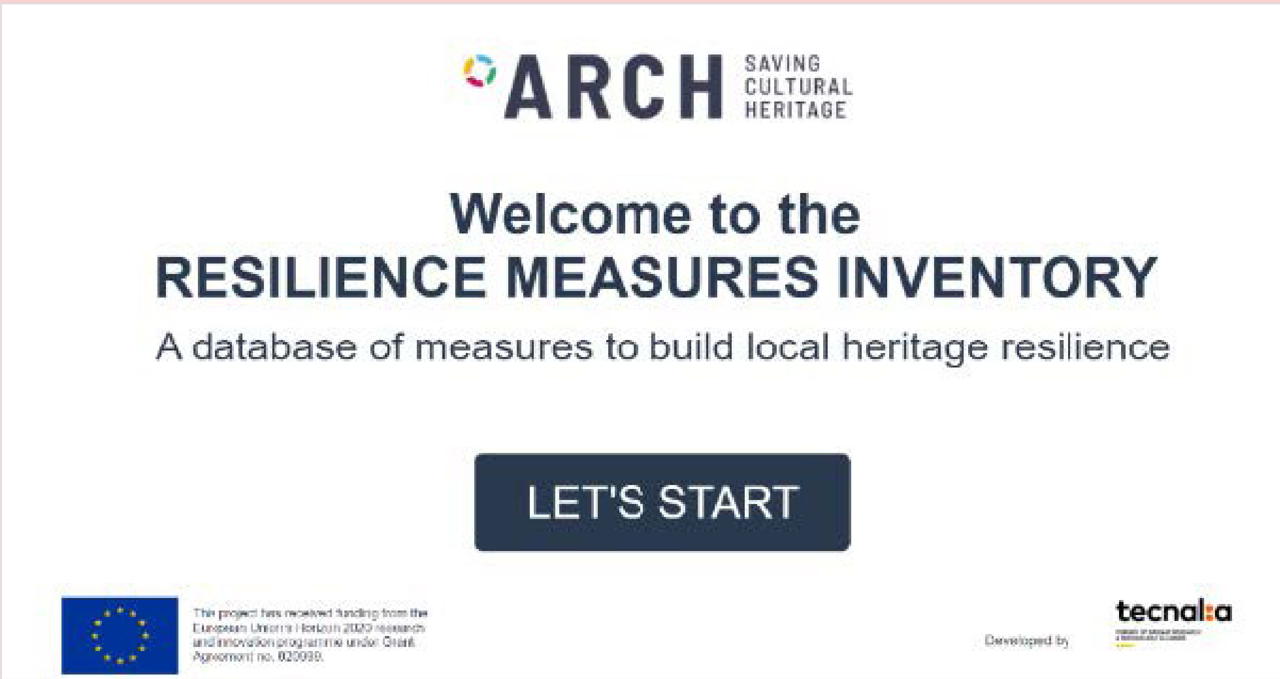
*** https://www.urbangreenbluegrids.com/measures/

Heritage Toolbox 1

The ARCH Resilience Measures Inventory and SHELTER Solution Portfolio provide databases focused on building local heritage resilience.

The ARCH Resilience Measures Inventory is designed to help identify measures along the disaster risk management and adaptation process to improve the resilience of historic areas.

The inventory is divided in two sections:
urban built heritage and agricultural heritage. It also provides addition information on general co-benefits and negative effects provided by the measures and the impact they could have on heritage.



The SHELTER Portfolio of solutions for emergency phases includes existing solutions/strategies gathered for their suitability for Climate Change Adaptation (CCA), preparedness, response and reconstruction, taking into account all the considered hazards (earthquakes, storms, floods, heat waves, wildfire and subsidence).

The Portfolio includes a Benefit-Cost Analysis and a simplified Life Cycle Assessment. The solutions/strategies are defined according to various indicators. The portfolio presents solutions and strategies to be implemented to tackle climate hazards. It is integrated in the Decision Support System of the SHELTER project.

Adaptive solution	**Temporary flood protection systems: Sandbags (buildings)**			**Prioritization Index**	0.87	Shelter	
DRM phase	☑ Emergency	☐ Prevention	☑ Preparedness	☐ Response	☐	Recovery & BBB	
Hazard	☐ **Heat waves**	☑ **Flooding**	☐ **Earthquakes**	☐ **Subsidence**	☐	**Wildfires**	☐ **Storm**
Action Scale	Building	**Function (1)**	Building protection	**Function (2)**			
Type of AS	Soft	Architectural and engineering solutions		**Technical requirement**		Low	
Impact on cultural value:	No			**Reversibility**		Yes	
Impact on protected CH	No						
Building:	☐						
Façade	☐ Material	☐ Components	☐ Carpentry	☐ Colour/finishing			
Roof:	☐ Material	☐ Volumetry	☐ Components				
Structure:	☐ Material	☐ Structural system					
Public zone:	☐ Pavement/ material	☐ Natural species	☐ Path/ Gradient	☐ Parc / natural environment			

Implementation time	Short time
Cost	Low
Effectivity	Temporal solution
Maintenance	Low
Recyclable	Yes
Reusable	Part

Pictures

Description

The use of sandbags is a simple, but effective way to prevent or reduce flood water damage. Properly filled and placed sandbags can act as a barrier to divert moving water around, instead of through buildings. Traditionally, sandbags have been used to block doorways, drains and other openings into properties. They can keep water out for short periods which can be improved by using them in conjunction with plastic sheeting.

Material

Burlap or woven polypropylene filled with sand or soil. Usually completed with plastic tarps or lones.

Other aspects:

Positive aspects:	**Negative aspects:**
Effective protection against minor flooding. They can filter out some muddy sediments found in flood waters. They are cheap and easy to obtain. No electricity or energy is needed. Adaptable and modulable. Usually traditional way to protect against floods.	Limited protection against major flooding. They take time to fill and laying them can be time consuming. They can be difficult to handle. Sacking material is biodegradable and will perish if left in place for a long time. When they come into contact with floodwater they tend to retain contaminants and bags can often only be used once. Flexible in small scale, but not easily adaptable for buildings covering a great area.

References

Environment Agency, Temporary and Demountable Flood Protection Guide, 2011.
Historic England, Flooding and Historic Buildings, 2015.
State Historical Society of Iowa, 1952.

Heritage Tip 2
V. Rebollo and V. Latinos. (2020) Good practices in building cultural heritage resilience. Deliverable 7.2. EU ARCH Project GA no. 820999.

This report is meant to serve as an inventory of good practices in building cultural heritage resilience. It contains an overview and classification of 40 cultural heritage resilience initiatives, providing information on their location, biogeographical region and lead(s).

32 of them are featured as snapshots and eight of them as case studies (containing in-depth information on aspects such as main outcomes, factors of success and lessons learned). Additionally, and reflecting upon the term "replicability", the report proposes a set of criteria to evaluate their transferability potential to other urban contexts.

3.2.6 CASE STUDY 2:

Patios de la Axerquía: Regenerating historical courtyards through social innovation

Type: Managerial -Governance model
Main hazard(s): Extreme temperatures, drought, desertification

Location: Cordoba, Spain
Biogeographical region: Mediterranean
Lead: PAX- Patios de la Axerquía

Background:

With a growing tourism industry and very little industrial activity, Cordoba (a city of some ca. 300,000 inhabitants) is now transforming itself and gradually becoming gentrified. The city is rich in architectural and intangible cultural heritage, and agriculture is very relevant for the economy. The unemployment rate in Cordoba is amongst the highest in Spain (at 28.5%).

Case description:

The historic district of Cordoba is suffering de-population as long-term residents abandon their courtyard houses seeking a more comfortable life away from mass tourism. In April 2018, PAX (Patios de la Axerquía) Association was established by local groups to regenerate the historic centre by restoring the abandoned courtyard houses (casa-patio) of the Axerquía (neighbourhood) together with resident groups constituted in housing cooperatives. An innovative operation of governance has been applied by the group fostering a change to the conventional urban development model based on speculation to one of rehabilitation of neglected areas, avoiding tourist-focused gentrification and allowing the people of Cordoba to reclaim their city's historic environment and its intangible heritage. PAX is a local experiment that is expected in the near future to evolve into a larger scale 'start-up' of urban governance facing gentrification processes.

PAX provides a new style of governance in relation to urban regeneration, incorporating social innovation in a heritage city by acquiring vacant houses and cooperatively using them; implementing multi-level co-management between the city administration and the local residents, and among the residents themselves. The project is pursuing urban regeneration of a specific vulnerable area by greening the city, recovering the architectural and intangible heritage value of the courtyard houses and forming a social and solidarity-based economy; therefore, the model bridges multiple concepts.

Pixabay / Frank Nürnberger

For more information on PAX, visit:
http://patiosaxerquia.org

Contact info:
Gaia Redaelli
gaia@patiosaxerquia.eu

Relevant sources:
www.built-heritage.net/gaia-redaelli-issue9

Courtyard Housed of Axerquia

El País article on Pax in the Mediterranean frame

Interview with Gaia Redaelli, co-founder and president of PAX

When considering the resilience measures for addressing the impacts and risks identified in Step 1: Preparing the ground and setting objectives, it can be the case that a long list of potential measures is identified. In this case, it may be relevant to classify (Figure 23) them to have an overview of the identified measures and ensure no gaps exist, or if they do exist, to be aware of them.

During this step not only can future resilience measures be identified but also past and current measures that could be further deployed. At the end of this sub-step a portfolio of resilience measures should be in place per impact or impact chain.

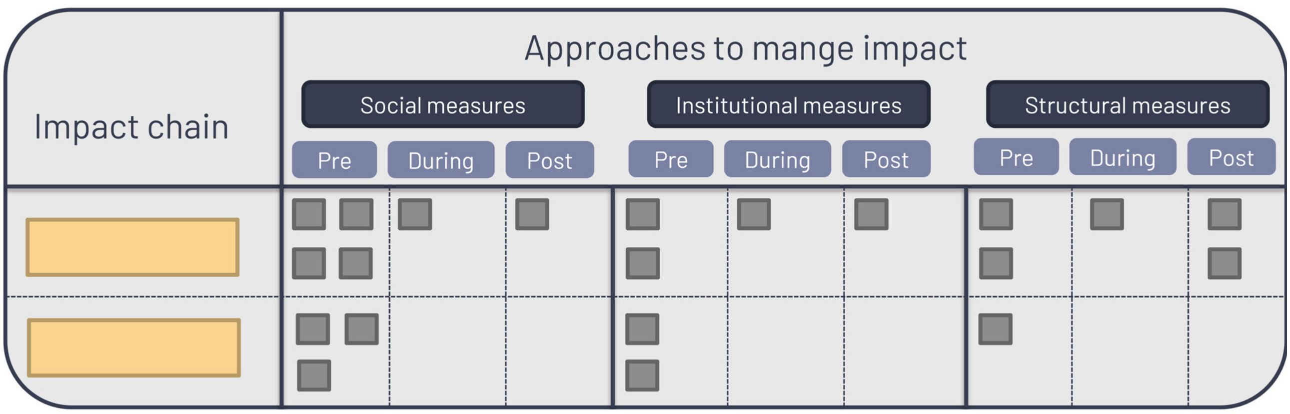


Figure 23 – Example of resilience measure's classifications

Step 2.2
Selection and characterisation of resilience measures

Objectives

- Establish the feasibility information or criteria for the selection of measures appropriate to our historic area or municipal reality
- Set the most suitable criteria for the characterisation and prioritisation of the resilience measures
- Characterise the resilience measures
- Identify appropriate methods for the prioritisation of resilience measures.

Step 2.1 aims at screening and building a portfolio of possible resilience measures, that is, to gather all resilience measures that can help prepare for, mitigate, and manage the impacts and risks of the previously prioritised hazards. Step 2.2 aims at characterising the measures based on relevant information for the stakeholders. This characterisation aims to help with the selection of resilience measures suitable for the historic area or municipality (Figure 24). This can be done sequentially in various steps or in one step depending on the number of identified resilience measures in step 2.1.

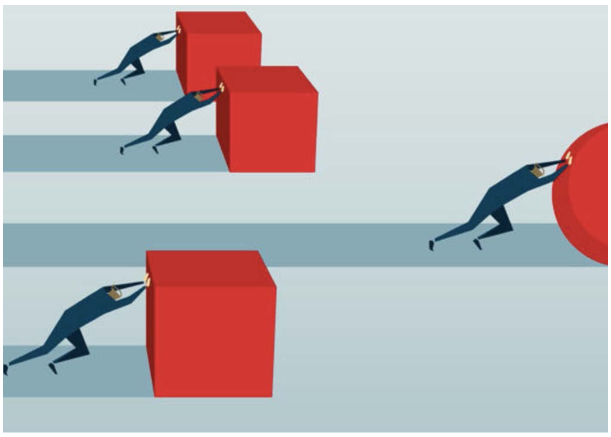


Figure 24 – Framework for assessing and selecting resilience measures. The long-term vision and impact and risk analysis may determine the evaluation criteria, while the methodology for effectiveness assessment will influence the pathway effectiveness assessment

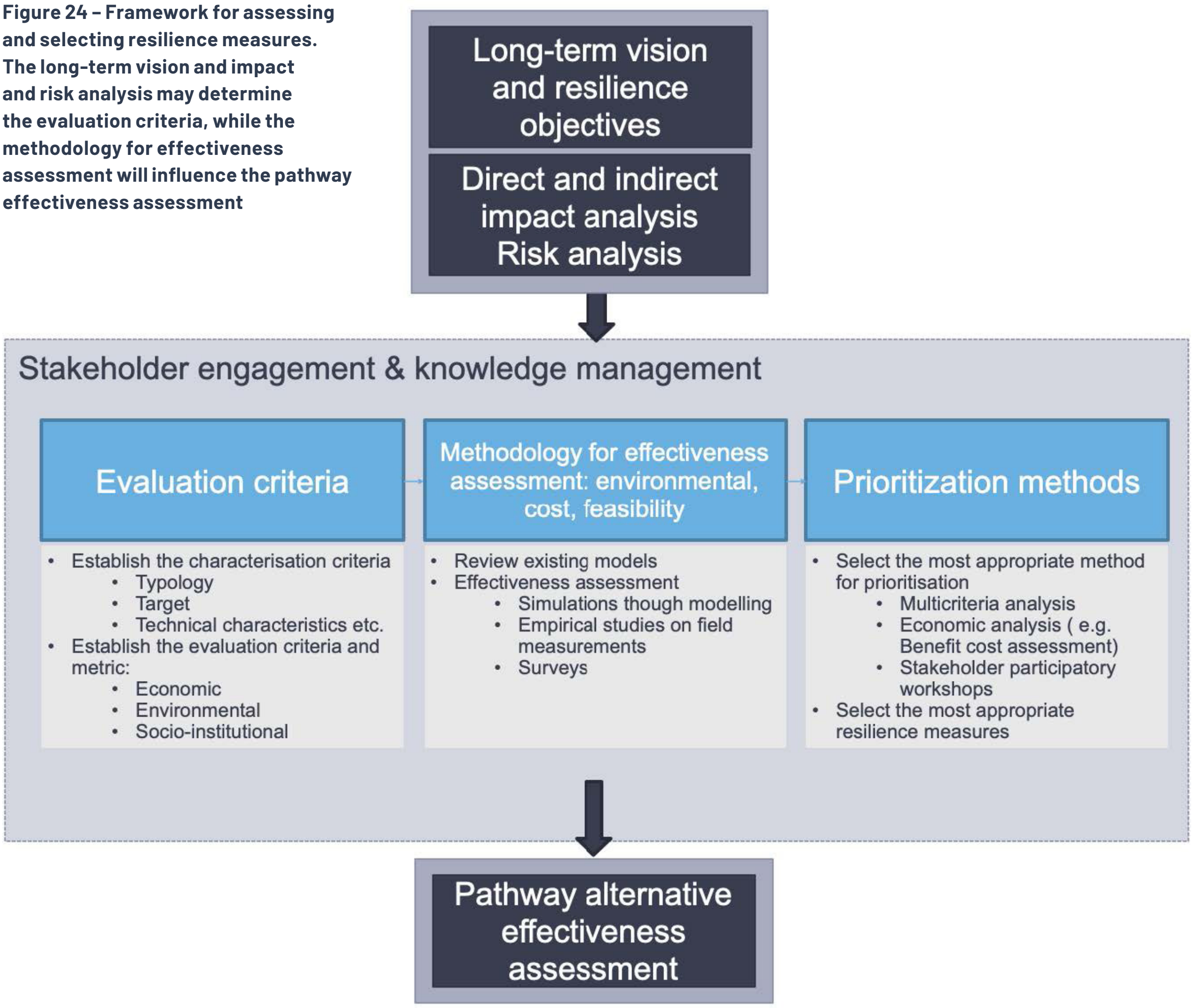
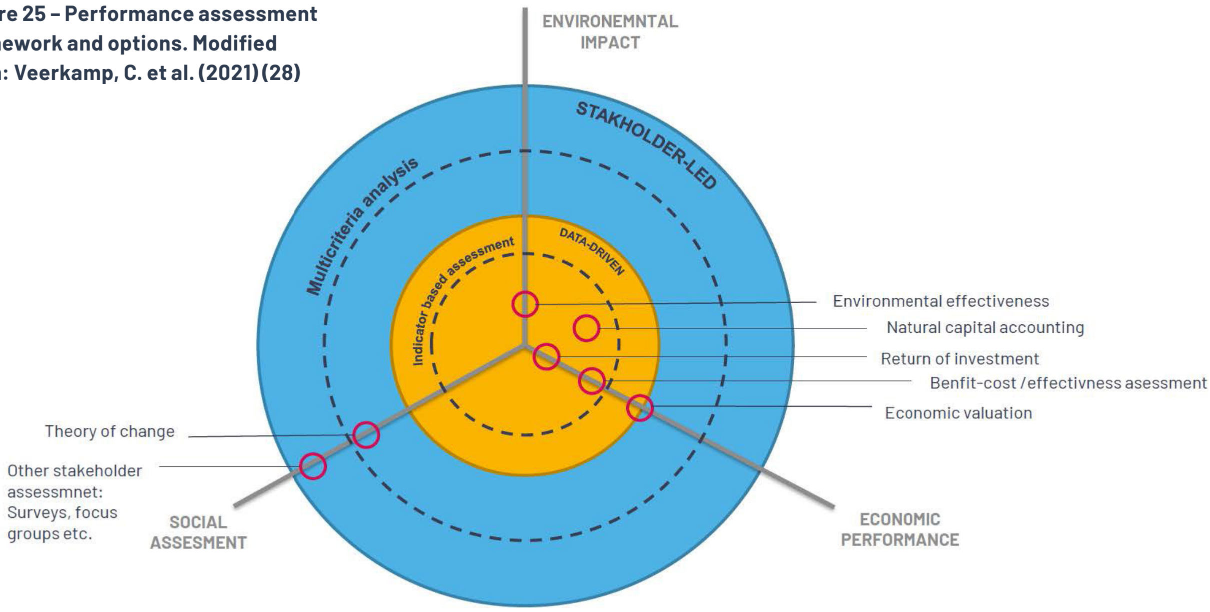


Figure 25 – Performance assessment framework and options. Modified from: Veerkamp, C. et al. (2021) (28)



In the Resilience Pathway approach, it is important to select the characterisation criteria considering the following matters:

- Whether it will be a stakeholder-led (participatory) or a data-driven pathway approach (Figure 25)

  _ Stakeholder-led assessments are often based on qualitative analysis of various criteria based on expert knowledge and experience. This may imply the consensus of a variety of stakeholders, for example on the socio-institutional acceptability of resilience measures. In this case, good knowledge of the local context and resilience themes (e.g. heritage, disaster risk management, climate change etc.) is essential. These stakeholders are especially useful to build on resilience narratives based on the description of potential climate change or other hazard impacts and possible responses if/when conditions worsen. This approach encourages understanding of the bigger picture and interconnections between adaptation to climate change, disaster risk management and heritage. It is also based on awareness-raising and stakeholder dialogue, which builds cohesion.

  _ Data-driven assessments often require a quantitative or semi-quantitative approach based on indicators. These indicators are often related to economic performance or environmental impact, such as benefit cost ratio and flooding height reduction, respectively. This information may be derived from modelling, literature information from laboratory or site-specific testing, statistical data, etc. It allows for the direct addressing of hazard impacts based on evidence.

- The availability of data to assess and prioritised the resilience measures. Often quantitative data may not be available for all the identified resilience measures, in this case qualitative assessment may be sought.

- The robustness of the data. This may determine the importance of the criteria in the selection and prioritisation of the criteria.

Table 8 – Example of characterisation criteria. Economic performance, environmental effectiveness criteria are included together with criteria that describe the nature of the measures (what they are for and general characteristics).
BCR: Benefit Cost Ratio

Measure name	Disaster Risk Management phase	Nature of measure	Target	Effectiveness as Expected Annual Loss reduction (%)	Cost	BCR
Awareness raising	Pre—during—post	Social	Community and stakeholders	—	Low	High
Building strengthening	Pre—post	Structural	Building & structures	High	High	Medium—High
Protocols and guidelines	Pre—during—post	Institutional	Community and stakeholders	—	Medium	Medium
Early warning system	Pre—during	Structural (social)	Community and stakeholders	—	Medium	Medium
Public and private economic instrument	Pre—post	Institutional	Community and stakeholders	—	Medium—High	Medium
Risk mapping	Pre	Social	Community and stakeholders	—	Low	Medium
Emergency stabilization	During	Structural	Building & structures	High	High	Low

As previously mentioned, the resilience measures' characterisation may be performed in one stage (see example in Table 8 or (29)) or subsequent stages. The number of resilience measures to be assessed, the type of criteria, the complexity of acquiring the information, and the pathway assessment approach (stakeholder-led or data-driven) may determine the final procedure. For example, when all measures gathered in the portfolio may not be viable for implementation and their environmental performance assessment may be difficult to obtain for all, a preliminary feasibility assessment may be done as a starting point (see Table 9 for an example). Then, the environmental effectiveness or economic performance can be assessed or searched for in literature for the shortlist of resilience measures. The feasibility criteria may vary across local contexts, but may include:

- **Heritage criteria such as the physical, visual, spatial impact that the measure may have on heritage or how the measures may affect the authenticity and heritage significance**

  _ Will the resilience measure's implementation entail a significant change in the heritage significance and function?

  _ What changes in the historic area are possible without its identity to be threatened?

- **Legal criteria such requirements from e.g. the Cultural Heritage Protection Act**

  _ Does the national/regional/local heritage legal framework hinder the implementation of specific resilience measure?

- **Technical criteria such as ease of implementation or technical knowledge requirements**

  _ Can the resilience measure be implemented at local administrative/government level without further support? If support is needed, would be very difficult to get this support or acquire this knowledge in the future? Can the resilience measures be implemented while maintaining the heritage values without further support?

  _ Would the necessary skills and competencies to manage and maintain the resilience measure's function be available for this measure? If not, would be very difficult to get support or get these skills in the future?

- **Environmental criteria such as environmental trade-off**

  _ Does the resilience measure's implementation result in environmental damage?

- **Social criteria such as community acceptability, social equity and inclusiveness or social trade-offs**

  _ Does the implementation of the resilience measure undermine other social policy objectives?

  _ Would the local community accept this resilience measure?

- **Institutional criteria such as institutional acceptability, mainstreaming potential and other enabling conditions**

  _ Would local stakeholders accept this resilience measure?

  _ Is there a specific limiting factor on the implementation or upscaling of this type of resilience measure?

  _ Could the resilience measure be integrated with existing local government planning and policy development?

- **Economic criteria such as economic constraints**

  _ Is there a lack of financial resources and economic structure to support this type of resilience measure? Can this constraint be overcome?

  _ Does the municipal or management entity have potential access to funding to cover the cost? (See Step 1.6 Financing the flexible Resilience Pathway)

Feasibility screening can be seen as a first characterisation step which can help on the pre-selection of most suitable resilience measure or to narrow down the number of resilience measures. The next step would be to perform a deeper assessment or characterisation of the new portfolio of measures based on their **environmental or economic performance** and any other relevant criteria such as barriers, co-benefits or "maladaptation" potential (i.e. may entail associated or undesirable side effects). Feasibility and impact characterisation performed subsequently may facilitate the process of resilience measure selection and their ranking, if needed.

Tip 8
Feasibility assessment

Table 9 – Example of a possible feasibility assessment and prioritisation methodology

Resilience measures	Feasibility criteria					Result	Priority actions
	Heritage	Technical	Environmental	Social	Economic		
A	Low (1)	Medium (2)	High (3)	High (3)	Low (1)	10	3
B	Low (1)	Low (1)	High (3)	Medium (2)	Medium (2)	9	4
C	Low (1)	High (3)	Medium (2)	High (3)	High (3)	12	2
D	Low (1)	Low (1)	High (3)	Low (1)	Medium (2)	8	5
E	Medium (2)	Low (1)	Low (1)	Medium (2)	High (3)	9	4
F	High (3)	High (3)	Low (1)	High (3)	High (3)	13	1

Tip 9
Resilience pathways, in contrast to Adaptation Pathways, consider not only structural measures to directly address the hazard impact based on evidence (data-driven pathway), but also social and institutional ones (Table 4). Socio-institutional measures are also important to decrease the impact of extreme events, however most socio-institutional resilience measures do not have a direct effect on the reduction of natural hazards' impact. Thus, Resilience Pathways should be assessed using an economic performance metric such as the benefit-cost ratio (BCR).

Tip 10
Threshold analysis (Step 1.4 Define resilience threshold or objectives) may only be performed when working with environmental performance.

Tip 11
It is worth noting that many performance metrics depend on multiple local factors. This should be kept in mind when extracting performance data from literature. The range of effectiveness (the difference between the maximum and minimum values) will allow for a better understanding of how context-dependent the performance of the specific resilience measure may be.

Prioritisation of measures is undertaken with the aim of selecting the most efficient and adequate options to face challenges and enhance the resilience of the historic area/ municipality. The most commonly used methods are:

- **Monetary Analysis**
  The methodologies under the monetary analysis are based on assigning monetary values to inputs and outputs, and thus facilitating the comparison of a resilience measure or a group of them working towards an objective. Cost effectiveness analysis (CEA) and cost benefit analysis (CBA) are among the most used methodologies.

- **Multi-criteria (Decision) Analysis**
  is a method which has the advantage of considering not only monetary based criteria, but e.g., environmental, social, cultural criteria in the evaluation. It allows stakeholders to organise information and to contribute to supporting decision-making processes (often with a high degree of uncertainty) based on the transdisciplinary understanding of the problem.

Tip 12

Multi-criteria analysis (MCA) manual for making government policy provides guidance for government officials and other practitioners on how to undertake and make the best use of multicriteria analysis for the appraisal of options for policy and other decisions (30).

Typical eight step process in MCA are summarized below:

1. **Establish the decision context**

   How can the MCDA fit into Climate Change Adaptation? How can the overall problem assessment be broken down? What do we want to know?

   1.1 Establish aims of the MCDA, and identify decision makers and other key players
   1.2 Select technical and economic resources for conducting the MCDA
   1.3 Consider the context of the appraisal

2. **Identify the options to be appraised**

   Identify alternative policies, programmes, plans, projects or designed solutions. Are there any options? How many options should be compared in a MCDA? Which options should be compared with each other?

3. **Identify objectives and criteria**

   Can criteria be identified and formulated? Is there enough data for the evaluation?

   3.1 Identify criteria for assessing the consequences of each option
   3.2 Organise the criteria by clustering them under high level or lower-level objectives in a hierarchy

4. **"Scoring". Assess the expected performance of each option against the criteria. Then assess the value associated with the consequences of each option for each criterion**

   4.1 Describe the consequence of the options
   4.2 Score the options on the criteria
   4.3 Check the consistency of the scores on each criterion

5. **“Weighting”. Assign weights for each criterion to reflect their relative importance to the decision**
   Identification of priorities at all the levels of the hierarchy structure, i.e. what is the assessment focus? Which hierarchy elements are more or less important than others?

6. **Combine the weights and scores for each option to derive an overall value**

   6.1 Calculate overall weighted scores at each level in the hierarchy
   6.2 Calculate overall weighted scores

7. **Examine the results**
   This is an iterative process, and if the user is not satisfied after the results the evaluation and repetition of the previous steps is recommended

8. **Sensitivity analysis**

   8.1 Conduct a sensitivity analysis:
   Do other preferences or weights affect the overall ordering of the option?
   8.2 Look at the advantages/disadvantages of selected options,
   and compare pairs of options
   8.3 Create possible new options that might be better than those originally considered
   8.4 Repeat the above steps until a “requisite” model is obtained

Step 2.3
Spatial planning

Objectives

- Facilitate the effectiveness assessment of pathway alternatives
- Identify feasible places to deploy each type of resilience measure
- Assist spatial planning of structural measures to achieve resilience objectives and minimize risks

Resilience measures' impact may depend on their spatial deployment and their effectiveness may vary, for example, on the total implemented area, the existing landscape or structures of a given area. For example, depending on where infiltration techniques are implemented at the city/neighbourhood scale*****, the pluvial flooded areas may decrease or not. To provide another example, at the building level, depending on the vulnerability of buildings towards earthquakes, the deployment of measures may vary. This spatial planning of measures is mainly relevant for structural measures and modelling exercises (Figure 26) to assess the environmental performance of pathway alternatives (Step 3).

At this stage the focus is on where the identified measures can be implemented to minimize impacts, and thus, increase resilience. This step requires the involvement of e.g. planning experts to reflect what resilience measures are feasible to deploy at the local level and to identify feasible locations for the implementation of measures. In order words, the idea is to create an "opportunity map". This can be done, for example, by cross-linking land use typology with resilience measures as seen in Table 10 .

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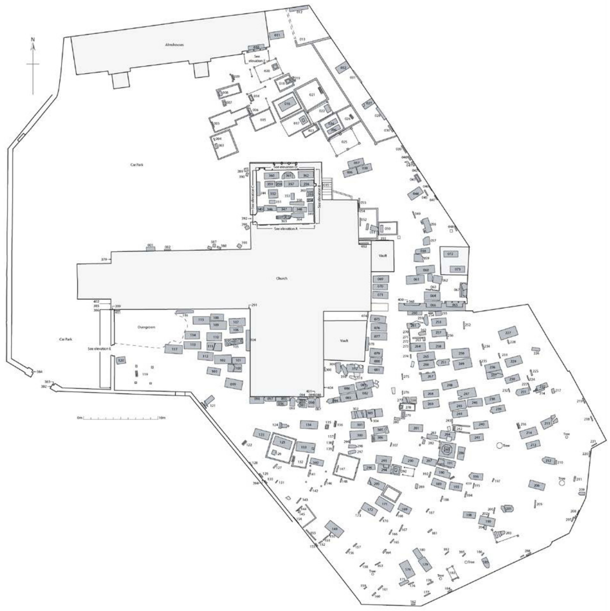
* Infiltration components are used to capture surface water runoff and allow it to infiltrate (soak) and filter through to the subsoil layer. Infiltration components can be incorporated into a range of sustainable drainage systems



Plan of Saint Mary's Church and Graveyard, Kilkenny City
(Numbers refer to inventory entries)

Figure 26 – Modelling outputs without and with resilience measures

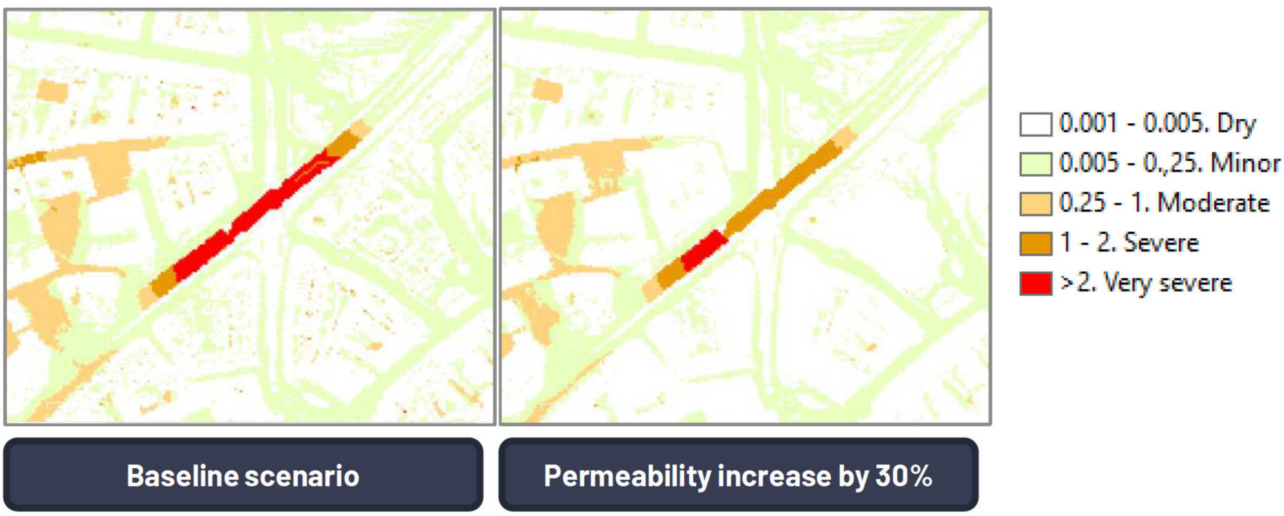
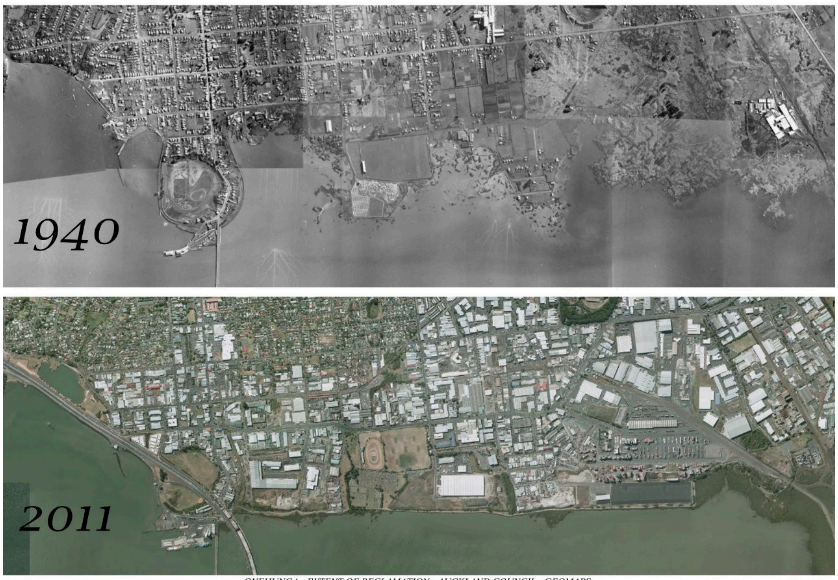


Table 10 – Example of prioritisation of resilience measures to address pluvial flooding per land- use typology and heritage significance of the area for Bratislava case study

Measure	Public spaces		Sidewalks		Buildings		Green areas	
	Historic	Other areas	Historic	Other areas	Historic	Other areas	Historic	Other areas
Grass	2	2					2	2
Permeable pavement	1	1	1	1			1	1
Water Plaza	4	5						
Trees	3						3	3
Parks/ gardens	5	3						
Infiltration trenches		4	2	2			4	4
Rainwater harvesting					1	1		
Green roofs						2		



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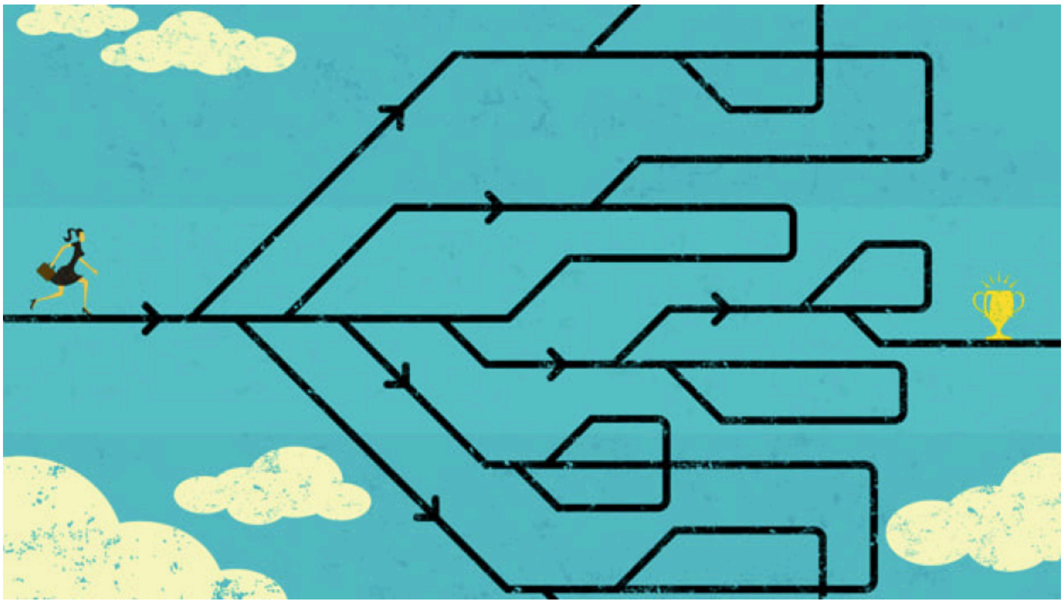
Step 3
Developing pathway alternatives

This step aims at analysing and benchmarking the environmental effectiveness or economic efficiency of different groups of resilience measures or pathway alternatives. This step requires a stakeholder dialogue to set the criteria to (i) re-organise the resilience measures in groups, (ii) define the most suitable pathway alternative (Step 4: Selection of best pathway alternative) and (iii) sequence the order of the deployment of resilience measures. To minimise resource use, often the selection of best pathway alternatives is performed prior to the visual representation of the pathway. The visual representation of a pathway alternative may vary, but often is created via the sequencing of the resilience measures, like a road map.



Step 3.1
Resilience pathway alternative development

Objectives

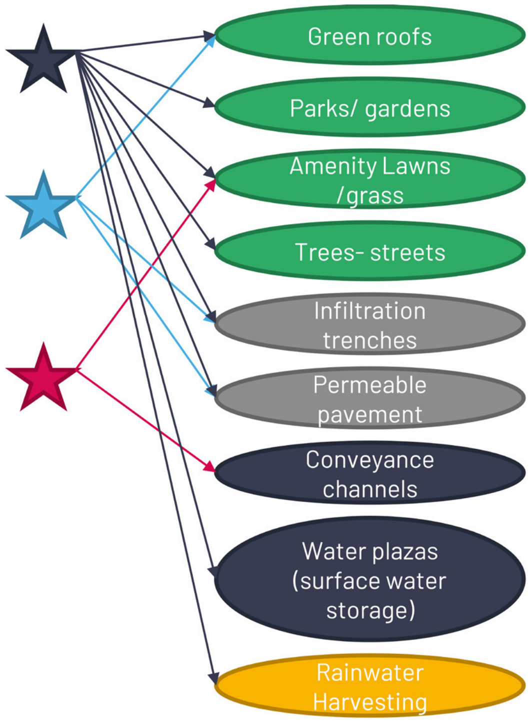
- Encourage the consideration of a wide range of measures to help achieve a long-term vision in term of resilience
- Clustering resilience measures based on relevant criteria or considerations

What is a Resilience Pathway alternative?
A pathway alternative is a cluster of resilience measures, similar to a resilience or adaptation strategy. This cluster is usually built based on a criterion or on stakeholder preferences. Criteria may vary depending on local needs and preferences. Criteria may be related to the type of mechanism of action, nature of the measure, barriers, costs, heritage significance alteration, heritage identity preservation level etc.

Figure 27 presents an example to clarify this concept. In the figure, no criterion has been applied for pathway alternative 1 considering all measures that may have hypothetically been selected in Step 2. In pathway alternative 2 just one typology of resilience measure is considered, based on the aim to address pluvial flooding, while the pathway alternative 3 is the result of the stakeholders' preferences.

Figure 27 – Example of resilience measure clustering based on different criteria

- **Pathway alternative 1:** All selected measures are considered
- **Pathway alternative 2:** Just infiltration techniques are considered
- **Pathway alternative 3:** Just grass and conveyance channels are considered



What is the advantage of considering a cluster of resilience measures in the resilience building process?

It can help to tackle a challenge in a more holistic way by assessing the impact of all potential measures simultaneously. This is especially important if the effectiveness assessment of the pathway alternatives (step 3.2) is performed by modelling or an ad-hoc economic performance analysis.

Pathway alternatives allow for better assessments of the impact of a possible resilience strategy and benchmark the performance of different clusters of measures (pathway alternatives) at the same time. When considering an environmental performance assessment in order to address the challenges indicated in Step 1, the pathway alternative will allow to determine if our objectives or thresholds are achieved.
In other words, pathway alternatives will allow, in a flexible way, to determine how much pathway deployment is needed to reach to the set objectives over time (in relation to steps 3.2 and 3.3).

Step 3.2
Assessment of effectiveness

Objectives

- Assess the performance (e.g. effectiveness or efficiency) of each pathway alternative
- Reveal which pathway alternatives can reach the established thresholds or objectives
- Provide information that will support the sequencing of actions by providing e.g. the effectiveness or efficiency of each resilience measure
- Understand how much adaptation or resilience is needed for various futures

In performance-oriented or data-driven pathways to address climate change and other natural hazards, there are two different approaches to assess the performance of resilience measures:

- **Quantitative**

  _ *Environmental performance*
  Simulations via modelling, as the ones shown in Figure 26) allow for the consideration of the local context and spatialization of resilience measures. Modelling accounts for drivers that may increase or decrease the impact of the hazard. Effectiveness can be presented in a dynamic way and at different scales. It assists with the identification of "hot-spots", or areas where problems may arise.

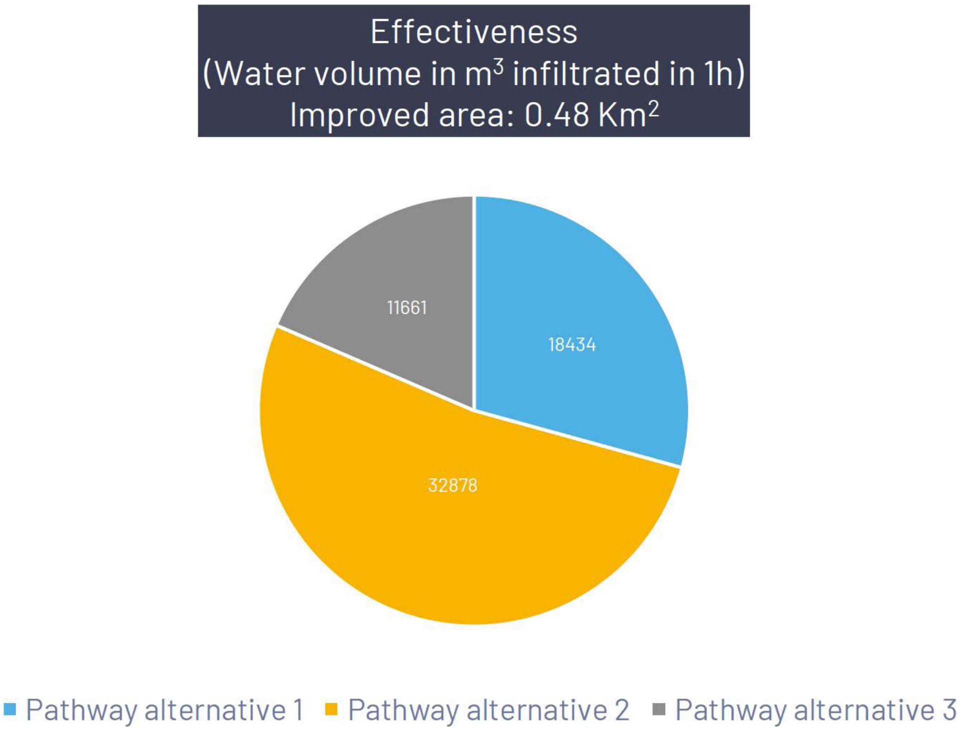
  _ *Economic performance*
  Scenario-based cost benefit analysis, or other similar methodologies, help inform the assessment of the robustness and economic desirability of the pathway alternatives, by seeing them as investment choices. It accounts for the local context, thus being more accurate than the semi-quantitative approach. It also may allow, in the design step of the flexible Resilience Pathway, to better identify which investments are necessary as starting points and keep options open to increase protection in the future, while maintaining economic efficiency.

- **Semi-quantitative**

Through the use of scientific data, the overall theoretical pathway effectiveness or efficiency can be calculated as the sum of an individual measure's performance (see Figure 28 as an example). Despite being less accurate than the quantitative approach in determining each pathway alternative's impact, it allows for benchmarking of the pathway alternatives and helps by presenting the pathway alternative with the highest performance.

This approach may not be able to determine whether measures are relevant to lower the risk in specific vulnerable areas but will allow ranking of the different pathways based on their effectiveness in reducing the impacts of a climatic or other natural hazard. This was seen by Mendizabal et al. (2018) (29) by assessing various Adaptation Pathways' effectiveness towards pluvial flooding. This approach requires fewer resources and technical knowledge than the quantitative assessment.

Figure 28 – Example of result achieved by semi-quantitative performance analysis of pathways alternatives considered in Figure 27 for pluvial flooding



As shown in Table 4, Resilience Pathways, in contrast to Adaptation Pathways, need to be assessed using an economic performance metric such as the Benefit-Cost ratio to allow the consideration of socio-institutional measures. These measures are vital to be included in the full disaster risk management cycle. Adaptation pathways may be complemented with socio-institutional measures in a parallel qualitative pathway, which would be outside the environmental effectiveness assessment.

Tip 13

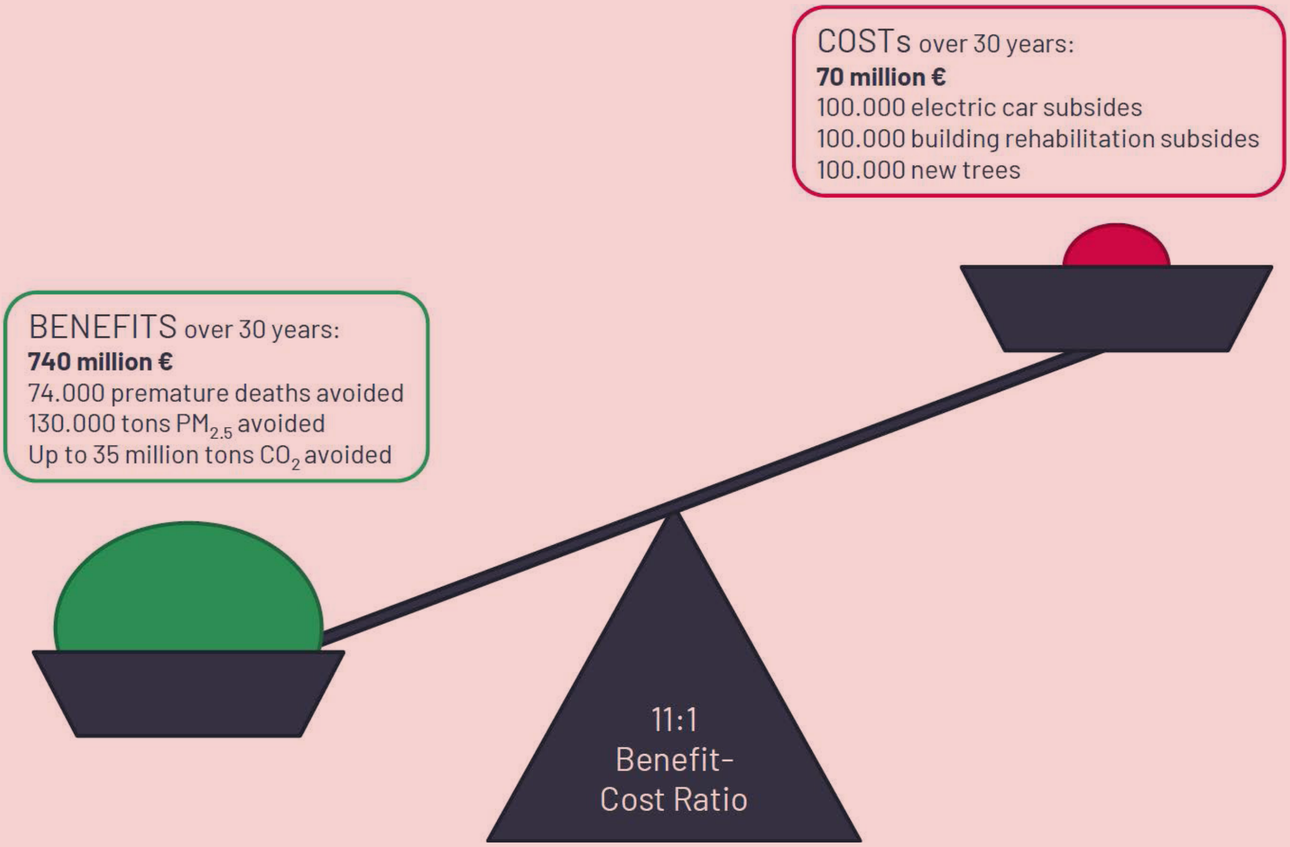
The Australian National Climate Change Adaptation Research Facility published an information manual (31) which provides guidance on a Cost-Benefit assessment to help decision makers to assess the costs and benefits of adaptation interventions and Adaptation Pathways. It advises on how to navigate the difficult landscape of deciding when, why and how to assess the costs and benefits of adaptation.

Heritage Tip 3

Benefit-Cost analysis may help:

- Decide which heritage places to protect and conserve first (when physical interventions have spatially been decided. See Step 2.3) based on their risk to hazard, their heritage values and community benefits. This will for example help the allocation of scarce budget.

- Decide on which pathway alternative's benefit is likely to be the greatest in comparison to the costs involved to increase the resilience of the historic area.



Step 3.3
Assessment of effectiveness

Objectives

- Create a roadmap of resilience by assembling sequences of resilience measures to address the identified risks
- Reflect under which conditions the measures loose effectiveness and new measures are needed
- Select what measures have highest priority for implementation considering risks and spatial planning if necessary (where to implement)

Once the effectiveness of the resilience measures and pathway alternatives have been assessed, there is a need to draw a roadmap representing the possibilities of the measure's deployment. Generally, this roadmap is represented by a sequence of the resilience measures. It is important to consider the previously gathered information (the current situation, future expected risks, defined threshold/objectives, etc.) and other relevant criteria that may support decision-making, such as urgency of action, when establishing the order of deployment. The sequencing can be done for all pathway alternatives or just for the pathway alternative most suitable for the historic area's context (see Step 4: Selection of best pathway alternative).

The order by which the measures should be implemented over time can be decided by:

- direct stakeholder judgment
- a co-creation process
- multi-criteria analysis (see guide on page 84)
- Feasibility analysis (e.g., Table 9)

Which criteria may be relevant to help on the sequencing?

There are several criteria that may determine the order in which the resilience measures may be deployed to achieve the desired goals, as shown in Figure 30. The relevance of the criteria will depend, among other factors, on the local socio-institutional context including: the participating stakeholders in the resilience-building process; relevant hazards; historic area characteristics and how resilience will be built.

Figure 29 – Example of criteria that may be used to prioritise the roadmap development

Effectiveness

- Physical damage reduction (%)
- Annualized collapse probability reduction (%)
- Mortality decrease (%)
- Economic loses reduction (%)
- Benefit cost ratio

Easy implementation

- No need extra support from e.g. other authorities/ stakeholders
- Time required on implementation

Impact on heritage significance

- Aesthetic
- Social significance
- Historic value
- Authenticity

Cost

- Investment cost
- Maintenance

Other

- Urgency of action or risk level
- Stakeholder acceptability
- Feasibility

What are the key elements when drawing an Adaptation Pathway?

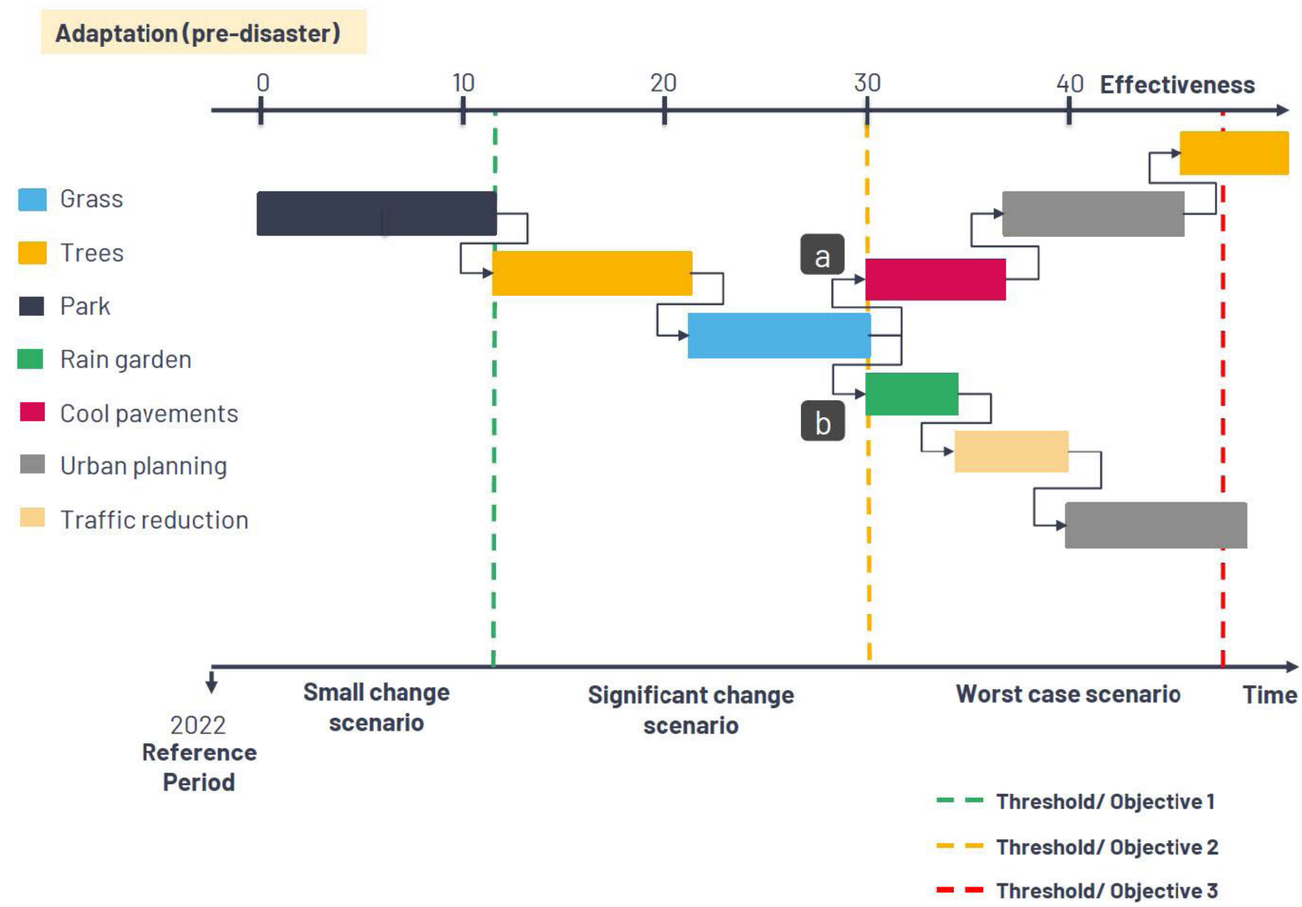
There is not only one way to design Adaptation Pathways. As previously mentioned, they are represented as a sequence of actions. They can range in complexity, and can be drawn as a linear sequence (Figure 32) or have a decision tree structure (Figure 30). Furthermore, there are few elements that should be considered, and which makes the pathway approach unique:

1. Performance and appraisal of the pathway alternatives
Dynamic adaptive policymaking tools, in which Resilience Pathways are included, were conceptualized to address uncertainty in decision making, while incorporating evidence-based information. Though an appraisal of the pathway alternative's effectiveness is done in Step 3.2 Assessment of effectiveness, the graphical displays associated with the sequencing are also informative, with regards to how the order of the adaptation measures contributes to meeting the set objectives.

In Figure 30 an example of a quantitative graphical display is shown. The upper horizontal axis can represent the environmental or economic indicator to assess the effectiveness/efficiency of the resilience measures (larger size of the bar indicates higher level of effectiveness) as well as the cumulative performance, while the lower horizontal axis represents time.

Tip 14
In an evidence-based (quantitative) pathway approach, the individual and/or cumulative resilience measures' effectiveness are represented as a sequence over time. In qualitative pathways (often stakeholder-led pathways, which may be used to create narratives towards heritage resilience), performance is not represented in this way, rather just the order in which the measures should be deployed and assigned to different hazard scenarios.

Figure 30 – Example of the sequencing graphical display of an Adaptation Pathway (pre-disaster)



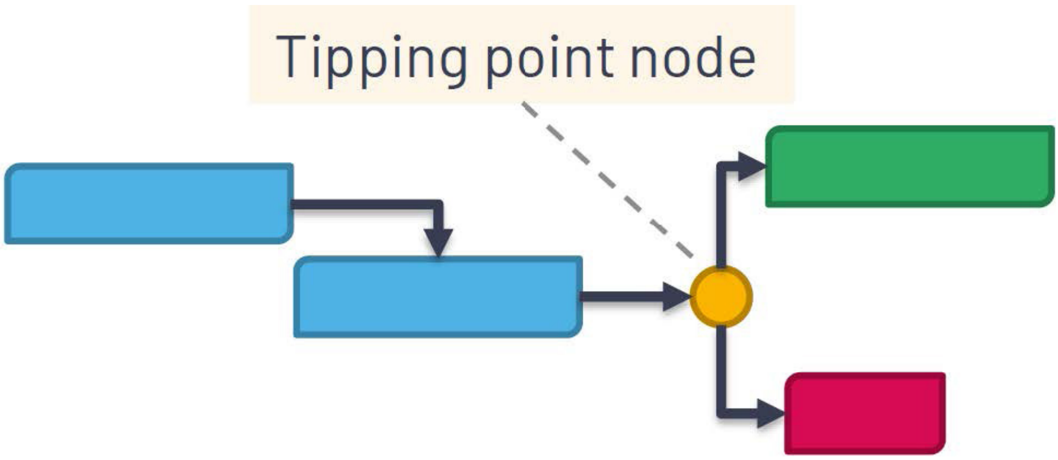
2. Thresholds/ tipping points or objectives

In Adaptation Pathways, different future scenarios are considered and planned for – and generally those which are linked to thresholds (dashed vertical lines in Figure 30) or tipping points. Thresholds represent the point at which the system is no longer effective or when the impacts associated with a hazard are deemed not to be bearable. In this instance, the system would reach a "tipping point" which implies a decision needs to be taken. At this moment the pathway alternative is reinforced with another set of measures.

For example, in Figure 30 a tree graph-like design is presented when reaching the worst-case scenario (vertical yellow dashed line). In this case, it should be decided which of the two possible routes (a) or (b) to implement. However, it should not be forgotten that Adaptation Pathways are a representation of a plan designed well ahead to prepare for future envisioned climate change impacts while their deployment is initiated once certain "tipping point" conditions occur.

Tip 15

There are different representation forms of tipping-points in the diagram. The most common ways are as a decision node or with thresholds lines like in Figure 32.



3. Flexibility with measures deployment time and roadmap possibilities

Flexibility is considered within the Adaptation Pathways in various forms, and which depends on the availability of new or more precise knowledge:

- *Measure deployment*
  Adaptation pathways ensure the consideration of various future scenarios and, depending on the evolution of the problem, the road map is reinforced with another set of measures, modified or even delayed. In other words, in Figure 30 it may happen that after deploying measures like parks, trees and grass, there is no need for further measures deployment as the result of a successful policy, e.g., climate change mitigation actions. Thus, maladaptation would be avoided by avoiding measures that are not needed such as cool pavement, urban planning associated measures and extra trees (route a) or those included in route b.

- *Thresholds*
  These are related to scenarios of change or conditions that negatively impact the historic or urban area. These scenarios are bound to an estimated timeline which can be affected by uncertainty as to when they will take place. Thus, thresholds may need to be shifted, as the likelihood of reaching them earlier or later is known. This will help to avoid an inappropriate use of resources by acting too early or too late.

- *Route of deployment*
  As seen in Figure 30, when tree-like pathway design is possible and various routes have been designed for a pathway alternative, when reaching threshold/ objective 2 (yellow dashed line), the decision-makers can choose to reinforce the pathway with route (a) or (b). This will enable to take into considerations the historic area and local context at the point of decision and not only on planning.

- *Maladaptation*
  As implementation of past adaptation measures and their impacts are observed via a monitoring and evaluation strategy, the pathway approach should inform best practices to guide decisions away from maladaptation. Thus, the pathway approach allows "steering the wheel" when necessary for better adaptation.

What are the similarities and differences with Adaptation Pathways when drawing Resilience Pathways?

The most important difference is that resilience accounts as well for disaster planning and management, through the lens of sudden risks as well as slow-onset (future) risks. The ARCH Resilience pathways are conceived based on the ARCH Resilience definition for historic areas, which takes a holistic perspective, where dimensions such as the social, cultural or political are considered.

ARCH Definition: Resilience of a historic area
"The sustained ability of a historic area as a social-ecological system (including its social, cultural, political, economic, natural and environmental dimensions) to cope with hazardous events by responding and adapting in socially just ways that maintain the historic area's functions and heritage significance (including identity, integrity and authenticity)."

1. Performance and appraisal of the pathway alternatives

Adaptation pathways, when data-driven, have been focused on reducing the hazard impact mainly by structural measures (mainly the environmental dimension of resilience*****). The performance of the pathway alternatives in these cases have been assessed by either environmental or economic indicators. However, Resilience Pathways aim at incorporating the community and institutional****** sphere of resilience more explicitly. Environmental metrics are generally not suitable to assess the performance of these two relevant spheres of resilience. Thus, in the case of Resilience Pathways, economic efficiency-related metrics are indicated both for pre-disaster as well as during and post-disaster phases.

Resilience pathways can plan the future deployment of measures based on cost efficiency, on how climate is expected to unfold, or on scenarios of change in the frequency or intensity of geophysical hazards (pre-disaster phase). Thus, when economic performance is used, the necessary measures to safeguard the historic area's functions are identified while maintaining the cost efficiency per scenario (quantitative approach). When quantitative approaches are not available, the resilience measures can be assigned to each scenario, setting specific objectives for each scenario (semi-quantitative approach). In this case, it is desirable to document how the objectives were determined and the reasons behind the decisions and assumptions made need to be documented then.

The graphical display of the pre-disaster phase is similar to the one for Adaptation Pathways as seen in Figure 31. However, a Resilience Pathway complements the pre-disaster figure with a second graphical display dedicated to planning for during and post-disaster phases, which can also represent the performance of the resilience measures by an economic indicator such as Benefit-Cost ratio. A decision tree structure representation can be used in the planning of during and post-disaster phases to acknowledge the different routes depending on the severity of the disasters.

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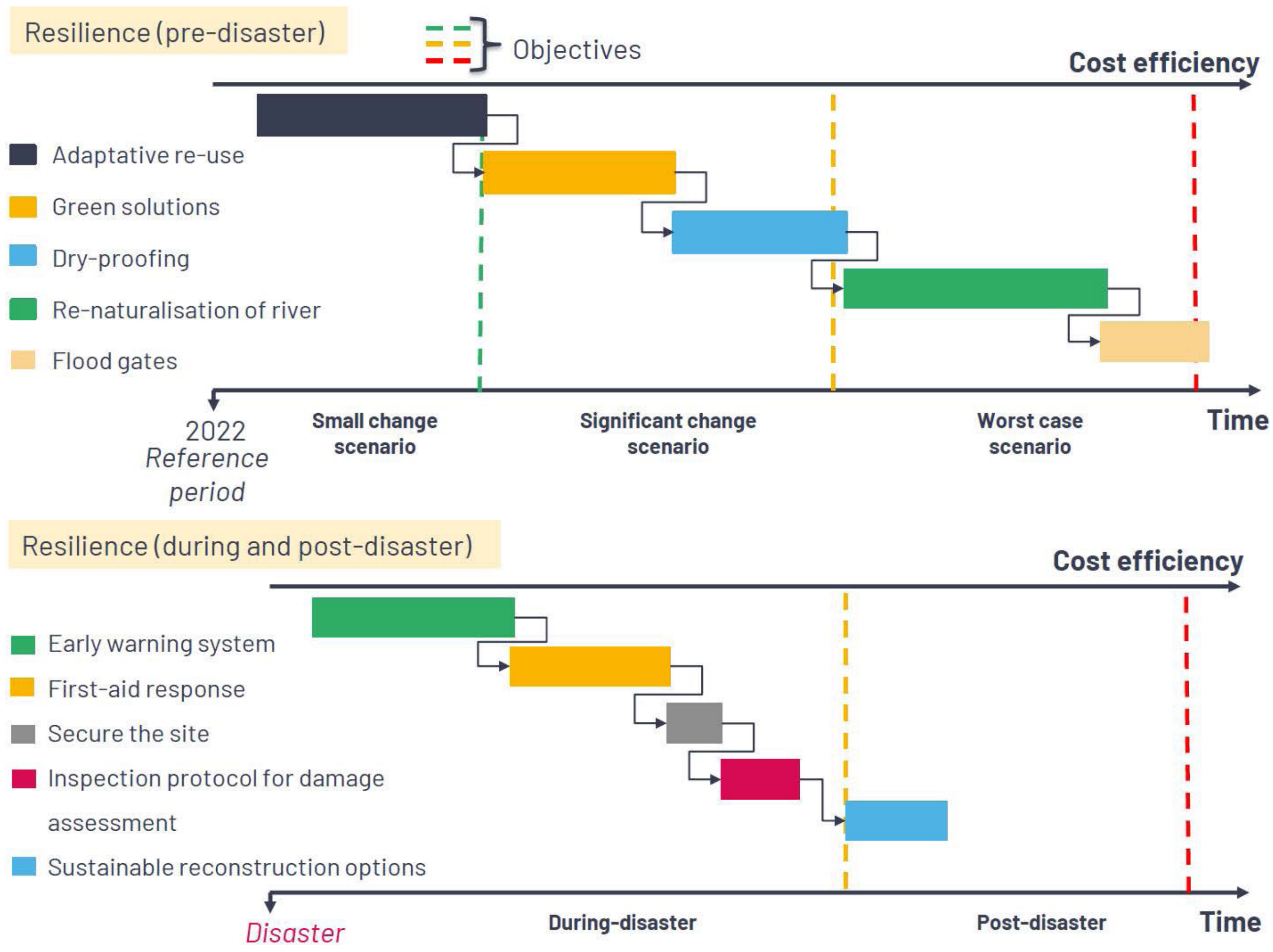
* Structural resilience, which corresponds to the resilience of the ecological system and consists of: (i) resilience of (built) environment and services; (ii) resilience of natural ecosystems.

** Community resilience, which covers the socio-cultural part of the social system and consists of: (resilience of social systems, meaning people and communities; (ii) resilience of cultural systems, meaning resilience of cultural identify, local knowledge and intangible heritage; Institutional resilience, which covers the political and economic part of the social system and consists of: (i) resilience of government institutions, policies, and processes; (ii) resilience of economic institutions and processes. Source (16)

Figure 31 – Example of the sequencing graphical display of a Resilience Pathway. Pre-disaster on top and during and post-disaster on the bottom



2. Tipping points or objectives

Resilience pathways have two types of tipping points:

- *Pre-disaster tipping point or objectives*
  Similar to adaptation tipping points, these represent when the past implemented measures lose their effectiveness, or their effectiveness is no longer sufficient to the new conditions. Pre-disaster tipping points or objectives of resilience can be represented in a similar way to adaptation thresholds (see Figure 31).

- *Disaster tipping point*
  When a disaster occurs, that is when the emergency operating phase needs to be activated. At this point the during and post-disaster measures need to be deployed (bottom graph in Figure 31). Disaster tipping points are not represented in the pathway approach, but in the Resilience Management Framework (Figure 4).

3. Flexibility with measure deployment timelines and road map possibilities

The conditions and premises of flexibility applied to Adaptation Pathways are equally valid for resilience measures. As conditions evolve, the pathway may a) be reinforced with another set of measures either for the pre-disaster or the during disaster period, then to be followed by post-disaster measures, b) modifications or even c) delays.

Step 4
Selection of best pathway alternative

Objectives

- Reflect on which of the pathway alternatives (roadmap) best aligns with the resilience needs (step 1.3), the vision (steps 1.4 & 1.5) and the local context in terms of feasibility (e.g. step 1.6)
- Discuss and assess the expected outcomes of each pathway alternative
- Determine the methodology for the selection of most suitable pathway alternative
- Select the resilience pathway to be implemented

This step consists of the selection of the most suitable Resilience Pathway alternative for the historic area or municipality, depending on the focus of the work. This starts with the selection of the methodology by which the most appropriate pathway alternative is to be selected. The most common methodologies are:

- **Multi-criteria analysis**
  In this exercise the criteria to be selected may be associated with the impact of the pathway alternative, heritage significance preservation, its co-benefits and implementation cost, or management. Investment cost or available financing mechanisms (Step 1.6) for the included measures may be relevant as a way to ensure the long-term sustainability of resilience planning. Furthermore, it also allows for the consideration of barriers, stakeholder preferences and policy priorities and is meant to be incorporated into the decision-making process in a structured, systematic and transparent way (33).

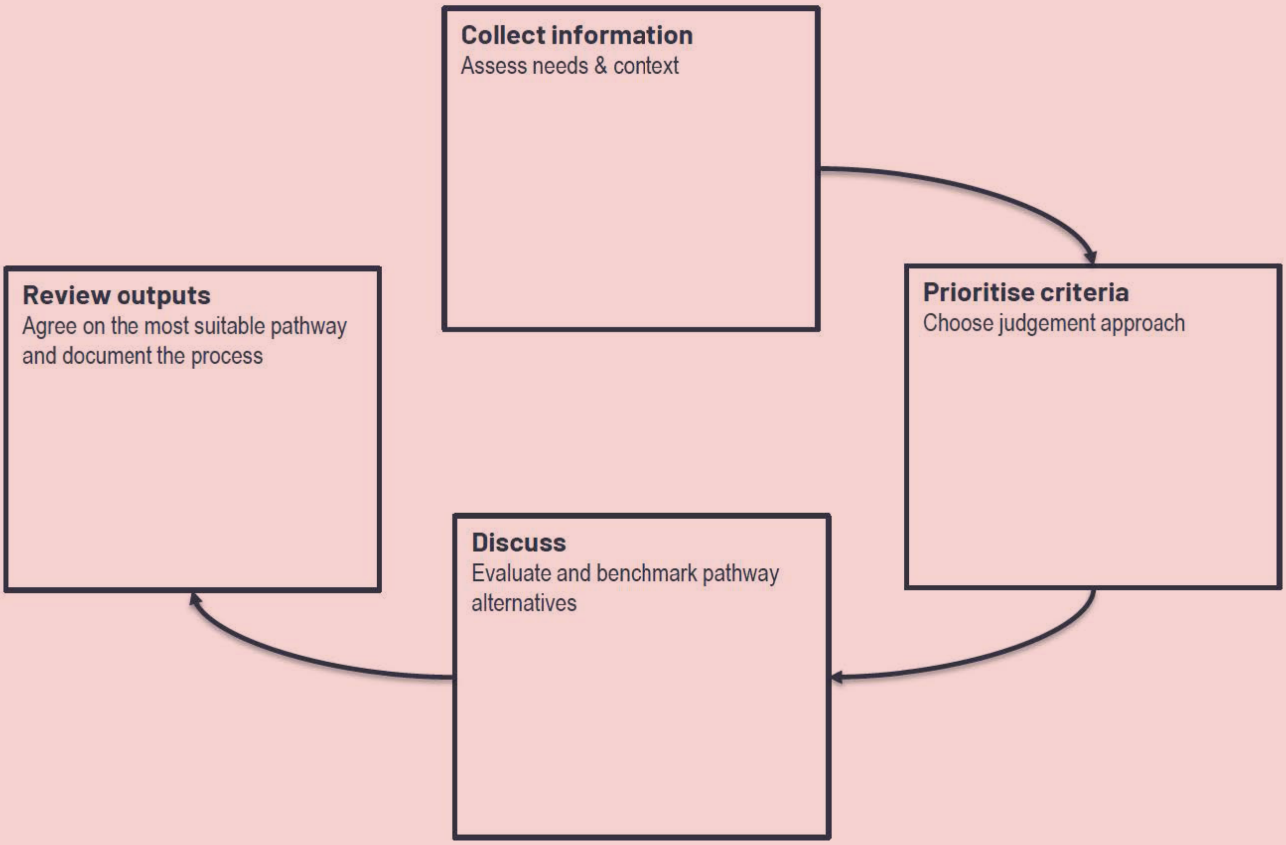
- **Cost effectiveness or Benefit-Cost analysis of each Resilience Pathway**
  This methodology is used if pathways were assessed by environmental effectiveness or other non-economic methodologies. This may imply the realisation of an ad hoc study to perform this evaluation with its subsequent expenses. However, the combination of environmental and economic performance analysis will result in more robust decision making.

- **Stakeholder participatory workshop**
  This methodology promotes discussion of stakeholders from different knowledge areas, backgrounds and competencies within the resilience-building process. This will promote a consensus on the best way forward on resilience building among different perspectives. An example of a supporting tool that may be used is shown in Toolbox [4].

Toolbox 4

Decision loop is a tool that helps to define how the work that has been done (e.g. the definition of resilience pathways) informs what to do next, in this case the pathway selection. This tool is an example of the type of methodologies that could be used in a stakeholder participatory workshop. The tool offers a framework based on methods, systems and processes to help with decision making in a collaborative way.

Figure 32 – Example of a co-creation tool to select the most suitable pathway alternative



At the end of the Resilience Pathway development, it is important to document the process, methodologies, and the final outputs to facilitate the process of revision in the future. Afterwards, it can be relevant to communicate and disseminate the outputs of the process to maintain the engagement and ownership of the results among stakeholders. This can also be a chance to communicate with other parties about the work done so that the vision can be shared. This buy-in will in turn reduce the risks for the pathway's future implementation. Furthermore, monitoring and evaluation of Resilience Pathways is key for various reasons:

- To understand when new measures should be deployed (related to thresholds and "points of no return"* as shown in Figure 15 and objectives) and be economically efficient (34)
- To monitor the implementation of resilience measures
- To assess the outcomes of the deployment of the selected Resilience Pathway

* Often known as "tipping points"

Tip 16

This step does not necessarily need to be the last one. Depending on the available resources, or on the Step 3.3 expected outcomes, the selection of the most suitable Resilience Pathway can be done prior to the design of the sequencing of the pathway

04 Chapter 3
Resilience Pathway Visualisation Tool in the Context of the Handbook

The ARCH project aims to enhance the resilience of areas of historic and cultural value to climate change-related and other hazards. One of its objectives is to offer an integrated framework and guide for resilience management which integrates both climate change adaptation and disaster risk management (ARCH Resilience Management Framework (16) and ARCH Standardisation activities (20)). Furthermore, ARCH also supports resilience building of historic areas through supporting tools such as the Resilience Measures Inventory (RMI) and the Resilience Pathway Visualization Tool (RPVT).

The ARCH RPVT is web-based tool to create and visualize **Resilience Pathways**. It provides a user-friendly digital interface with which users interact to **select, prioritize and sequence potential resilience measures** over time, which can be deployed as circumstances evolve. Measures can be selected and prioritised according to various performance metrics (35).

The aim of the RPVT is to support the Resilience Pathway development for use by city administrators, heritage managers and/or decision makers in the context of historic areas, and help these stakeholders with the visual representation of pathways.

The RPVT, as it is based on the RMI, focuses on (i) heritage building & structures as well as (ii) cultural heritage landscapes, with a focus on agricultural heritage. This chapter will briefly explain how and in which steps of Resilience Pathway development the RPVT can be used for support.

Figure 33 – The RPVT process for pathway graphical representation

Resilience Pathway Visualization Process

1. Pathway Characteristics
This step consist in setting the main characteristics of the pathway by selecting the hazard, metric of interest for the assesment and other requested parameters.

3. Resilience Measures
This step supports and guides the selection of measures aimed at strenghtening the resilience, based on enviromental effectivness and/ or economic analysis.

5. Pathway Visualization
This step supports the graphical representation of the sequence of resilience measure over time. This helps communicate outputs from the planning process and assist decision-makers to visualize a dynamic response to changing conditions.

2. Setting Objectives
This step aims at gathering the resilience objectives for the historic area's challenges based on expected changed changes in climate or natural hazards.

4. Pathway Alternatives
This step allows to create different clusters of measures based on specific criteria. It also supports to visualize and compare the effectiveness of each pathway alternatives and select the most appropriate one.

The RPVT can help:

- **to select and compare measures based on environmental effectiveness and/ or economic analysis**

This handbook describes in Chapter 2 the relevant information to prepare the ground for resilience building and setting objectives (see *Step 1: Preparing the ground and setting objectives*) which could serve as an input when using the RPVT in setting the pathway characteristics and objectives (*Figure 33*). On the other hand, in *Step 2: Selecting resilience measures* of this handbook, some resources have been included: For example, the RMI provides general information around 261 resilience measures, but does not include environmental effectiveness or economic efficiency information.

The RPVT, on the contrary, includes performance information for 99***** of these resilience measures (See example in *Figure 34*). This information can also support decision making during the selection of resilience measures to be considered in Resilience Pathway development.

- **to create and benchmark different pathway alternatives (clusters of measures) based on different performance metrics**

The RPVT allows for the clustering of resilience measures based on different available criteria, such as the nature of the measure, as shown in *Figure 35*. The RPVT also helps to visualize the cumulative effectiveness per pathway. This permits users to benchmark which cluster of measures will be more economically efficient or more effective to target the hazards. This is covered in *Step 3.1 Resilience pathway alternative development* and *Step 3.2 Assessment of effectiveness* of this handbook.

The RPVT includes different metrics****** to assess the performance of the individual resilience measures and pathway alternatives as shown in Figure 36. Thus, the RPVT can help develop data-driven Resilience Pathways when metrics presented in Figure 36 are of interest.

Furthermore, when metrics present in the RPVT are not suitable for the development of the Resilience Pathway or other assessment methods are preferred (*see Table 4. Characteristics of the different pathway approaches and methodology*), the RPVT can show the representativeness of resilience measures, as shown in Figure 37.

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* Those available through literature search in (35)

** a standard for measuring or evaluating something

Figure 34 – Screenshotofthequalitative economic performance information available from Step 3 from the RPVT

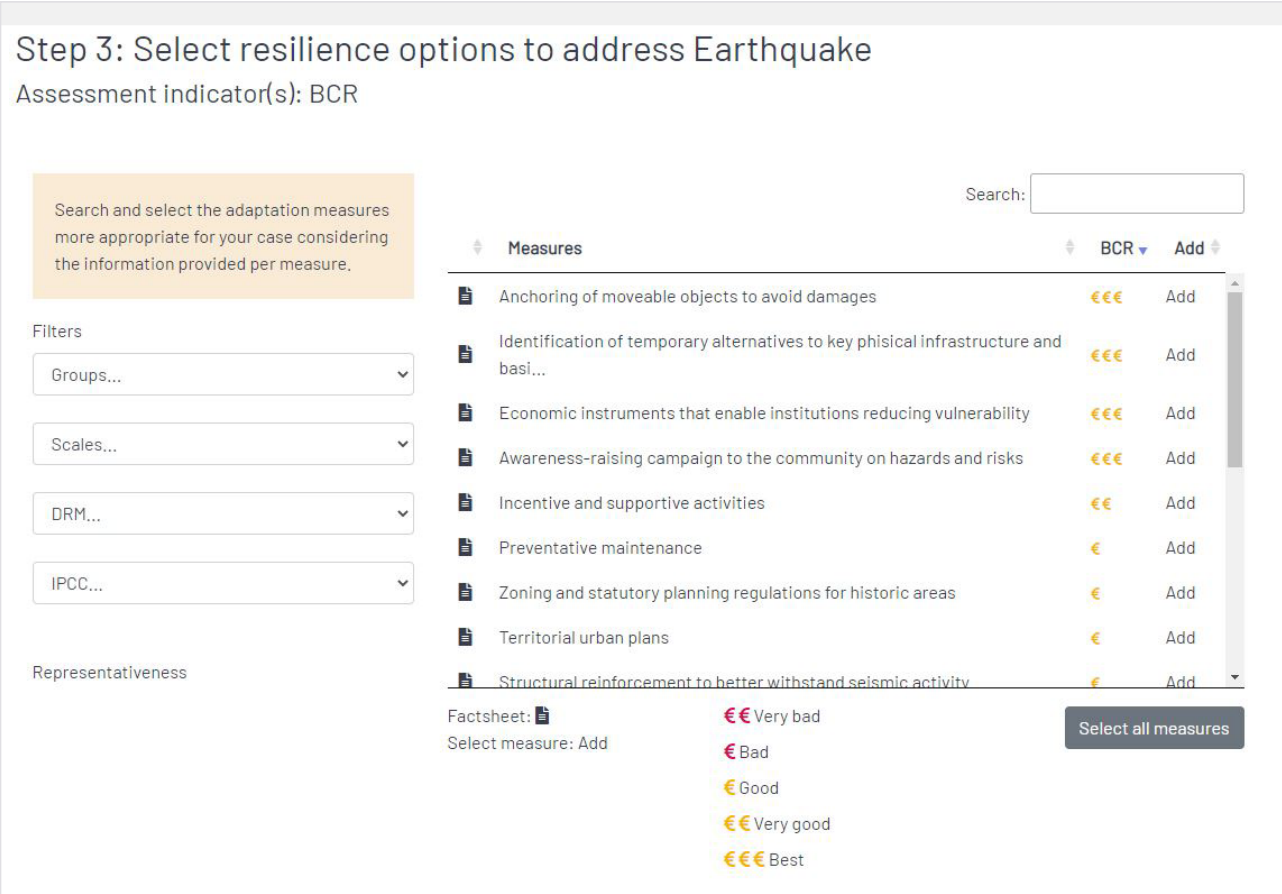


Figure 35 – Resilience pathway alternatives based on institutional and social measures (top) and structural measures (bottom) and their cummulative performance (yellow bars)

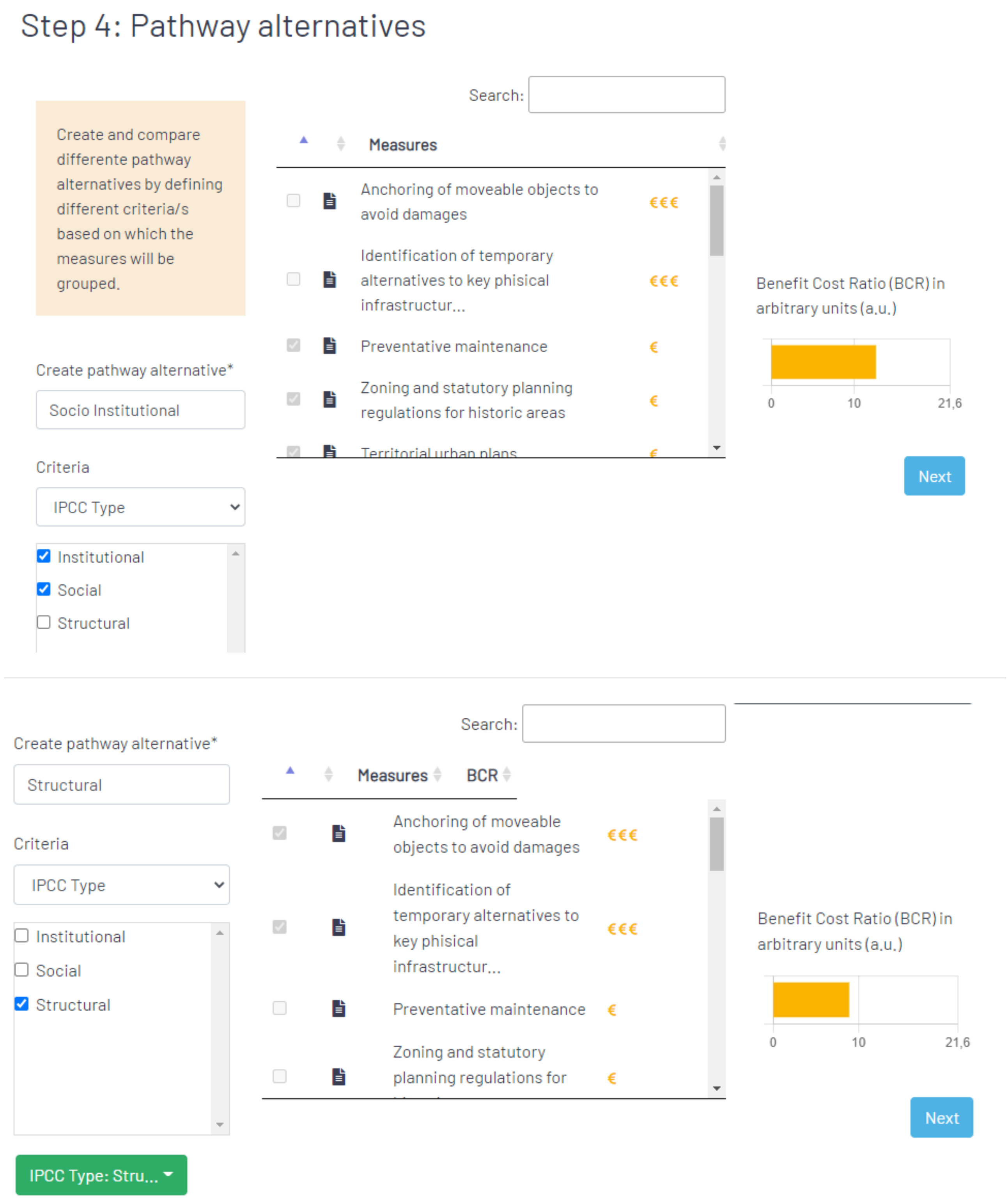
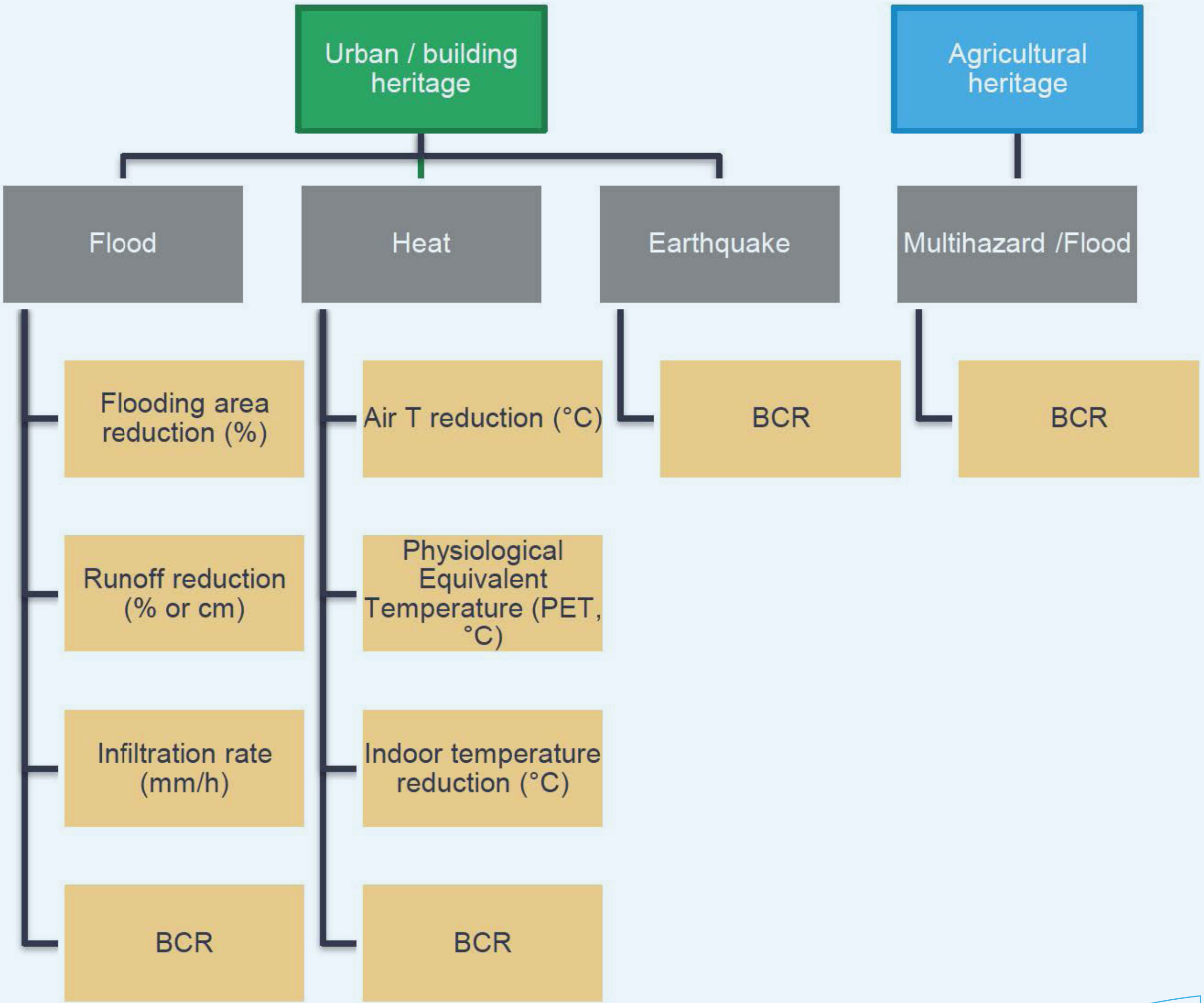


Figure 36 – Metrics included to assess the performance of the resilience measures per inventory sections and hazard. BCR: Benefit cost ratio. PET is suited to the evaluation of the human thermal comfort



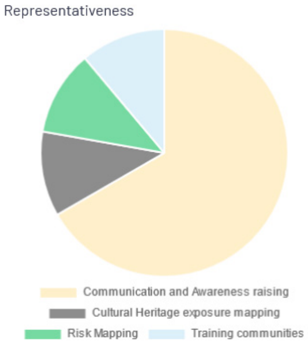


Figure 37 – Screenshot of an example of representativeness chart of selected measures (top). The representativeness of measures is based on the RMI subgroup of resilience measures (in the bottom a screen showing the RMI subgroups' description)

Measure Subgroup	Description
Cultural Heritage exposure mapping	Cultural heritage exposure mapping
Communication and awareness raising	Measures that aim at promoting information exchange and disseminating knowledge about climate change-related hazards and risks, DRM and adaptation measures and good practices
Risk mapping	Risk maps provide visual data for identifying, prioritizing and communicating specific risks by analysing the hazard, exposure and vulnerability, likelihood to occur and the destructive capacity that certain hazards may have in a territory with presence of vulnerable cultural heritage
Training communities	Training instruments that enable a community being resilient to the damages that an hazard may cause in their cultural heritage and therefore to the community itself

Click on the option that you want to include in the analysis:

Awareness raising	Communication and awareness raising	Hazard mapping	Mitigation and adaptation regulations (buildings)	Vernacular resilient technical solutions
Buildings and structures construction codes and stan…	Community ties	Indigenous management strategies and planning	Risk mapping	Vulnerability assessment methods
Built cultural heritage codes	Cultural Heritage exposure mapping	Information and communications technology (…	Training communities	Vulnerable groups exposure mapping

The RPVT can help:

- **to build Resilience Pathways (roadmaps) by sequencing the potential measures over time, considering different scenarios or changing circumstances.**

Step 3.3 Sequencing over time in the Resilience Pathway Handbook describes what factors may be relevant to consider when sequencing the resilience measures, i.e. how to prioritize the order of measures. The RPVT helps graphically represent this order (see Figure 38, Figure 39) and clarifies under which scenario they should be deployed. Resilience pathways are meant to have a flexible deployment as climate or geophysical conditions evolve.

To simplify the planning of the implementation of resilience measures, some of the graphical representations included in the RPVT show scenarios in terms of time periods that can be associated with specific dates. The user should note that these dates should be considered flexible and may be modified as conditions evolve and/or more accurate knowledge becomes available. In other words, near, medium and far future timelines should be considered as representing small change, significant change and worst-case scenarios. The graphical displays can also help communicate and assist decision-makers to visualize a dynamic response to changing conditions.

Figure 38 – Example of the type of graphical display that the RPVT allows to perform

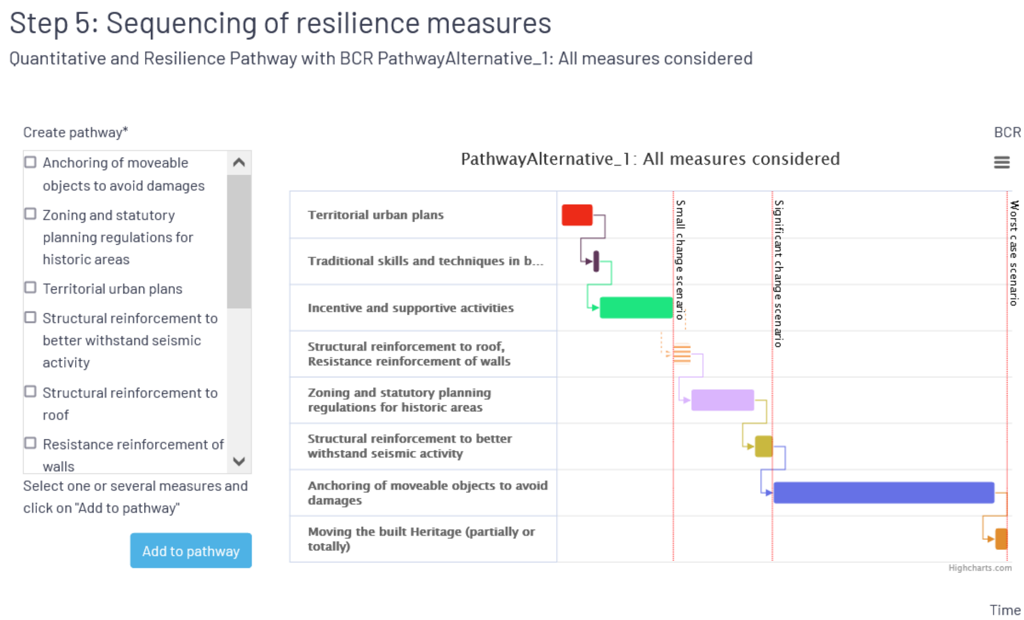
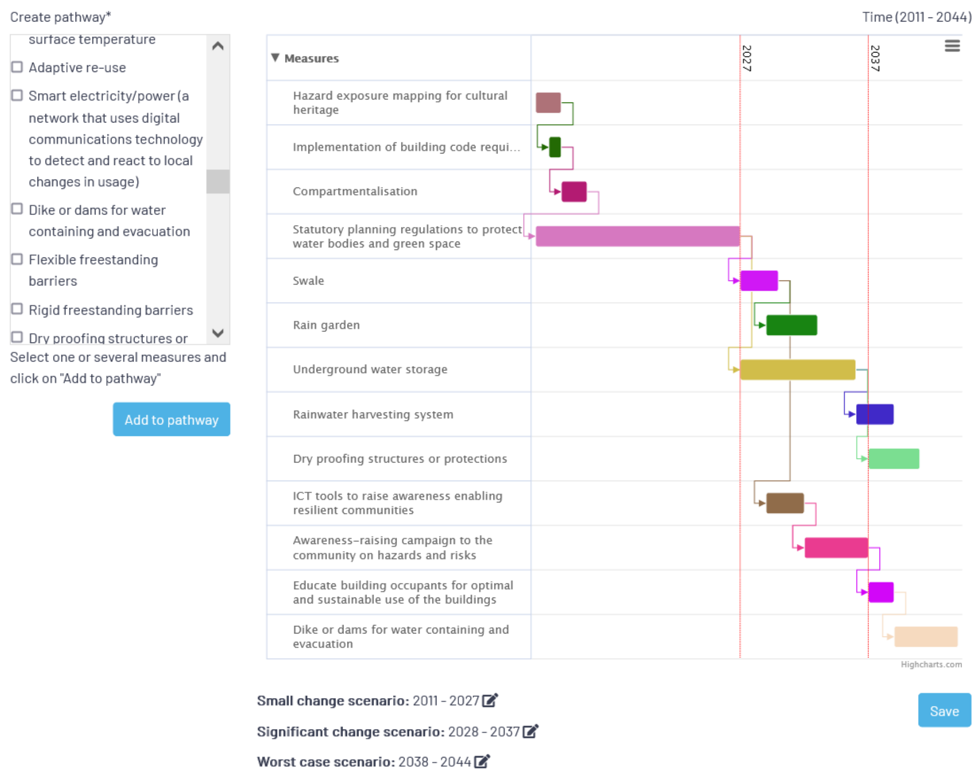


Figure 39 – Qualitative representation example of a Resilience Pathway (pre-disaster)



05 Chapter 4
Co—creating and testing activities

Co-creation processes, despite having different definitions and methodologies, have been identified as valuable tools to bring greater research impact and to allow better local knowledge uptake. This is especially true in the case of research applications dedicated to support local policies. Thus, the ARCH project team has adopted a co-creation process and created a guideline on co-creation (36) to ensure that project results are applicable and relevant in practice.

The testing activities on the pathway approach have had different levels of intensity and different degrees of ownership over the results. This has been the result derived from the content of the ARCH Grant Agreement and the stakeholder engagement possibilities. Three degrees of testing have been applied for the different ARCH pilot cities:

- **Valencia**
  The pathway approach has been tested involving the local ARCH partner, LNV, as well as some local stakeholders, and has aligned with current policies

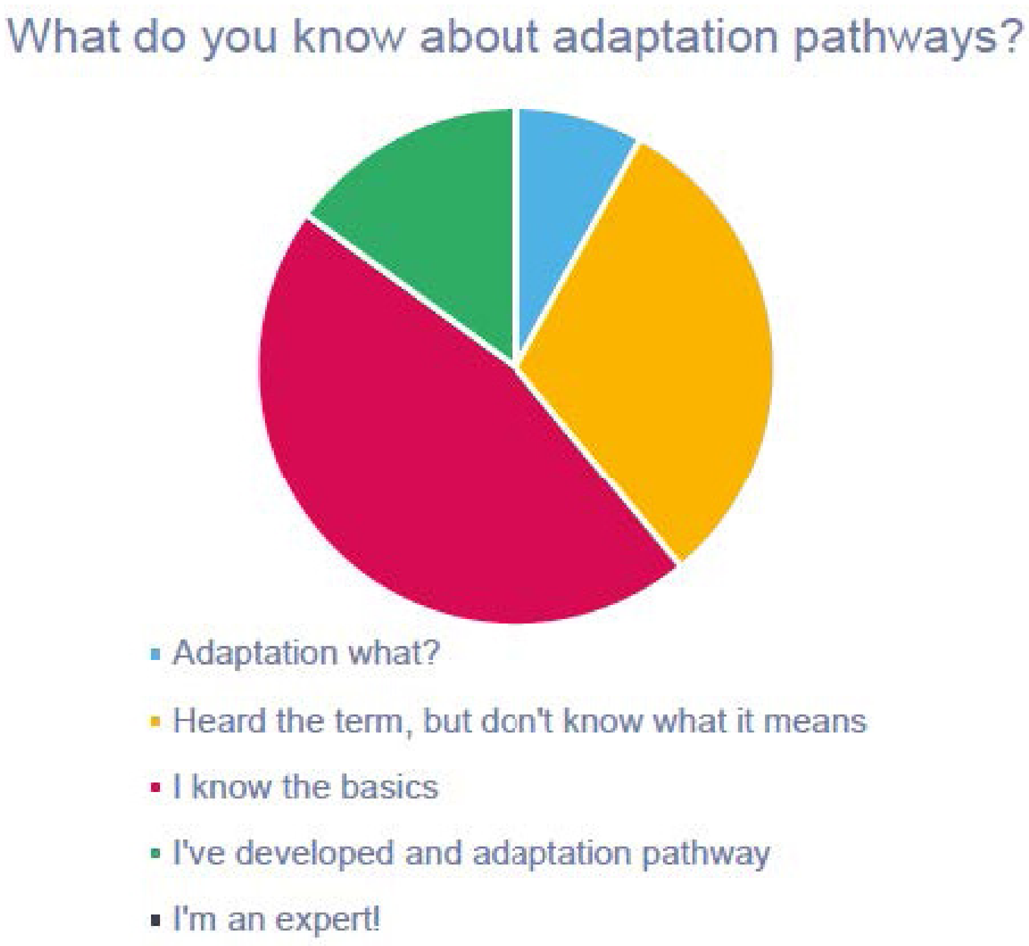
- **Bratislava**
  Three sessions combining theoretical information and co-creation exercises have been carried out to showcase the main steps of the pathway approach with the local ARCH partners

- **Camerino and Hamburg**
  Transferability workshops have been performed to share the outputs from Valencia and Bratislava and discuss how the methodology could potentially be applied to each context

Prior to the testing activities, two training sessions were carried out to explain the theoretical background of Adaptation Pathways and how it was applied to Antwerp and Bilbao in the RAMSES and RESIN projects. At the start, it was observed (see Figure 40) that most of the participants know the basics about Adaptation Pathways, but this was followed by 39% participants having no or very little knowledge on Adaptation Pathways.

This confirmed that this area of knowledge was new to the majority of ARCH city and research partners. After the training sessions, the level of understanding of attendees was assessed by asking them how well they understand the Adaptation Pathway methodology with a scale from 1-5. All respondents scored either a 3 or 4 with an average score of 3.4.

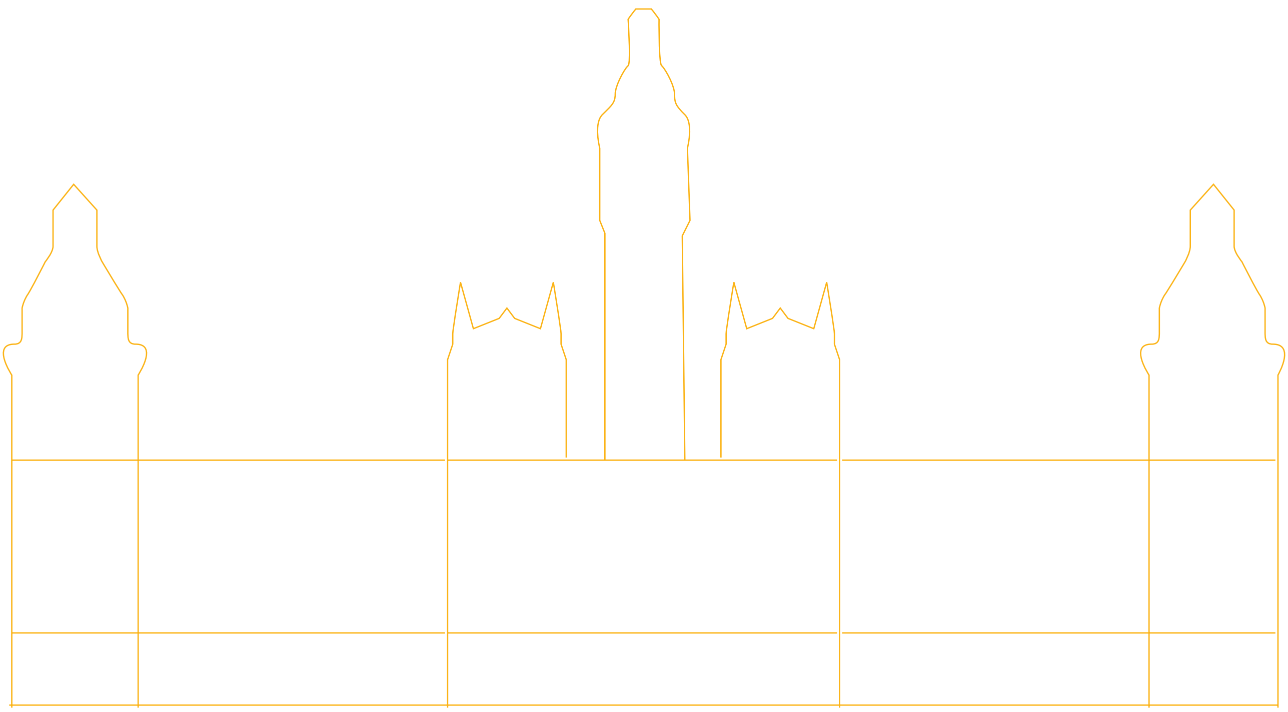
Figure 40 – Initial knowledge on the concept of Adaptation Pathways by participants to the ARCH training session 1. 13 respondents.



4.1 Valencia case study:
Adaptation pathway towards heatwaves

The City of Valencia selected two large cultural landscapes as their target historic areas: the Huerta irrigated peri-urban farmland, one of six remaining such landscapes in Europe and the Albufera, a large coastal lagoon, supporting a diverse range of species including bird life and fish, and bordered by land for rice cultivation. These two cultural landscapes are part of Valencia's socio-ecological system as its social, cultural, natural and economic spheres are closely linked to these areas.

Furthermore, within ARCH, Valencia identified three priority objectives with respect to building resilience of both the Huerta and Albufera cultural landscapes: 1) to acknowledge and explore how the Huerta and Albufera help to mitigate the effects of climate change in the urban environment of Valencia, 2) to understand and demonstrate in detail the impacts of possible climate change scenarios on the Huerta and Albufera, and 3) to design detailed resilience strategies in order to cope with these identified impacts. This last objective is fed by one of its strategies: Improving resilience in the socio-ecological system Huerta / Albufera / City of Valencia through Adaptation Pathways.



Step 1
Preparing the ground and setting objectives

- Preparing the ground & context analysis
- Long-term vision & objectives
- Threshold definition

Step 1.1 Setting the purpose of the Adaptation Pathway

The effect of extreme heat and heatwaves in agriculture, tourism, and the whole socio-ecological system at the end is a major concern for Valencia. Thus, the aim of the Adaptation Pathway was set to increase the thermal comfort of the urban and peri-urban open spaces, including the Huerta, so that the areas can be as liveable as possible and for as long as possible throughout the year (an adaptation perspective rather than a Resilience Pathway perspective).

This is especially important for the intangible heritage associated to agricultural practices as this needs to be sustainable over a long period of time. By increasing the thermal comfort around agricultural practices, as well as for residents, will allow this intangible heritage to endure over time. Furthermore, the Adaptation Pathway was set to have a special emphasis on the following co-benefits:

1. **increasing the natural connectivity and biodiversity (Albufera and the Huerta).**
   _ Biodiversity improvements will improve the ecosystem services (e.g., healthy soils, pollinators, and pest control). This leads to better crops, making agriculture more sustainable, and thus protecting this heritage landscape, the agriculture sustainability in the Huerta and Albufera and their ancient practices.
   _ Designing a pathway favouring green and blue solutions

2. **the promotion of sustainable tourism and mobility**
   _ Designing a pathway that helps to connect places of interest through e.g. climate shelters and comfortable routes.

These co-benefits were considered to contribute to safeguarding the cultural landscape's activities by increasing the thermal comfort of agriculture workers, tourists and residents in general, as well as promoting biodiversity which is key as much for agriculture as the natural environment. Thus, the pathway approach was set to work in a holistic way, that is as a socio-ecological system* considering the connections between La Huerta, Albufera and the city of Valencia.

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* complex systems of people and nature, emphasising that humans must be seen as a part of, not apart from, nature

Step 1.2 Preparing the ground

In view of the objective of the ARCH project*, in terms of decision-making, the goal for the pathway was to set a roadmap of measures with various alternatives to promote a change towards a strategic aim: to make the urban and periurban areas more resilient towards heat extremes (Table 2). Given the research nature of the ARCH project, the pathway approach followed a "hierarchical with scientific knowledge" decision making approach (see Table 5), with Tecnalia as technical expert and LNV as the ARCH project's local stakeholder representative. These partners led the process with specific inputs form various local stakeholders already belonging to one of Valencia's ARCH working groups.

Step 1.3. ARCH: Context analysis

Climate context

There is plenty of evidence of global warming and expected climate projections which can be consulted through different resources, as shown in Figure 41. However, local regionalized data may not always be available or scattered. The ARCH project, in the framework of work packages 4 (37) and 5 (38), has continued advancing on the generation of evidence for Valencia on how climate will evolve (e.g. how often will the heatwaves occur) and a meso scale thermal modelling considering different "typical days," corresponding to different periods of the century. Outputs from this work showed that the number of heatwaves will increase in intensity and frequency (Figure 43) and displayed how the maximum temperatures will evolve and how they will be spatially distributed in Valencia (Figure 44). Thus, there is a need to prepare for these changes, especially as the effects of heatwaves on human health are well known. For example, the 2003 heatwave shown in Figure 43 presented an increase of deaths by 4-fold.

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* ARCH is a European-funded research project that aims to better preserve areas of cultural heritage from hazards and risks. The project will present various models, methods, tools and datasets to support decision-making.

Figure 41 – Climate projections under RCP 8.5 for the maximum temperatures from 2010 to 2100 in Valencia city. Source Adaptecca*

* https://adaptecca.es/

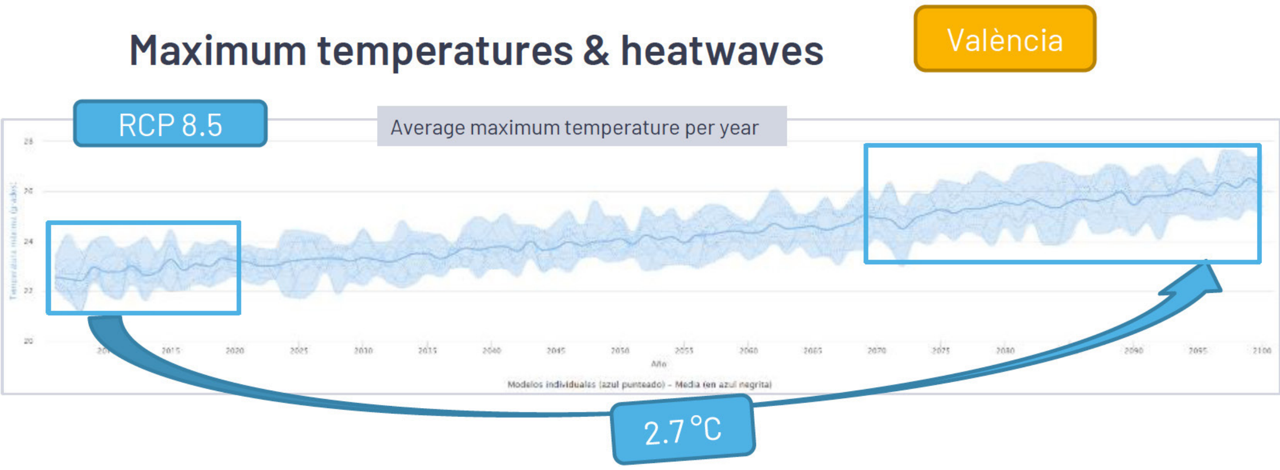


Figure 42 – Heatwaveintensity(vertical axis) and duration (horizontal axis) of heatwaves for the historic period and far future period considering RCP 8.5 projections. Source: (37)

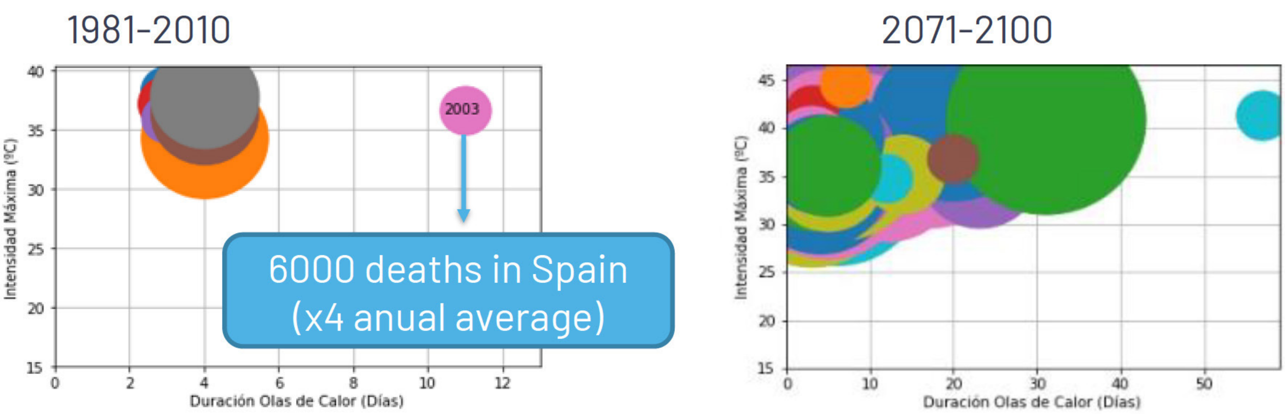


Figure 43 – Maximum temperature of a typical tropical day of each period considering the RCP 8.5 (worst-case scenario). Source: (38)

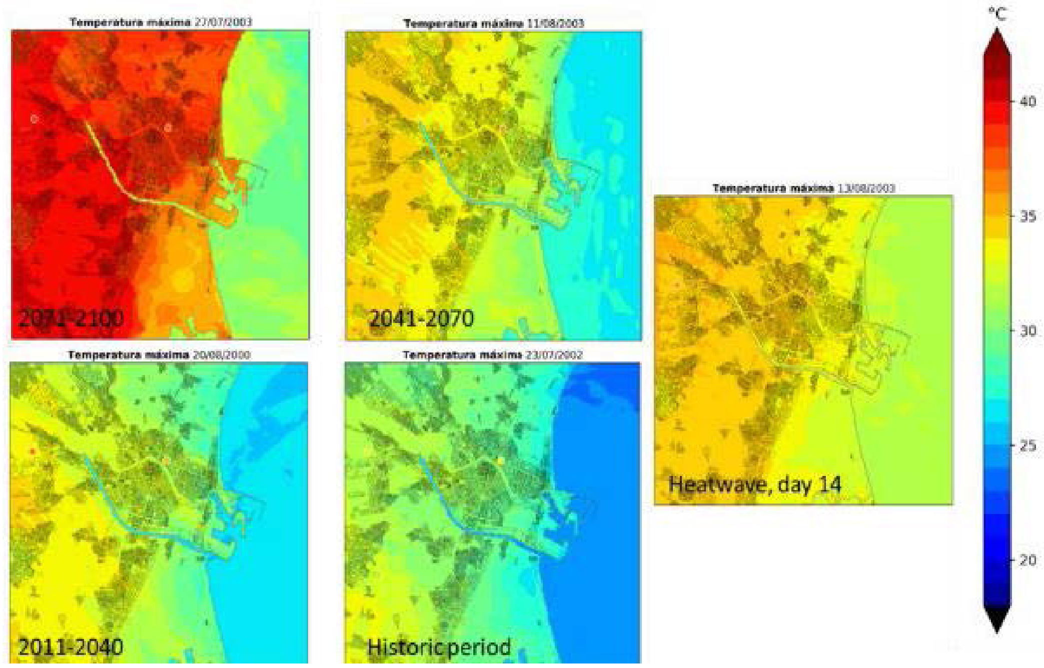
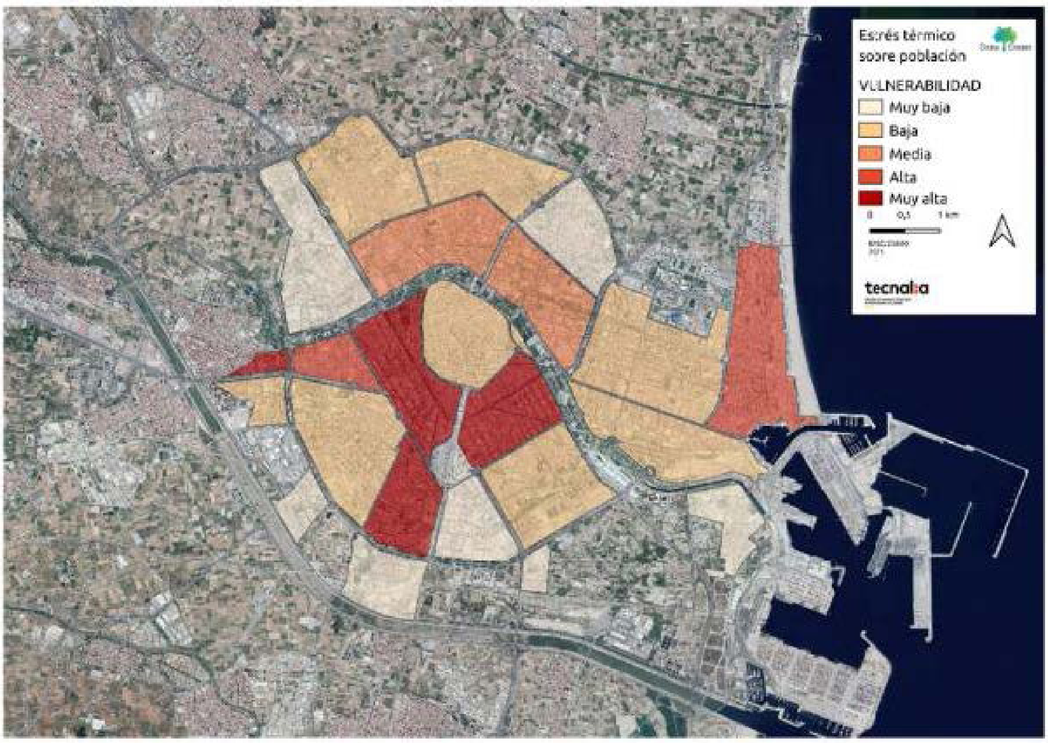
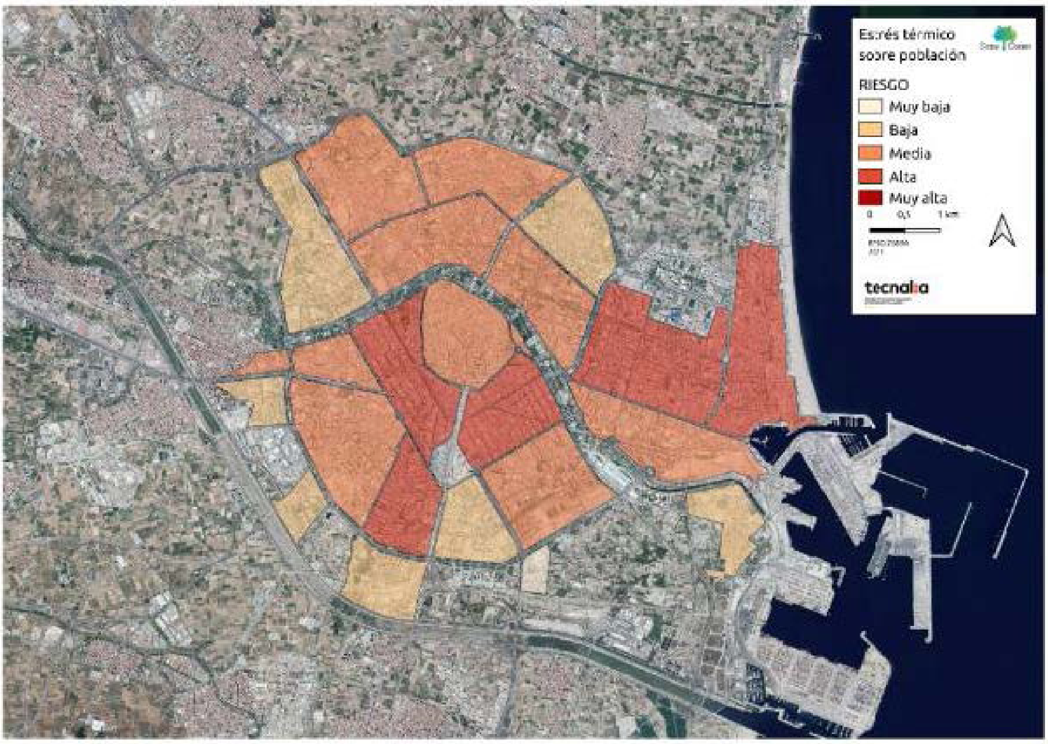


Figure 44 – Vulnerability of the population to heat stress. Unit of analysis: the Administrative Functional (AF) urban areas of Valencia. Source: GrowGreen project



The GrowGreen EU H2020 project analysed the vulnerability and risk of the impacts of heat stress to populations as seen in Figure 44 and Figure 45, respectively. This work identified the areas where population may have higher risk to heat stress in the urban area.

Figure 45 – Risk posed by heat stress to residents in different areas of Valencia. Unit of analysis: the administrative functional urban areas of Valencia. Source: GrowGreen project



Step 1.4 Define resilience threshold or objectives

Based on existing knowledge, it was difficult to define a specific threshold. To overcome this challenge, it was decided to work with minimum targets for adaptation, that is, to focus on improving the percentage of land use classification in terms of thermal comfort using the Physiological Equivalent Temperature (PET, °C) indicator (See Step 2.3 Spatial planning for further clarity).

Step 1.5 Alignment of the Adaptation Pathway with long-term vision of the system

There are several plans that have similar objectives and compose different pieces of a puzzle to achieve those objectives. The proposed Adaptation Pathway is aligned with them in the following terms:

1. **Regional Plan for the Huerta of Valencia***

   This plan is framed under the Law of the Huerta of Valencia, which has different objectives and actions, one of these objectives being the public use of the Huerta of Valencia. The Adaptation Pathway envisioned for Valencia is aligned with two of the actions included in this objective: (i) creating a network of green routes all over the Huerta; and (ii) promoting sustainable mobility. The only difference is that the Adaptation Pathway is dedicated to this purpose not only in the Huerta but also in the urban area.

2. **Programme for the prevention and attention to health problems derived from extreme temperatures in the Valencian region****

   The Adaptation Pathway aims to help bridging the gaps identified by this programme by improving environmental risk factors associated with mortality such as:

   - The lack of trees in residential areas the area around the house
   - Lack of access to cool areas during the working day (outdoor workers)
   - Lack of climatic refuges for the general population and tourists
   - Highly built-up environment (asphalt over permeable soils)

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* Source: https://politicaterritorial.gva.es/es/web/planificacion-territorial-e-infraestructura-verde/huerta-de-valencia. [Last accessed on 28th July 2022]

** Source: https://www.san.gva.es/web_estatica/index_va.html [Last accessed on 28th July 2022]

3. **Valencia's Green and Biodiversity Plan*****
   Similar to this plan's objective, the Adaptation Pathway aims also to contribute to the protection and improvement of green infrastructure and biodiversity with the following purposes:

- Adapt Valencia to the effects of climate change
- Increase urban ecosystems' biodiversity
- Connect urban green areas
- Connect with regional green infrastructure

4. **NbS Strategy in the city of Valencia. Climate proofing urban planning through NbS (GrowGreen Project Output)**
   The GrowGreen Project is supporting the new NbS Strategy development mainly through local planning, e.g. Local Master Plan. Among the considered strategic objectives the Adaptation Pathway can also answer their needs by:

- Improving environmental health and comfort
  (Objective 2, theme area 4. Public space security and health)

- Ecological and multiscale connectivity and accessibility
  (Objective 3, themes area 6. Relationship with ecosystems in the environment, mainly the Huerta and theme area 7. Sustainable mobility and accessibility to green areas)

*** Source: https://plaverdvalencia.com/ [Last accessed on 28th July 2022]

Step 2
Selecting adaptation measures

- Resilience measure portfolio
- Resilience measure characterisation
- Spatial plannification of resilience measures

Step 2.1 Identification of adaptation measures

In order to identify possible adaptation measures that could tackle heatwaves, the first step was twofold: first, to create a problem tree representing the conceptual model of the impact chain (Figure 46); and then to create an adaptation canvas identifying the main groups of measures that could be applied to address the impacts of heatwaves (Figure 47).

Only structural measures were selected, as seen in Figure 49, as the aim was to assess how these measures could improve the thermal comfort in the public spaces in the city, as well as in La Huerta. The indicator selected to assess human thermal comfort was the Physiological Equivalent Temperature (PET, °C) as previously mentioned.

Social and institutional measures do not directly address the temperature and humidity challenges that contribute to thermal comfort, and thus were not selected for the pathway assessment. The identification of adaptation measures was mainly performed using the databases RMI and RESIN Adaptation Option Library.

Figure 46 – Problem tree representing the conceptual model of the impact chain: heatwaves in human health

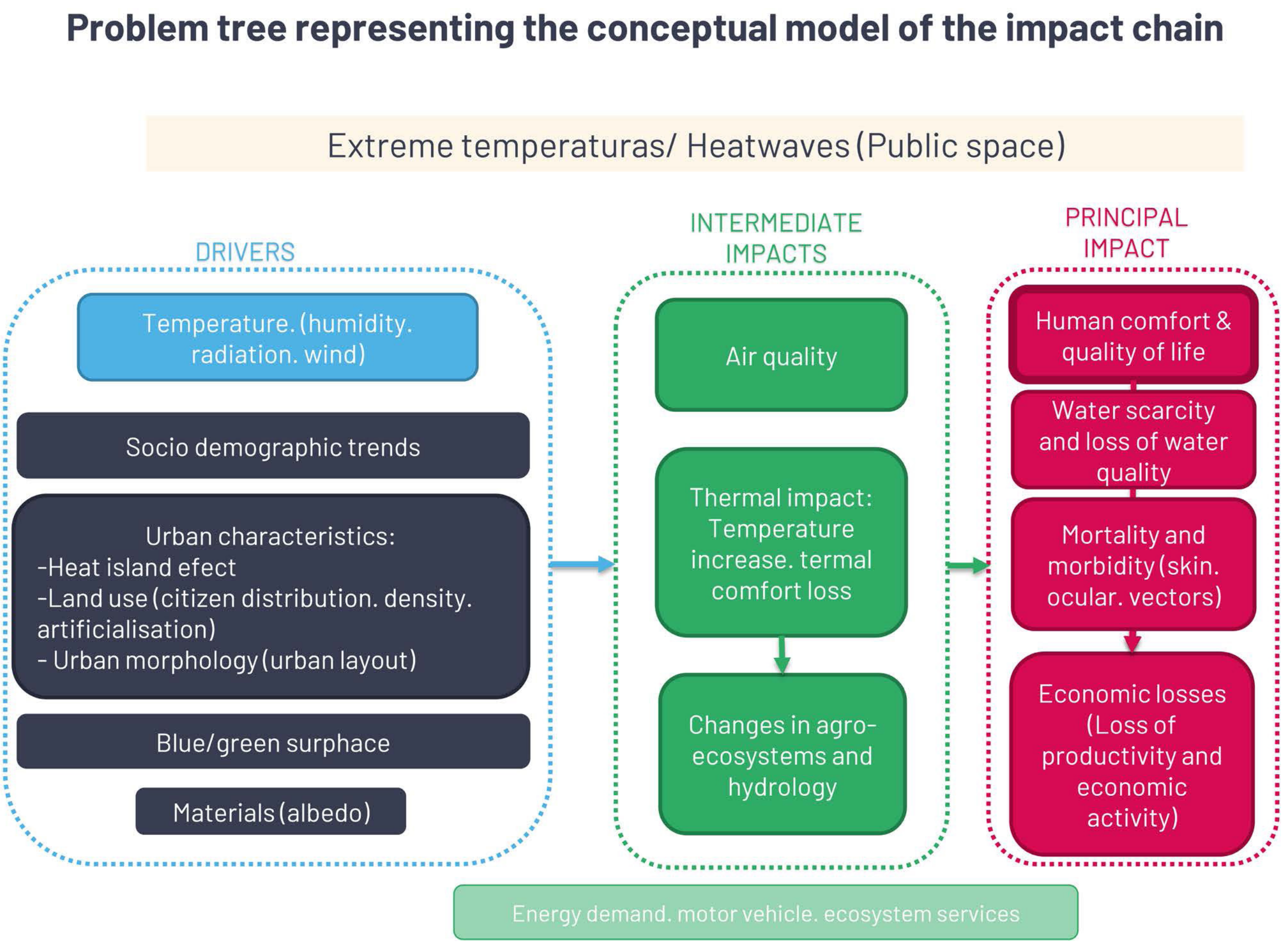


Figure 47 – Adaptation canvas at different level. Adaptation measures in grey (institutional), green (structural) and yellow (social). Adaptation measures with red line were selected for the Adaptation Pathway

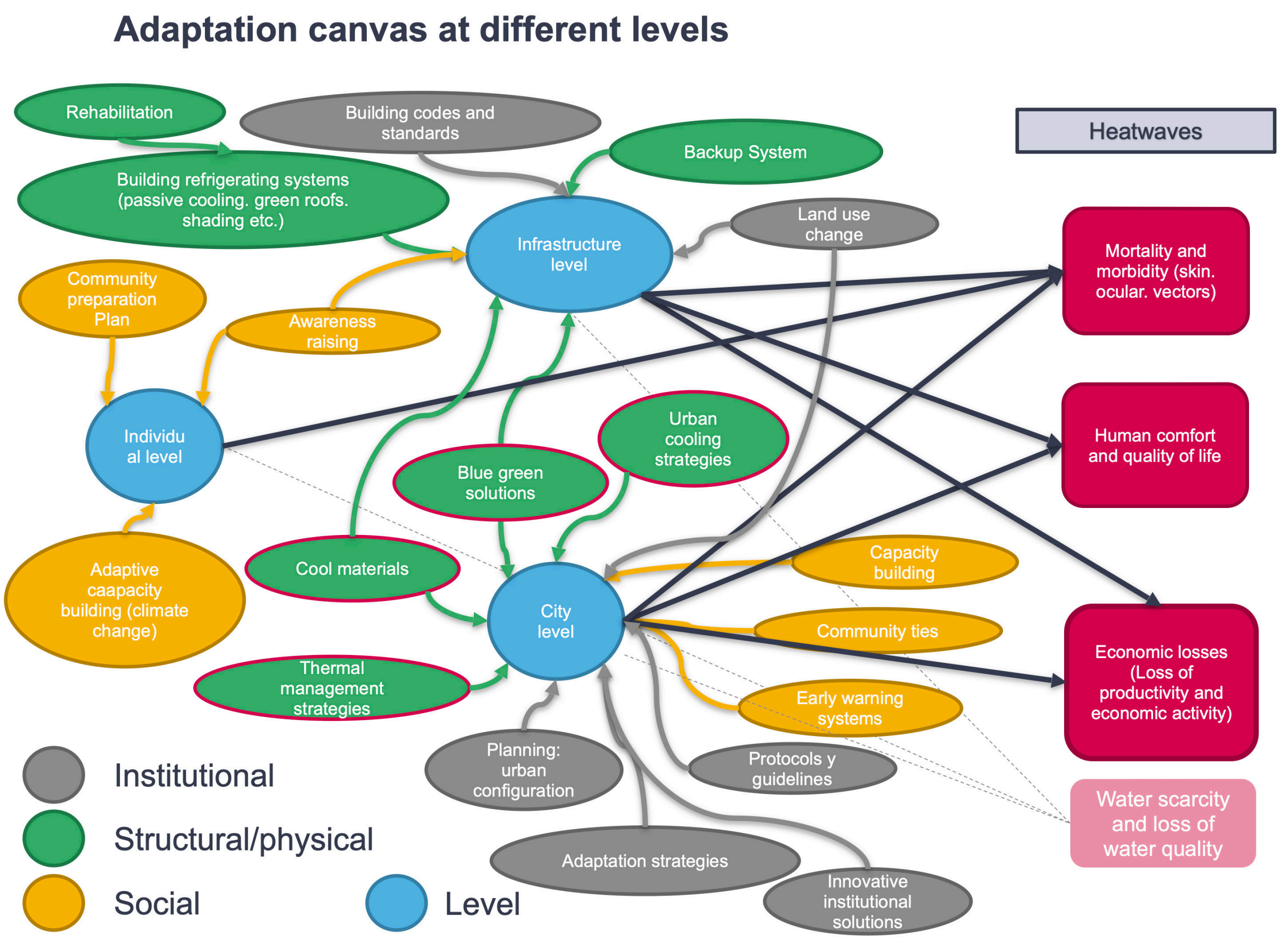
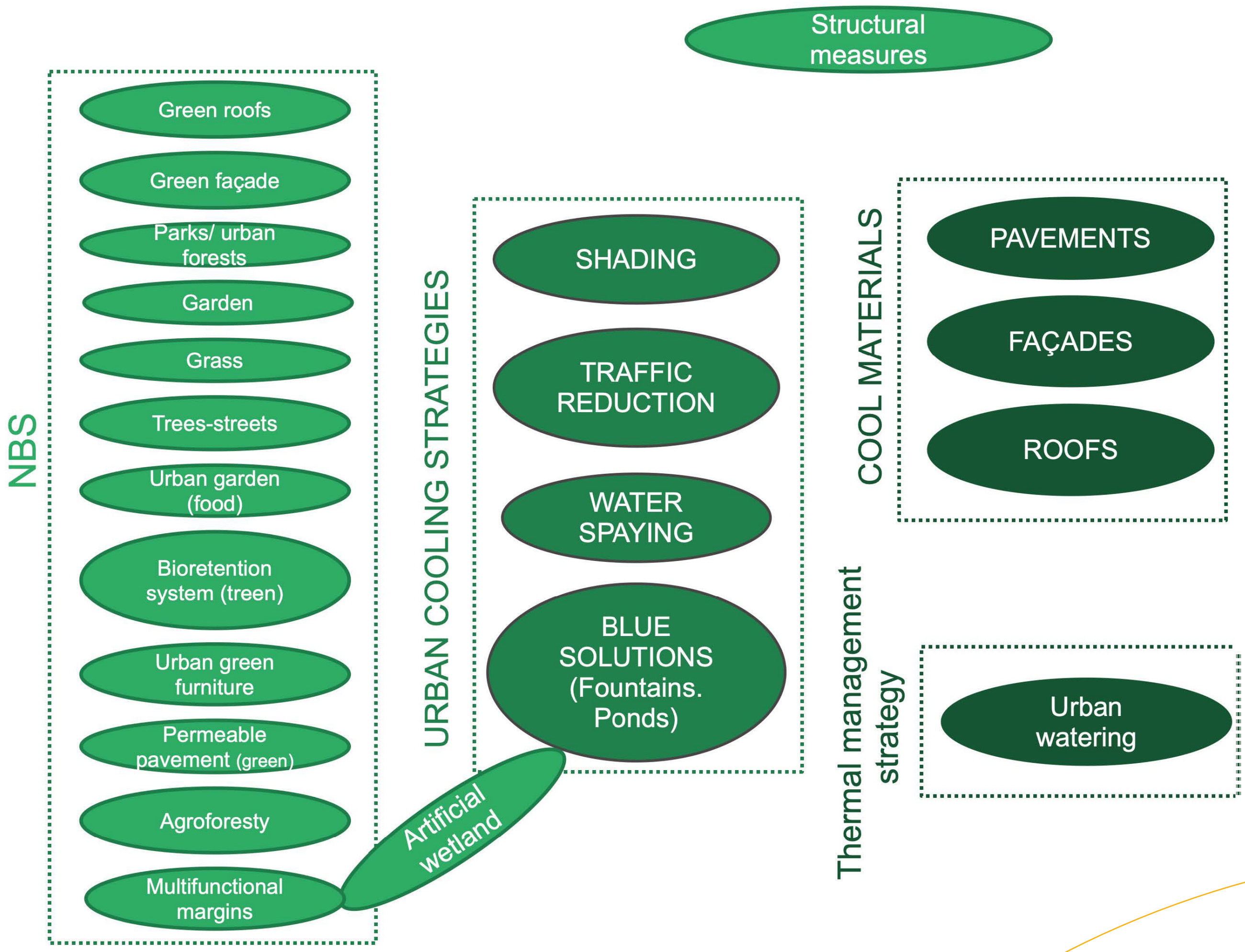


Figure 48 – Final list of adaptation measures by subgroup of measures



Step 2.2 Selection and characterisation of adaptation measures

The next step was to characterise and prioritise the adaptation measures based on relevant criteria for the Valencia case study. This was done by a multi-criteria analysis. The selection and weighing of the criteria was performed together with local stakeholders (Table 10). As eight criteria were selected, there were not a particularly large difference in the weighing of the different criterion, but environmental effectiveness was the most relevant out of those selected (Figure 50). The final score of each of the adaptation measures can be seen in Figure 51.

Once the multi-criteria analysis was performed and a ranking of measures was obtained based on the selected criteria, the results were cross-checked with local stakeholders. The barriers, general consideration and synergies with existing strategies were as well discussed, after which some barriers were considered to have more niche applicability and excluded from further analysis. Those adaptation measures that could have higher mainstream potential were considered for the opportunity mapping (spatial planning).

The reason for excluding the measures were:

- *Grass*
  Despite the fact that it could be implemented in areas where there is seasonal flooding, it was considered to have a high-water demand and cost. This was particularly relevant to the choice to exclude the measure because water scarcity is also a concern in Valencia.

- *Urban food garden*
  Despite the great synergy with the urban agriculture plan and the fact that such a garden could be ideal for the transition areas between city and the Huerta, it was not considered the most effective adaptation measure towards heat stress.

- *Artificial wetland*
  Due to the technical and spatial requirement it was considered not easily manageable in Valencia, with focus being instead shifted toward recovering and restoring natural wetlands. Other measures were prioritised in the more rural areas.

- Bioretention systems, which include trees, have the advantage of improving water infiltration, but as for the heat stress they would have similar effects as urban trees. Thus, to simplify, this type of measure was included under the trees category.

- Water spraying, due to its cost and high-water demand, was only considered to be applicable in specific sites and not as a mainstreamed solution.

- Blue solutions, including open swimming pools, were also considered to be applicable only in specific sites, and therefore not considered as a mainstreamed solution.
- Pavement watering was excluded as it had the lowest score, and it implies the use of a large amount of water
- Traffic reduction had a neutral reaction among the stakeholders, despite the fact that as a measure, it may help improve air quality and thus lessen the impact of heatwaves.

Table 11 – Criteria for characterisation and prioritisation of the measures

No.	Criteria	Category of criteria	Unit	Min/ Max
1	Cost (€/m²)	Economic	euros	Min
2	Biodiversity	Environmental	„1-5"	Max
3	Contribution to the connectivity of natural areas	Environmental	„1-5"	Max
4	Contribution to climate change mitigation	Climate	„1-3"	Max
5	Thermal effectiveness	Climate	„1-5"	Max
6	Generating opportunities for recreation, education and people gathering	Social	„1-5"	Max
7	Tourist activity enhancement	Economic	„1-3"	Max
8	Other co-benefits	Other	„1-10"	Max

Figure 49 – Weight of each criteria representing their relative importance as average to all stakeholders

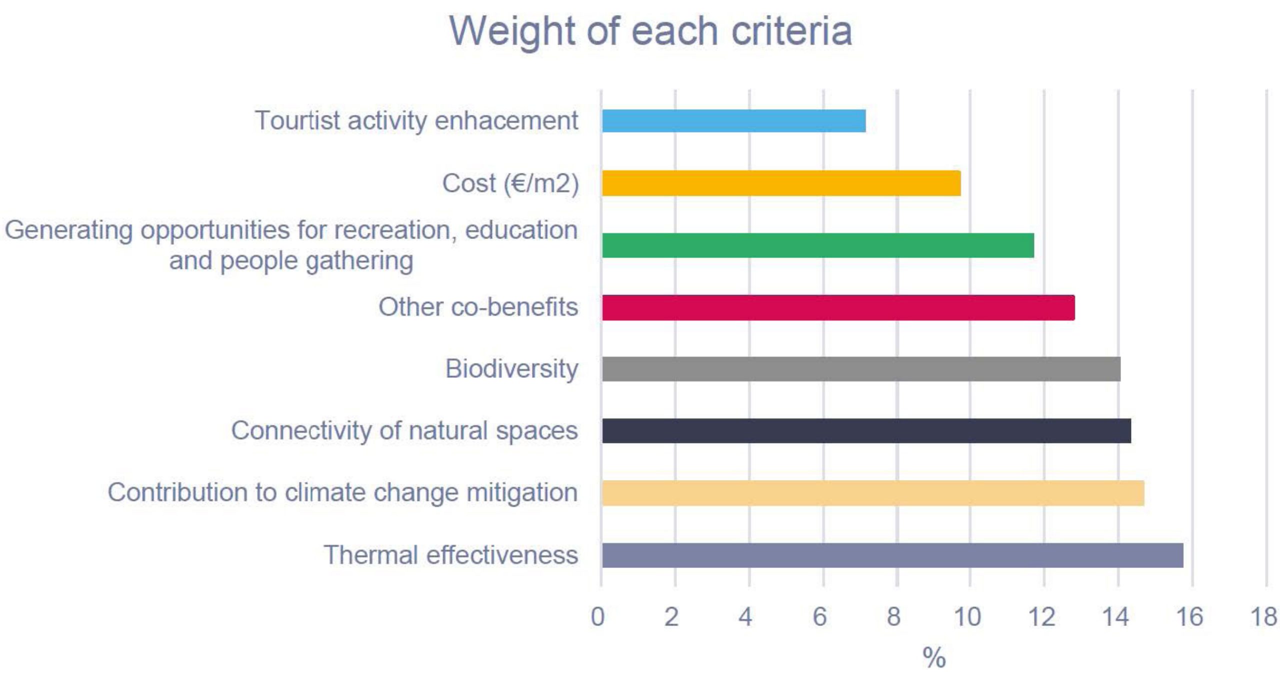
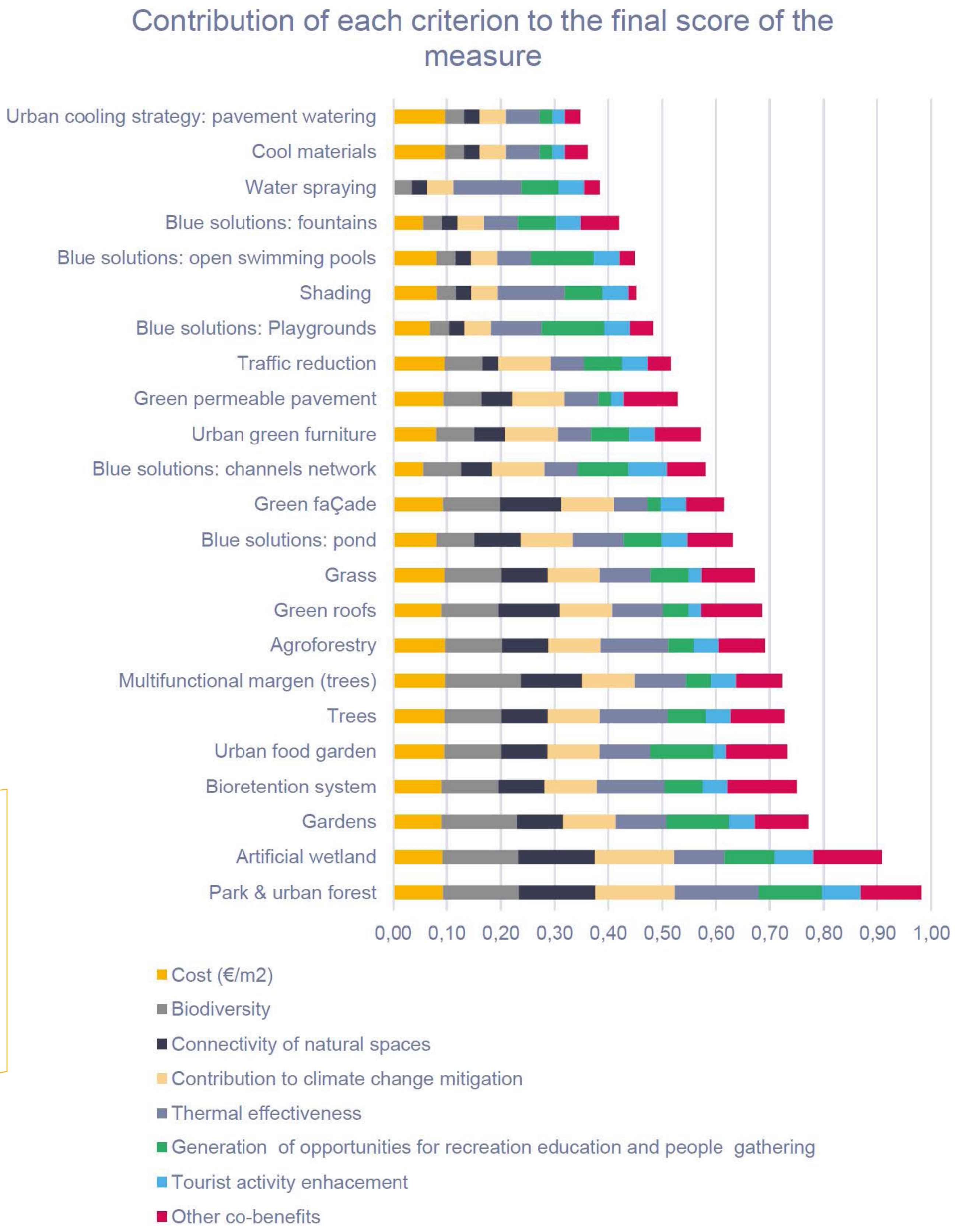


Figure 50 – Final score in the multicriteria analysis and the contribution of each criterion in the final score



Step 2.3 Spatial planning

This step was dedicated to create an opportunity mapping considering the administrative functional areas (depicted in Figure 44), in order to identify what type of adaptation measures can be implemented where. It should be noted that the methodology was built around the functional areas aligned with the GrowGreen project's outputs, due also in part to the fact that urban planners could not join in this work at the time of this project due to other commitments.

This analysis will allow for spatial consideration of the different pathway alternatives and link to the area of thermal comfort improvement. The methodology that was followed to build this opportunity mapping can be divided into six steps:

1. Download the Master Plan's land use classification (Figure 51)

2. Assign each land classification to a use
   - a Road network
   - b Building
   - c Public spaces
   - d Public spaces – green
   - e Orchard

3. Trim the building areas from the cartography to obtain what was defined as the area between buildings. This was done as the initial information considered not only the buildings areas but small areas adjacent to them. Figure 52 shows the six-land re-classification.

4. Use an algorithm for calculating vegetation areas within each land classification as shown in Figure 53. This was done to be able to calculate the available area for new adaptation measures.

5. Characterise functional areas according to surface area and available area per type of land use.

6. „Cluster" functional areas by typology. This clustering was based on the degree of artificialisation, green areas and amount of available land for future adaptation measures (Figure 54).

7. Preliminarily allocate potential adaptation measures according to land-use classification. This step was developed together with local stakeholders. The outputs of this work can be seen in Table 12.

Figure 51 – Master plan land use classification

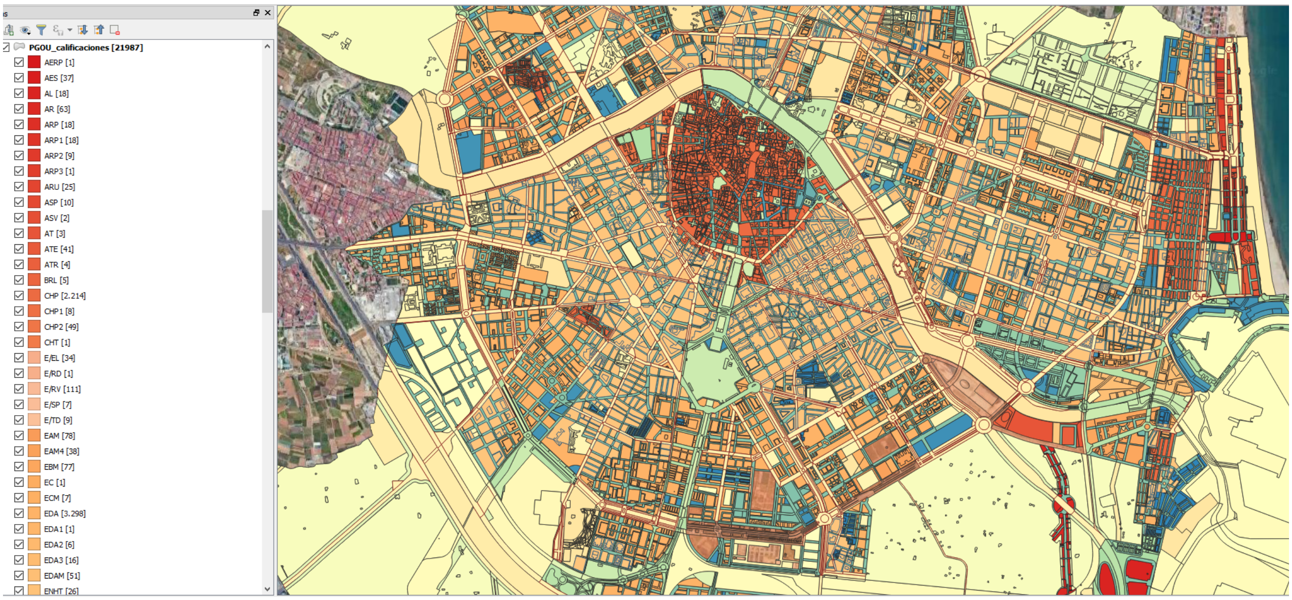


Figure 52 – Re—classification of the land use in 5 main categories: pink as building, red as "interblock" areas, blue as open spaces, dark green as green open spaces, grey as the road network and light green as the Huerta

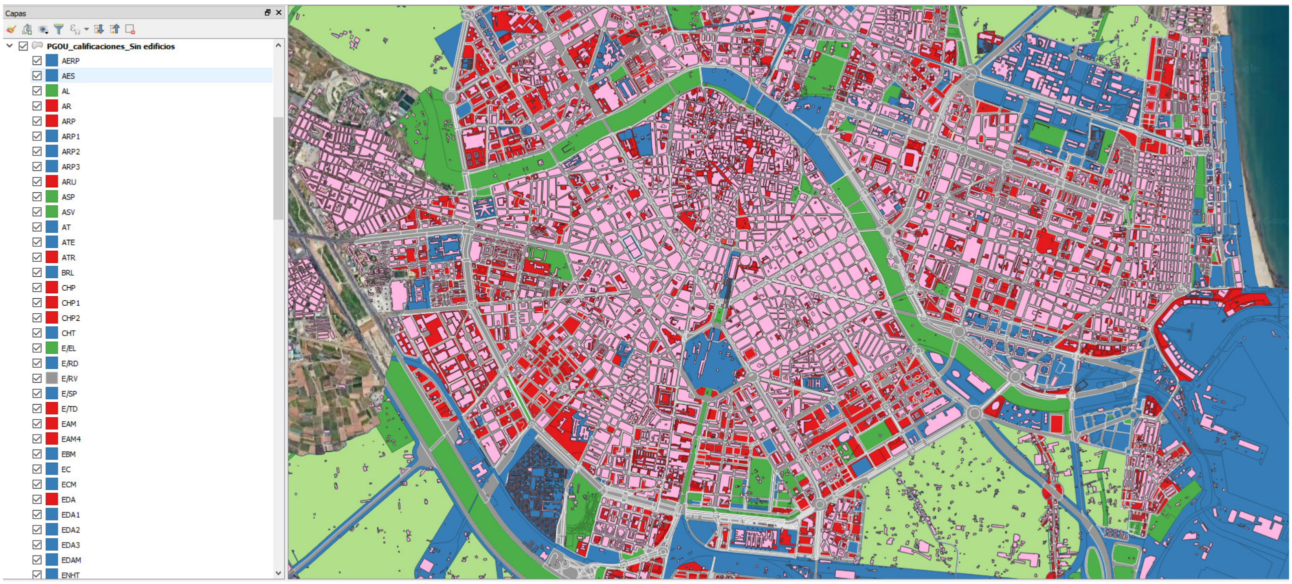
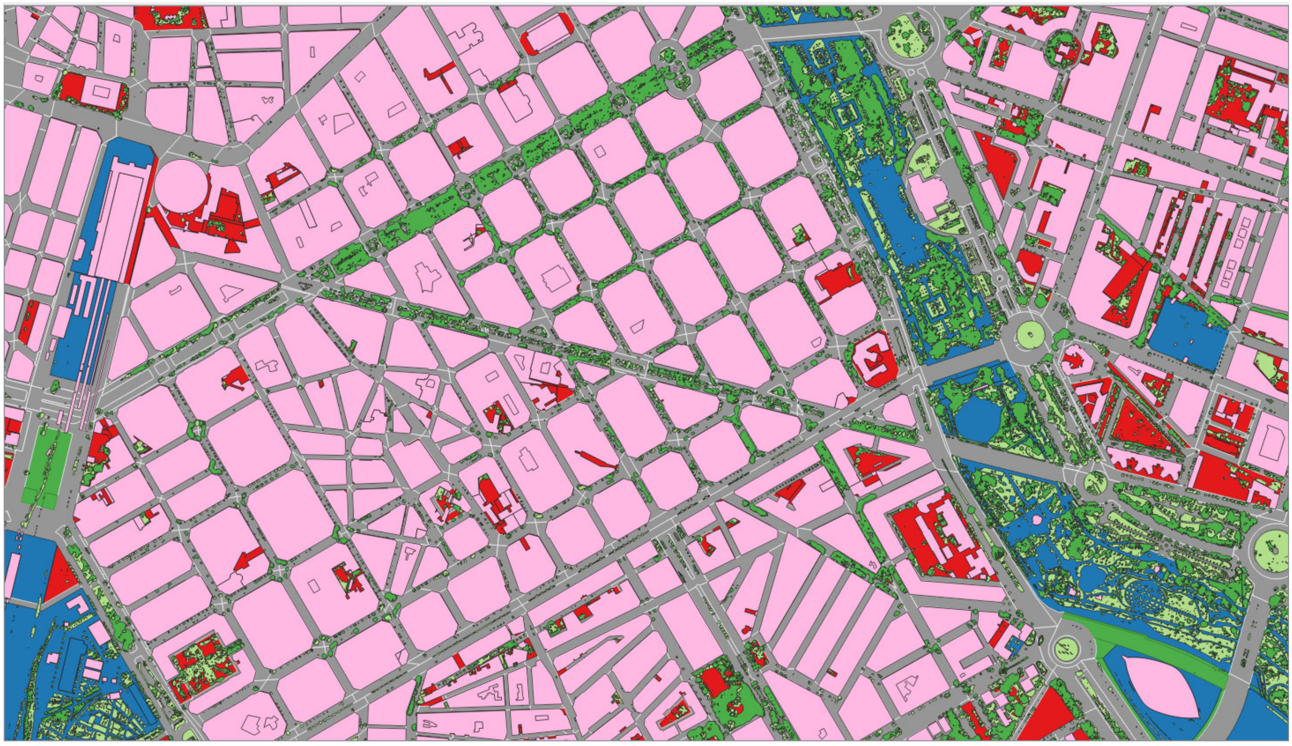


Figure 53 – Vegetation area determination per land use classification



"Clustering" of functional areas by typology

RISK

High risk, little scope for action	High risk, some room for improvement	High risk, high scope for action
2, 3, 13	7	8
Medium risk, little scope for action	Medium risk, some room for improvement	Medium risk, high scope for action
1	5, 14, 15, 17, 18	6,9, 11, 16, 23
Low risk, little scope for action	Low risk, some room for improvement	Low risk, high scope for action
	19, 21	4,10,12, 20, 22

SCOPE FOR ACTION

Clustering based on the degree of artificialisation. green areas and amount available land (scope for action)

Figure 54 – Clustering of functional groups by typology. Clustering based on the degree of artificialisation, green areas and amount of available land for future adaptation measures

Table 12 – Assignment of potential adaptation measures according to land-use classification based on the stakeholder's vision. Darkest green is the most preferable adaptation measure per land-use while the lightest green is the least preferable solutions

	Road network (footpath, roundabout, parking etc.)	Green areas	Open public areas	Interblock building spaces	Bike path	Building	Huerta (Orchard)
Trees							
Shading							
Cool materials							
Parks /urban forest							
Green permeable pavement							
Garden							
Urban green furniture							
Green roofs							
Green façade							
Fountains							
Water playground							
Multifunctional margins							
Agroforestry							

After the opportunity mapping development, it was easier to set adaptation objectives (Step 1.4 Define resilience threshold or objectives) as knowledge on available surface in terms of percentage and Km2 was made available. This information was confronted with local context knowledge to define the objectives as shown in Table 13. Scenario 3, which would be implemented in the worst-case climate scenario, involves a change of around 8% of the total urban area (not just the available or feasibility areas for further improvement). The amounts of area prone to be improved in each scenario are as follows:

- Scenario 1: 1.36 km^2
- Scenario 2: 2.72 km^2
- Scenario 3: 4.31 km^2

Table 13 – Target scenario for land use qualification change (improve adaptation).
***Excluding Ciutat Vella due to heritage value of the area,**
****considering the available area for further improvement**

Scenario 1			Scenario 2			Scenario 3		
Huerta	Building*	Urban area**	Huerta	Building*	Urban area**	Huerta	Building*	Urban area**
1%	1%	10%	2.5%	2%	20%	5%	5%	30%

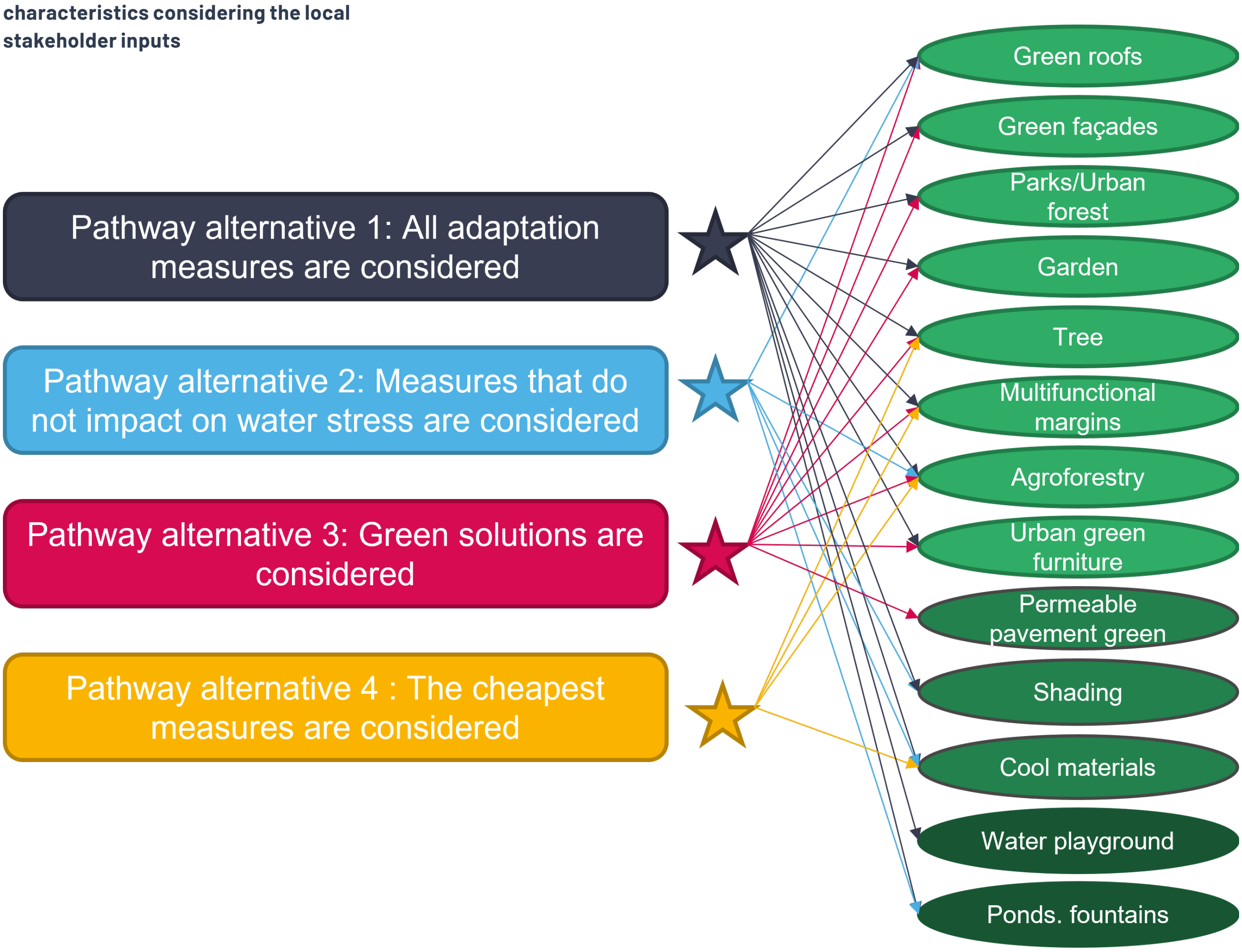
Step 3
Develop pathway alternatives

- Aggregation of different resilience pathways into the pathway alternatives
- Performance assessment of the pathway alternatives
- Sequencing the resiliencemeasure over time

Resilience pathway alternative development
Pathway alternatives are groups of measures, or clusters, which are considered simultaneously to address challenges. This aggregation of previous identified adaptation measures was built considering stakeholders' reflections. The selected pathway alternatives and their aggregation criteria can be seen in Figure 55.

Pathway alternative 2 was defined as many of the adaptation measures require water and this may promote water stress in the whole socio-ecological system. Nature based solutions are key elements of the policies that are being developed as it was presented in Step 1.5 Alignment of the Adaptation Pathway with long-term vision of the system (page 126), thus developing pathway alternative 3 with green adaptation measures. On the other hand, lack of economic finance for adaptation has been identified as a barrier. Therefore, the last pathway alternative (no 4) only considers the most economic solutions.

Figure 55 – Defined pathway alternatives for Valencia and their characteristics considering the local stakeholder inputs



Assessment of effectiveness

Micro-modelling exercises for all measures, except for multifunctional and agroforestry, were performed using envi-met software* to benchmark their effectiveness in terms of PET reduction (ºC) compared to actual status (baseline) of the modelled areas. Figure 56 shows where the modelling was performed and Figure 57 an example of the modelling exercise. Measures were classified as low effective, medium effective and high effective considering the thresholds shown in Table 14. The overall effectiveness for each pathway alternative was assessed using an effectiveness index, the calculation of which is based on how much area is improved per effectiveness range, as seen in Figure 58. Results are presented in Table 16. Pathway alternative 1 showed the best effectiveness followed by pathway alternative 3. The selection of the most suitable pathway was done prior to the sequencing of the pathways.

* A high-resolution commercial microclimate modelling system

Figure 56 – Modelled areas.
A: Green roofs, green façade, extra trees and grass (as garden) were modelled in a street.
B: Urban forest, grass as green permeable pavement, urban vegetable garden, pergola as shading, fountain, pond, water spraying as playground

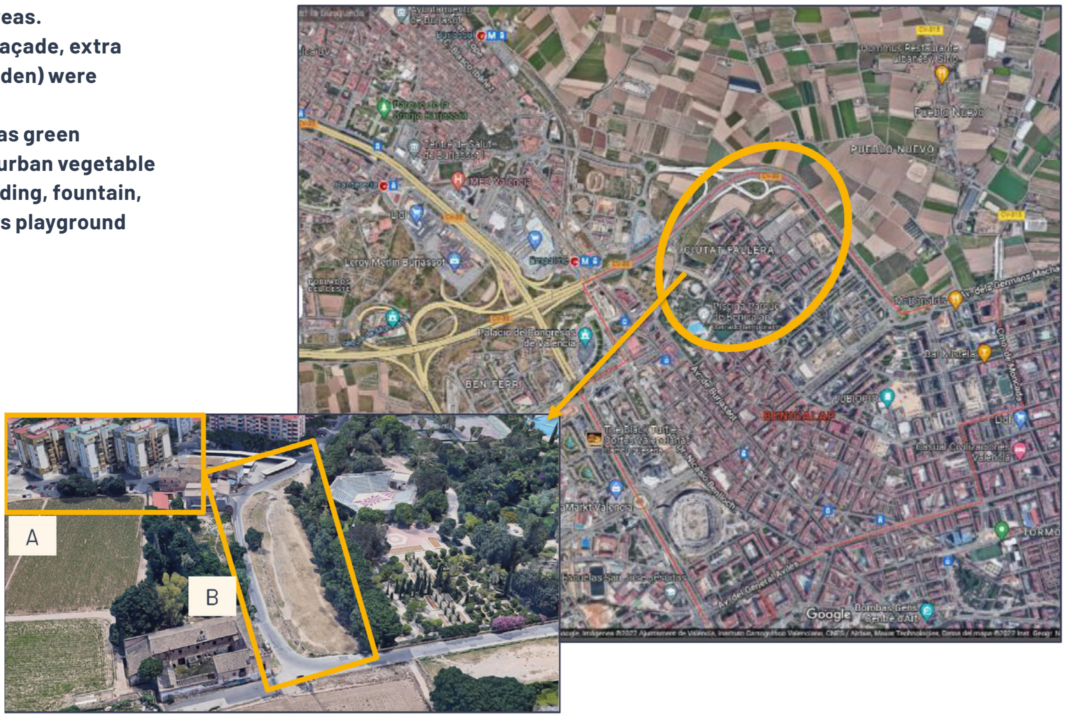
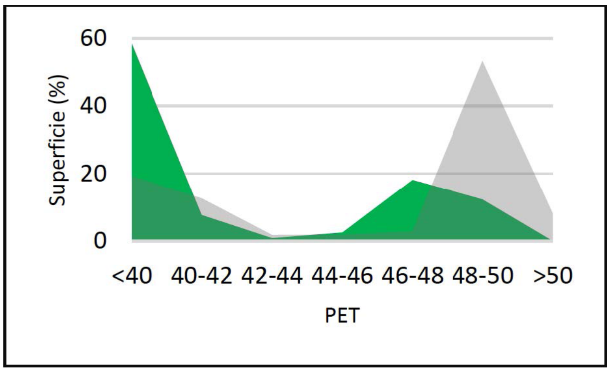
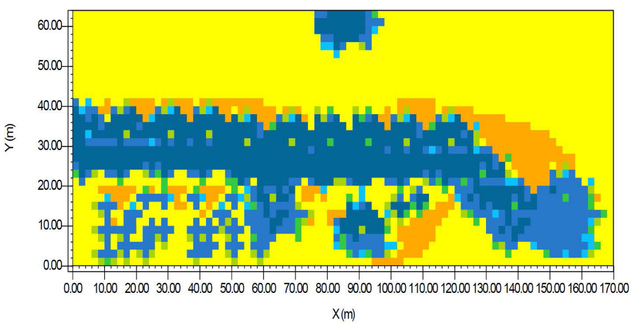
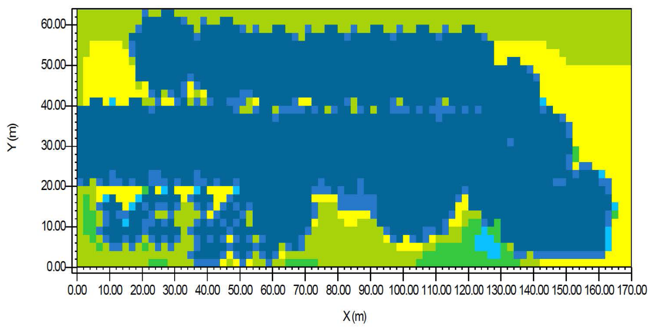


Figure 57 – Modelling outputs for the baseline (upper left) and the urban forest (upper right) in terms of PET. Differences in the distribution in PET ranges by surface area within the baseline and tree cover scenario (bottom image)



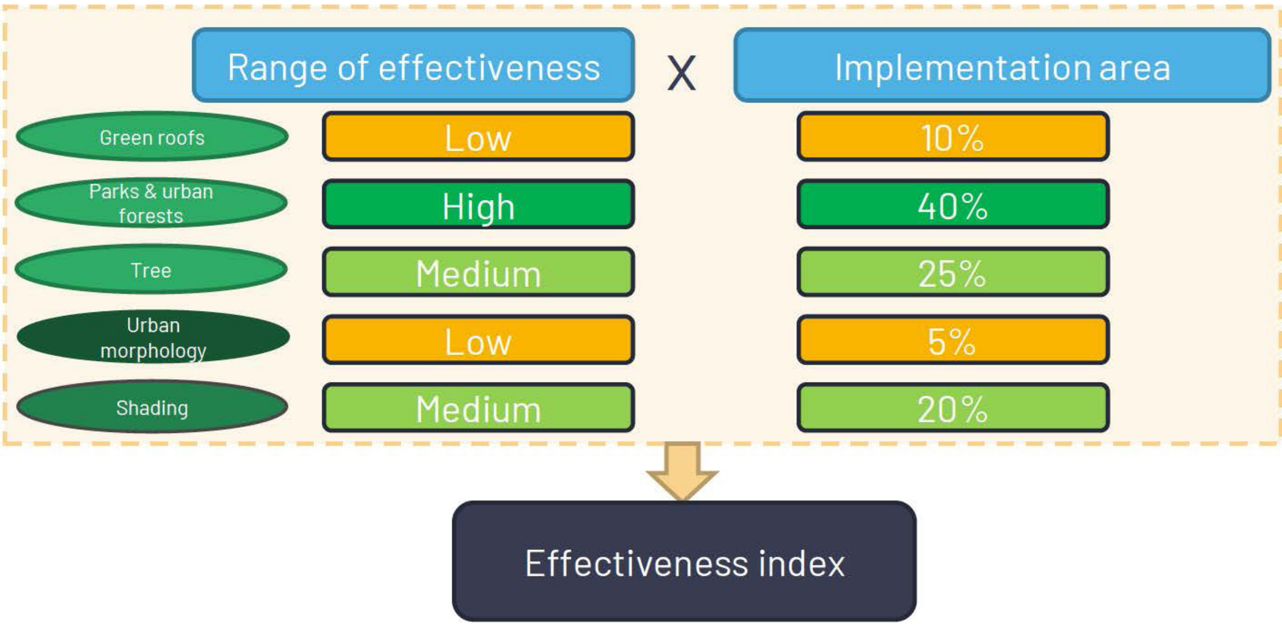




Threshold range	Performance
PET Reduction ≥ 3.5 ºC	High
0.75 ºC ≤ PET Reduction < 3.5ºC	Medium
0ºC < PET Reduction < 0.75 ºC	Low
PET Reduction <.0	Not effective

Table 14 – PET reduction (ºC) values characterising each threshold of effectiveness

Figure 58 – Conceptual example of how the overall effectiveness was calculated for each pathway alternative



Sequencing over time

This step was done after the preferable pathway alternative was established.
The order by which the adaptation measures can be deployed is linked to the vision and understanding of the local stakeholders of how the risk should be addressed. It represents the measures' priority given by the stakeholders to tackle the challenge. In the case of Valencia, the criteria for this sequencing were (by order of relevance):

- Urgency of action: The implementation of the measures should be prioritised in areas at high risk (see Figure 54).
- Touristic areas: one specific area, AF 1: Ciutat Vella, was given more importance as it has heritage importance and tourists visit this area more frequently. It was deemed important to provide comfortable open spaces for tourists.
- Effectiveness of the measures and the preferences of the stakeholders (Table 12).

A detailed sequencing of the measures was performed which accounted for what type of measure should be implemented where (AF) and how much deployment would be envisioned in that area. A section of the graph can be seen in Figure 59 and Table 15 includes all the potential interventions in the sequencing. The cumulative performance of the pathway alternative 3, if all measures are implemented, can be summarized as:

- 3.6% of the planned intervention areas improve thermal comfort in the high range of effectiveness
- 65.9% of the planned intervention areas improve thermal comfort in the medium range of effectiveness
- 30.5% of the planned intervention areas improve thermal comfort in the low range of effectiveness

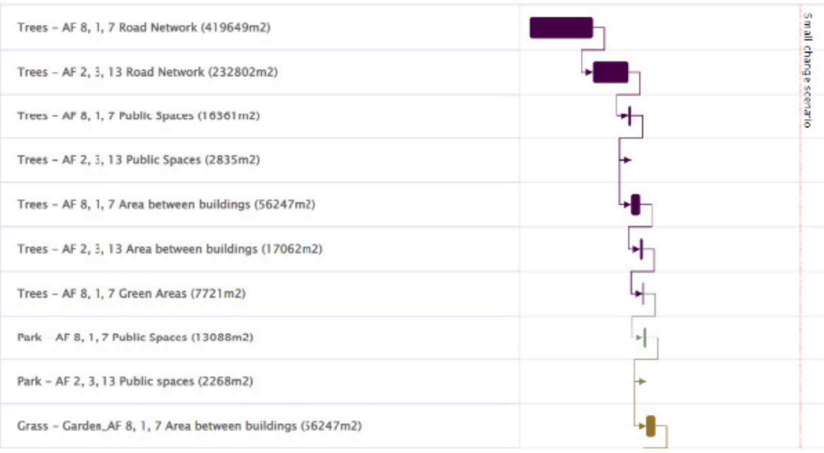


Figure 59 – A section of the graph including the measures in scenario 1 (small change scenario), see Table 13

Scenario 1

Table 15 – Order of the implementation of the adaptation measures corresponding to the pathway alternative 3: only NbS are considered. AF: Administrative Functional urban area

No.	Adaptation measure	Where	Implementation area (m^2)
1	Tree	AF 8, 1, 7 Road Network	419,649
2		AF 2, 3, 13 Road Network	232,802
3		AF 8, 1, 7 Public Spaces	16,361
4		AF 2, 3, 13 Public Spaces	2,835
5		AF 8, 1, 7 Area between buildings	56,247
6		AF 2, 3, 13 Area between buildings	17,062
7		AF 8, 1, 7 Green Areas	7,721
8	Park	AF 8, 1, 7 Public Spaces	13,088
9		AF 2, 3, 13 Public spaces	2,268
10	Garden	AF 8, 1, 7 Area between buildings	56,247
11		AF 2,3, 13 Area between buildings	17,062

Scenario 1

No.	Adaptation measure	Where	Implementation area (m²)
12	Green urban furniture	AF 8, 1, 7 Public Spaces, A. between buildings	59,519
13		AF 2,3, 13 Public Spaces, A. between buildings	17,629
14	Retention Pond	AF 8, 1, 7 Green Areas	5,147
15	Trees	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Road Network, Public Spaces, A. between buildings, Green Areas	230,297
16	Parks	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Public Spaces	14,286
17	Garden & Green urban furniture	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Public Spaces, A. between buildings	59,266
18	Retention Pond	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Green areas	6,957
19	Trees	La Huerta	445,980
20	Green roofs	All AF Buildings	111,937

Scenario 2

Table 15 – Order of the implementation of the adaptation measures corresponding to the pathway alternative 3: only NbS are considered. AF: Administrative Functional urban area

No.	Adaptation measure	Where	Implementation area (m^2)
21	Tree	AF 8, 1, 7 Road Network	83,930
22		AF 2,3, 13 Road Network	46,560
23		AF 8, 1, 7 Public Spaces	41,965
24		AF 2,3, 13 Public Spaces	23,280
25		AF 8, 1, 7 Area between buildings	11,249
26		AF 2,3, 13 Area between buildings	3,412
27		AF 8, 1, 7 Green Areas	1,544
28	Park	AF 8, 1, 7 Public Spaces	2,618
29		AF 2,3, 13 Public spaces	454
30	Garden	AF 8, 1, 7 Area between buildings	11,249
31		AF 2,3, 13 Area between buildings	3,412
32	Green urban furniture	AF 8, 1, 7 Public Spaces, A. between buildings	11,903
33		AF 2,3, 13 Public Spaces, A. between buildings	3,525

Scenario 2

No.	Adaptation measure	Where	Implementation area (m²)
34	Retention Pond	AF 8, 1, 7 Green Areas	1,029
35	Trees	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Road Network, Public Spaces, A. between buildings, Green Areas	690,891
36	Parks	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Public Spaces	8,242
37	Garden & Green urban furniture	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Public Spaces, A. between buildings	23,568
38	Retention Pond	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Green areas	2,985
39	Trees	AF 4, 10, 12, 19, 20, 21, 22 Road Network, Public Spaces, A. between buildings, Green Areas	92,343
40	Parks	AF 4, 10, 12, 19, 20, 21, 22 Public Spaces	8,242
41	Garden & Green urban furniture	AF 4, 10, 12, 19, 20, 21, 22 Public Spaces, A. between buildings	23,568
42	Retention Pond	AF 4, 10, 12, 19, 20, 21, 22 Green areas	2,985
43	Trees	La Huerta	668970
44	Green roofs	All AF Buildings	111,937

Scenario 3

Table 15 – Order of the implementation of the adaptation measures corresponding to the pathway alternative 3: only NbS are considered. AF: Administrative Functional urban area

No.	Adaptation measure	Where	Implementation area (m^2)
45	Trees	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Road Network, Public Spaces, A. between buildings, Green Areas	460,594
46	Parks	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Public Spaces	28,572
47	Garden & Green urban furniture	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Public Spaces, A. between buildings	118,531
48	Retention Pond	AF 5, 6, 9, 11, 14, 15, 16, 17, 18, 23 Green areas	13,914
49	Trees	AF 4, 10, 12, 19, 20, 21, 22 Road Network, Public Spaces, A. between buildings, Green Areas	461,713
50	Parks	AF 4, 10, 12, 19, 20, 21, 22 Public Spaces	41,210
51	Garden & Green urban furniture	AF 4, 10, 12, 19, 20, 21, 22 Public Spaces, A. between buildings	117,839
52	Retention Pond	AF 4, 10, 12, 19, 20, 21, 22 Green areas	14,927
53	Trees	La Huerta	1,248,744
54	Green roofs	All AF Buildings	335,811

Step 4
Recommend a pathway

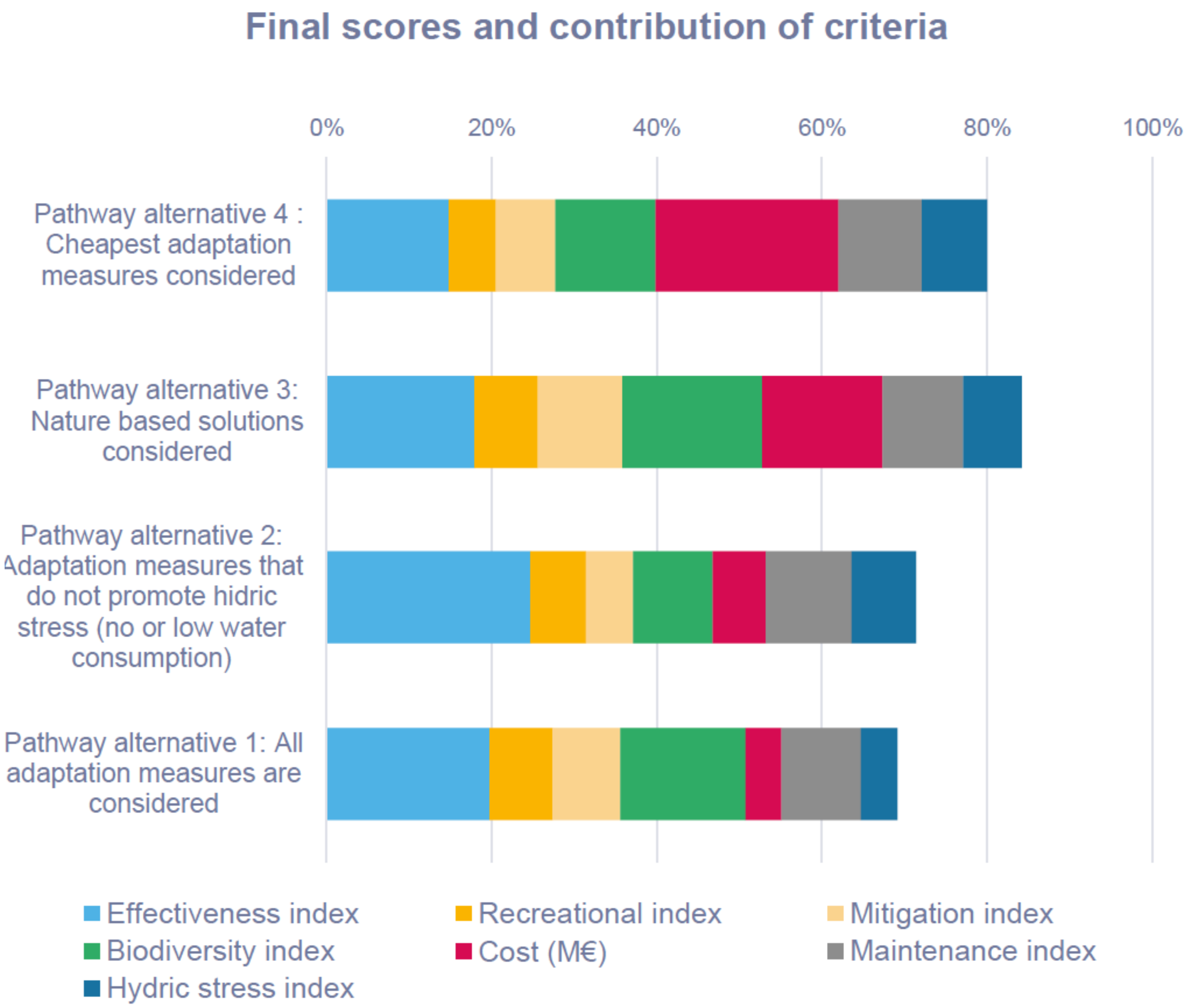
- Decide for the best pathway or rank them & communicate the outputs of the resilience pathway development

Pathway alternative 1 showed the best thermal effectiveness, however other criteria were considered relevant to assess the overall performance of each pathway alternative. The pathway alternative most suitable to Valencia should promote recreational spaces, help or be aligned with mitigation to climate change objectives, promote biodiversity and natural connection, and have as little impact as possible on local water stress. Furthermore, ideally it should be as economic as possible in terms of implementation cost, and have low maintenance cost. Table 16 presents the performance of each of the pathways for each of the criteria. With this information a multi-criteria analysis was carried out, and the outputs of this multi-criteria analysis (Figure 61) showed that overall pathway alternative 3 was the most suitable one considering all the mentioned factors. At this point pathway alternative 3 was selected and proceeded to its sequencing.

Table 16 –
Selected criteria to rank the pathway alternatives (PA) and their values

	PA1	PA2	PA3	PA4
Effectiveness index	0.64	0.80	0.58	0.48
Recreational index	0.64	0.57	0.65	0.48
Mitigation index	0.55	0.38	0.68	0.48
Biodiversity index	0.60	0.38	0.67	0.48
Cost (M€)	312	282	168	61
Maintenance index	0.67	0.62	0.66	0.64
Hydric stress index	0.59	0.34	0.39	0.33

Figure 60 – Contribution of each criterion to the final score of the multicriteria analysis for the pathway alternative



4.2 Lessons learned through the co-creation activities with Valencia, Bratislava, Camerino and Hamburg

Adaptive policymaking, in particular climate Adaptation Pathways, is creating great interest as tools develop to anticipate and plan for the impacts of climate change and associated disasters. However, there is a gap in knowledge around the concepts and methodologies as they relate to Adaptation Pathways, especially in the heritage field. And since Resilience Pathways have been developed within the ARCH project to respond to the ARCH Resilience Management Framework (Figure 4), the knowledge of Resilience Pathways is even at an "embryonic" stage. A few conclusions and lessons learned can be concluded from the testing and co-creation activities with ARCH City partners and Valencia's local stakeholders which have been structured in five main topics:

1. **Acquired knowledge through the training, co-creation and testing activities**
   The concept and data-driven methodology, often unknown for the ARCH City partners and local stakeholders, was initially perceived as complex. The training sessions proved to be a good starting point to bridge the knowledge gap and raise interest, as mentioned at the beginning of the chapter.

   As expected, the deeper the co-creation and testing work that was done between Tecnalia and the ARCH City partners, the better the understanding of the whole process progressed. This better understanding translated to higher understanding of the full potential of the adaptation approach as a decision-making strategy to help with planning for adaptation and resilience.

   More precisely the ARCH City partners expressed their learning uptake as:
   _ *"A logical step by step approach for creating a roadmap for increasing resilience"*
   _ *"A framework with which we can assess the potential resilience of different actions for pre-during or after natural disasters"*

Figure 61 shows various features of the Resilience Pathway approach that were of interest by the ARCH City partners.

Figure 61 – Elements of the methodology that the ARCH City partners valued most

Long-term vision

Concrete system to drive decision makers towards resilience programmes programmes and plans

A method based on knowledge and sensible data

Allows assessments based on costs and benefits

The use of multicriteria analysis

2. **Use of the pathway approach to your local context**
   All ARCH City partners perceived the potential applicability of the pathway approach. While in some cases, the link and support to current policies and initiatives such as the Covenant of Mayors for Energy and Climate and its Sustainable Energy and Climate Action Plan (SECAP) was clear, in other cases the applicability of the pathway approach was linked to different performance indicators than the ones considered within this handbook.

3. **Adaptation vs. resilience approaches**
   Both approaches were of interest. In some cases, a the broader or more holistic approach (resilience) was preferred, but for practical reasons the pre-disaster or Adaptation Pathway would be selected as a starting point. Resilience pathways were seen as a bit more complex, but at the same time with more opportunities as "it provides more options also for "bouncing back" and building certain capacity".

4. **General barriers of development and implementation of the pathway approach**
   During the training, testing and co-creation activities several barriers were identified in the development and implementation of Resilience Pathways. Since in the ARCH project the focus was on data-driven pathways, the main barrier identified by multiple ARCH partners or local stakeholders was the lack of data or the level of the detail required in the data for the successful deployment of a Resilience Pathway, especially when considering historic areas.

   The second most frequently mentioned barrier was the monetary and resource limitation that municipalities, regions or organisations managing heritage may have. A summary of other identified barriers is shown in Figure 62.

5. **Heritage perspective in the pathway approach**
   The testing activities carried out in ARCH Cites were cases where historic areas were understood as social-ecological systems. However, this approach may not always be transferrable to other historic areas where the pathway approach is sought just for the physical demarcation of the historic zone. This shows the importance again of the local context in resilience and adaptation building, especially when considering heritage.

   Another relevant consideration for historic areas is the importance of maintaining the authenticity of the historic areas which may conflict with several structural resilience measures. This brings another requirement for historic areas and shows the need for new performance indicators that may focus on heritage or account for criteria relevant to historic areas. This is especially relevant for World Heritage Sites.

   "The performance indicator for this cultural heritage cannot be environmental and economic but has to be the sustainably protected heritage with the least possible loss of substance and traditional use."

   Therefore, there is a need to continue working and exploring other heritage case studies to further refine the Resilience Pathway methodology if it is to be applicable to historic areas and draw broader conclusions.

Figure 62 – Other relevant obstacles in the development and implementation of Resilience Pathways

The pathway approach needs multidisciplinary skills and training to understand steps and relations

Difficulty in setting specific thresholds

Complexity of existing layers of decision making

Lack of efficient coordination among many different stakeholders

Different understanding and priorities among stakeholders. Cultural heritege needs a central role

Difficulties to find appropriate measures to historic buildings

Lack of willingness to change

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Annex A. Glossary

A

- **Adaptation (to climate change)**
  The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

C

- **Climate change**
  refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

- **Climate model**
  A numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for some of its known properties.

- **Climate projection**
  A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases and aerosols, generally derived using climate models.

D

- **Disaster**
  is a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources

- **Disaster risk management**
  The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster.

H

- **Historic area**
  Any groups of buildings, structures and open spaces including archaeological and palaeontological sites, constituting human settlements in an urban or rural environment, the cohesion and value of which, from the archaeological, architectural, prehistoric, historic, aesthetic or sociocultural point of view are recognized.

  Among these `areas', which are very varied in nature, it is possible to distinguish the following , in particular: prehistoric sites, historic towns, old urban quarters, villages and hamlets as well as homogeneous monumental groups, it being understood that the latter should as a rule be carefully preserved unchanged

I

- **Impact**
  Effects on natural and human systems (...) the term impact is used primarily to refer to the effects on natural and human systems of extreme weather and events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the interaction of climate changes of hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Note: Impacts are also referred to as consequences and outcomes

R

- **Resilience**
  The capacity of a social ecological system to cope with a hazardous event or disturbance, responding or reorganizing in ways that maintain its essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation. Building resilience needs to account for: the degree to which the community comes into contact with a hazard capable of causing harm; the amount of inherent susceptibility to harm in that community; and the extent to which people in the community are able to make adjustments in order to avoid negative consequences, taking into account existing imbalances in power distribution in that community and ensuring that neither the impact of the hazard, nor the policies and actions themselves exacerbate existing or create new inequalities across different groups

- **Risk**
  The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard.

S

- **Scenario**
  A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g. rate of technological change, prices) and relationships.

U

- **Uncertainty**
  A state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable

- **Urban (Urban area)**
  Urban 'is a function of (1) sheer population size, (2) space (land area), (3) the ratio of population to space (density or concentration), and (4) economic and social organization.'

V

- **Vulnerability**
  The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

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