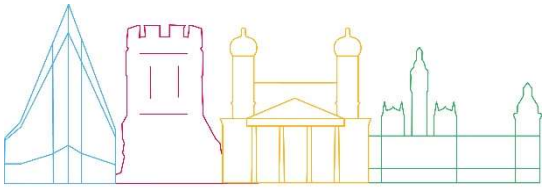
ARCH

ARCH Resilience Pathway Visualization tool

User guide



This 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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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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List of Abbreviations

Abbreviation	Meaning
ARCH	Advancing Resilience of historic areas against Climate-related and other Hazards
EU	European Union
IPCC	Intergovernmental Panel on Climate Change
SECAP	Sustainable Energy and Climate Action Plan
RPVT	Resilience Pathway Visualization Tool
RMI	Resilience Measure Inventory
BCR	Benefit-Cost Ratio
PET	Physiological Equivalent Temperature

1. Introduction

The ARCH project (Advancing Resilience of historic areas against Climate-related and other Hazards) 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 (ARCH Resilience Management Framework[1]) for planning both for the climate change adaptation[2] and disaster risk management cycles[3]. ARCH Work package 6 aims at supporting resilience building through, among other things, the development of an inventory of resilience measures targeting heritage and resilience pathways for historic areas. In line with this objective, the Resilience Pathway Visualization Tool (RPVT) has been developed.

A Resilience Pathway is a decision-making strategy, closely related to planning, that addresses both slow-onset climate change and natural disasters management. It is a roadmap - sequences of potential actions/choices that can be implemented progressively as conditions evolve (on how the future unfolds and the development of knowledge)

2. What is the RPVT?

The ARCH Resilience Pathway Visualization Tool (RPVT) is an easy-to-use web-based tool to create and visualize **resilience pathways.** It provides a user-friendly graphical interface through which users interact to **select, prioritize and sequence potential resilience measures** over time that can be deployed as circumstances evolve. Measures can be selected and prioritized according to various performance metrics (ARCH D6.2[4]).

The RPVT is a data-driven tool supported by a relational database that stores and provides access to the different type of measures characterization (RMI) as well as to effectiveness and economic performance.

3. What is the RPVT for?

The aim of the RPVT is to support the resilience pathway development to city administrators, heritage managers and/or decision makers in the context of historic areas. The RPVT should be used in conjunction with the Resilience Pathway Handbook, which will guide on the steps and give examples to enable building ad-hoc resilience pathways to each historic area typology covered within the RPVT.

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[1] Milde, K.; Lückerath, D. and Ullrich, O. ARCH Deliverable D7.3: ARCH Disaster Risk Management Framework. ARCH Project, GA 820999, 2020

[2] RAMSES, “Transition Handbook” 2018, H2020 GA No. 30849.

[3] R. Jigyasu, J. King and G. Wijesuriya, Managing disaster risk for world heritage, United Nations Educational, Scientific and Cultural Organisation, 2010

[4] Matesanz Parellada, A.; Nicolás Buxen, O.; Peña Cerezo, N.; Sopelana Gato, A.; Turienzo López, E.; Zorita Castresana, S.; Pedone, L.; Rosca, C.; Giovinazzi, S.; Morici, M.; Dall’Asta, A.; Barchetta, L. ARCH Deliverable D6.2: Assessment of long-term implementation options. ARCH Project, GA 820999, 2020

The RPVT is conceived for both climate change adaptation and disaster risk management with focus on (1) heritage building & structures as well as (2) cultural heritage landscapes with focus on agricultural heritage.

It is conceptualised to support and guide practitioners:

- to gather **evidence-based information** about resilience measures identified in the RMI;
- to select and compare measures based on **environmental effectiveness and/or economic analysis**;
- to create and benchmark **different alternatives** (cluster of measures) based on different performance metrics;
- to build resilience pathways (**roadmaps**) by sequencing **the potential measures over time** considering different scenarios or changing circumstances;
- to communicate and assist decision-makers to visualize a **dynamic response** to changing conditions.

These outcomes may be used:

- to understand which pathway may be more efficient to target our goals of resilience;
- to support awareness raising and capacity-building;
- to communicate and assist decision-makers to visualize a progressive and dynamic response to changing conditions;
- to support SECAP development in the framework of the EU Covenant of Mayors.

4. How to navigate and use the RPVT

This section contains a short manual of the ARCH RPVT tool. It describes the structure of the tool, its functionalities and the logical steps for using the tool with the intention of helping end-users understand the usage of this product and achieve its objectives.

4.1. Description of the tool format and technical requirements of use

The RPVT tool is a web application built with the Django framework v3.2.10 (www.djangoproject.com/) and Python language v3.10 (www.python.org). For the web view, JQuery v3.5.1 (jquery.com), Bootstrap v4 (getbootstrap.com), Highchart v10.1.0 (www.highcharts.com) and Chart.js v3.8.0 (www.chartjs.org) have been used. In turn, for the storage and management of information, a MySQL relational database (www.mysql.com) is used. Therefore, once deployed, there are few technical requirements for optimal performance by the user.

This tool works on all modern browsers and mobile devices. Legacy browsers - primarily IE 6-8 - are supported using polyfills and the old IE module.

Browser compatibility. We test our software on many browsers using the latest versions.

Brand	Versions supported
Firefox	2.0 +
Chrome	1.0 +
Safari	4.0 +
Opera	9.0 +
Edge	12.0 +
Internet Explorer	6.0-8.0 partial support using polyfills
Internet Explorer	9.0 +

4.2. The RPVT structure & sequence

The landing page to the RPVT presents the essence of the tool in two sentences. It also makes reference to the ARCH Resilience Measure Inventory (RMI) and to the Resilience Pathways Handbook that provides detail information about the resilience pathways concept and methodological process. It also provides direct access to this guide by clicking on “User’s Guide” link (See Figure 1).

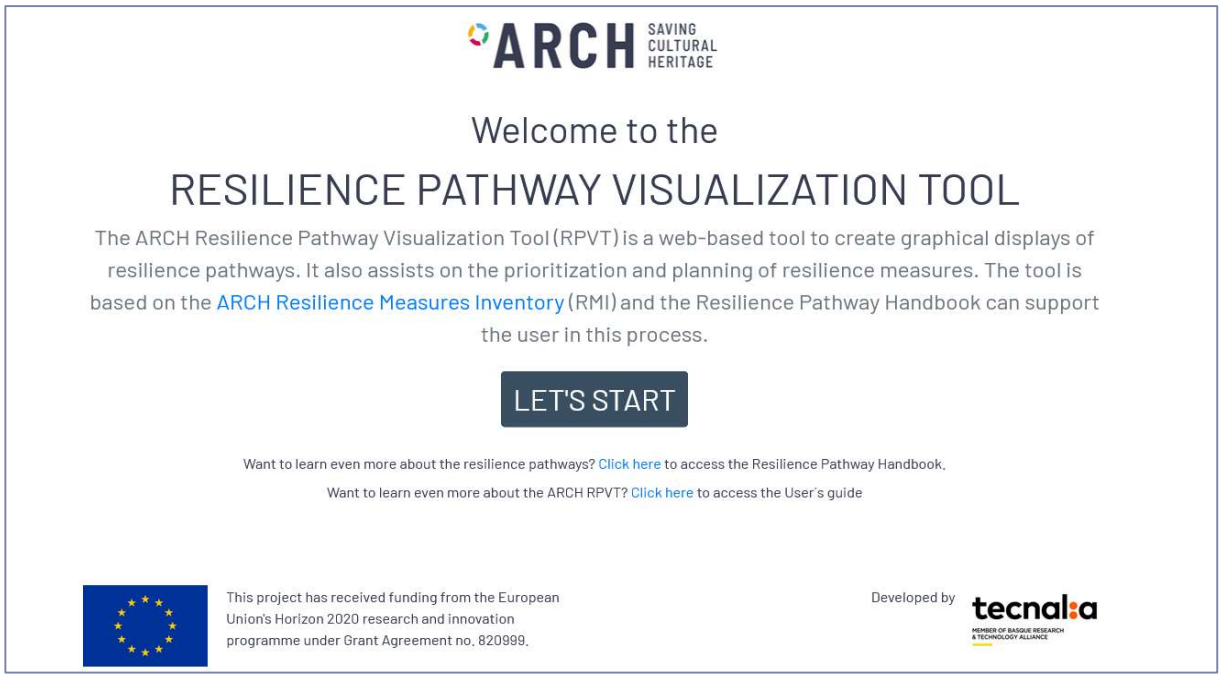
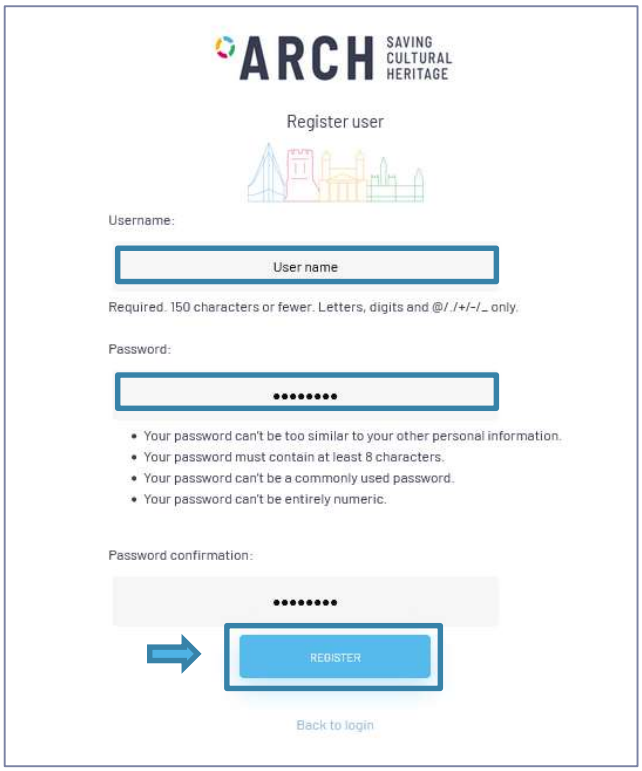


Figure 1. Landing page to the RPVT

Click on the “Let’s start” button to arrive to the user login/registration page (Figure 2). You require an account to get access into the tool. First, create an account by clicking on the “Register” button to create a new personal account. Then the new user registration page will open (See Figure 3).

Figure 2. User login/registration page



To create an account to get access into the RPVT tool is very simple, you just need a few minutes of your time to type a new *user_name* and a *password*, afterwards click on the "Register" button. Please, follow the recommendations and specification provided in this page to set the username and the password correctly. This information will be requested next time you enter into the RPVT and all your RPVT projects will be linked to your user account That is, to access and revise all pathways you create, you will need to remember your username and password in the future.

Figure 3. RPVT new user registration page

Once you've finished the registration process, click on "Back to login" and you will be redirected to the login page (Figure 2). Enter your user/password and click on the "Log in" button to enter

the introduction page (Figure 4) where each step of the resilience pathway visualization process is summarized.

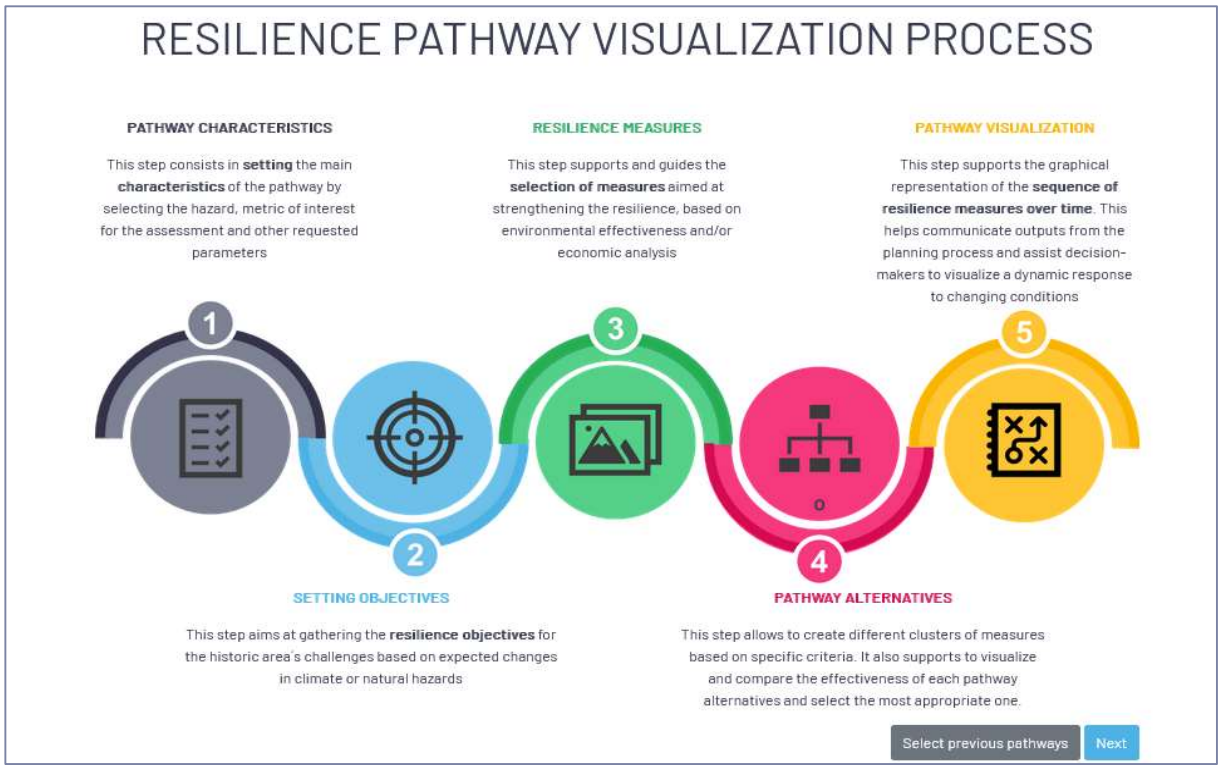


Figure 4. RPVT short introduction page, where the resilience pathway visualization process is described.

The resilience pathway process introduction page summarizes the aim of each of the steps needed to design a resilience pathway, ideal to be reviewed by first-time users. See subsections 4.2.1 to 4.2.5 for further information about the steps and the RPVT's functionalities.

Click on the "Next" button to start the creation of a new resilience pathway or click "select previous pathways" button to search for previously designed resilience pathways.

4.2.1. Step 1: Setting pathway characteristics

This step requests you to set the main characteristics of the pathway project that you are about to design in the next minutes. Setting the characteristics of the pathway is a very simple process, as the RPVT offers an integrated approach where drop-down menus are pre-configured according to the previous settings.

First, type the *pathway_name*, (Figure 5.a), note that the information linked to this project will be stored based on that name.

Next, type the description and/or aim of your pathway in the pathway_*description* input_text or any other relevant information (Figure 5.b), such as involved stakeholders. Note this input text is not mandatory so you can skip it at this moment.

Figure 5. Step 1 page - initial setting

Third, select the *type_of_inventory,* you are willing to base your pathway on (Figure 5.c). As you can see this input is requested through a drop-down menu where you can select from two types of heritage:

(i) urban heritage building & structures

(ii) agricultural heritage

Depending on your selection, the RPVT automatically pre-configures the next input drop-down menus, where different hazards affecting that type of heritage will be available for your next selection (Figure 6). Note that at this stage the RPVT can design pathways considering three individual hazards (flood, heat extremes, and earthquake) for the urban heritage. Instead, for agricultural heritage, only the flood hazard is selectable, however a multi hazard approach is also available to consider multiple hazards that may impact agriculture at the same time: heat, flood, biological activity, soil erosion, salinization of soil, water scarcity etc.

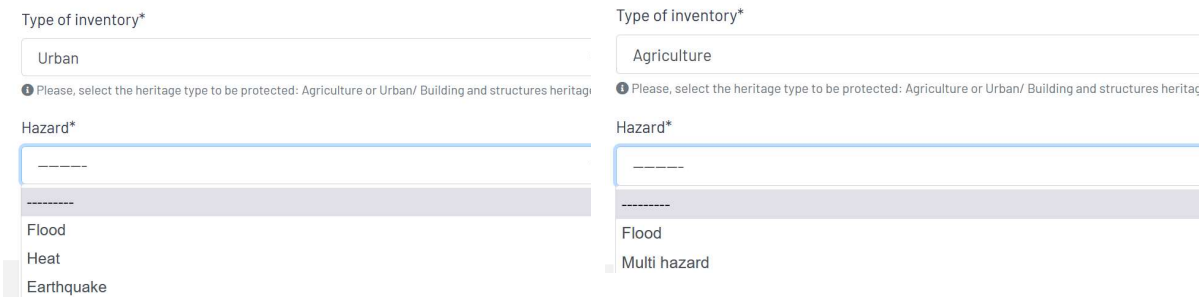


Figure 6. Hazards available per type of heritage

ARCH provides a resilience integrated framework to deal with both adaptation to climate change and disaster risk management (for more detail, see Section 1.2.1 from the Resilience Pathway Handbook). Based on this integrated framework , the RPVT offers the user to design a pathway considering two options, (1) an adaptation strategy approach (Figure 8) to address adaptation to climate change or (2) a resilience approach (Figure 7) to address both climate change adaptation and risk management of potential natural disaster events.

Therefore, once the hazard is selected, you have to define the type of pathway strategy you are willing to design by choosing from the available options: *adaptation or resilience*:

- *adaptation pathways approach* (Figure 8) is a decision-making strategy to address slow-onset processes resulting from climate change and preparedness to sudden weather extremes (pre-disaster)
- *resilience pathways approach* (Figure 7) is a decision-making strategy to address both slow-onset processes resulting from climate change adaptation (pre-disaster) and natural disasters (pre-, during and post disaster)

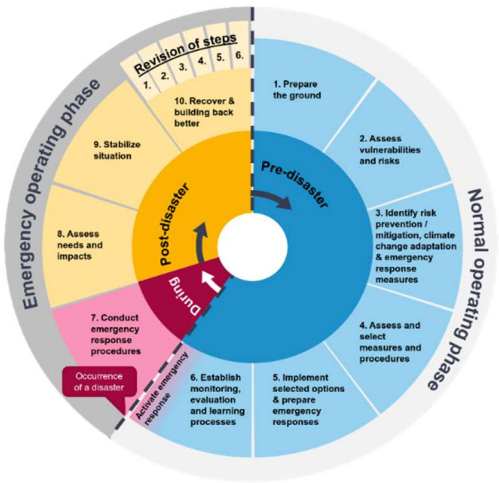


Figure 7. Resilience pathway approach where resilience measures available in the RPVT are considered (pre-, during and post disaster)

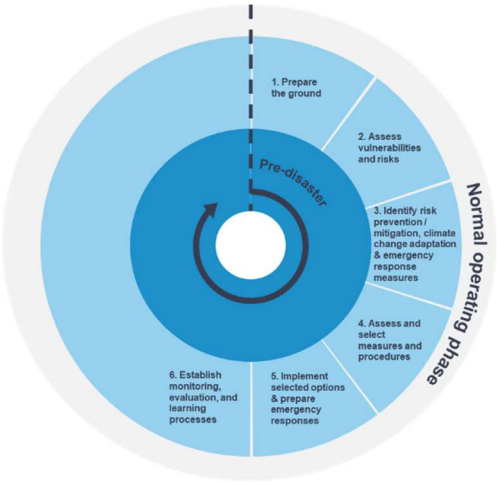


Figure 8. Adaptation pathways approach where adaptation measures available in the RPVT are considered (pre-disaster)

Once you select a pathway strategy (adaptation or resilience), the RPVT automatically requests you to choose the indicator over which the performance can be assessed. Figure 9 provides you an example of settings for an urban adaptation pathway.

Note that there are multiple options available depending on the previous type of pathway, hazard and/or strategy. For example, selecting the *resilience* strategy, the benefit-cost ratio indicator (for now on, BCR) is always considered to measure the economic performance, although additional physical indicators can be considered. On the other hand, selecting the adaptation strategy, a physical indicator has to be mandatorily selected, and the BCR is an optional indicator to include additional social or institutional measures considering their benefit cost ratio analysis. Note that there is also a qualitative approach where no metric is needed.

You can play with the different options available until you choose the most suitable selection for your case. Figure 10 provides you the decision tree behind the RPVT available options.

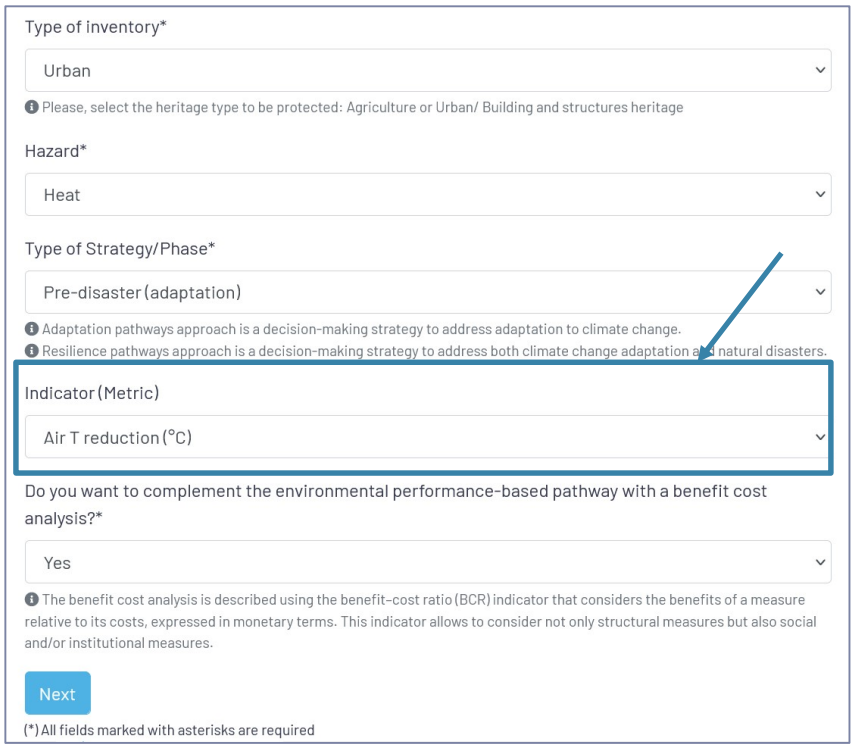


Figure 9. Step 1 page –settings for an urban heritage adaptation approach

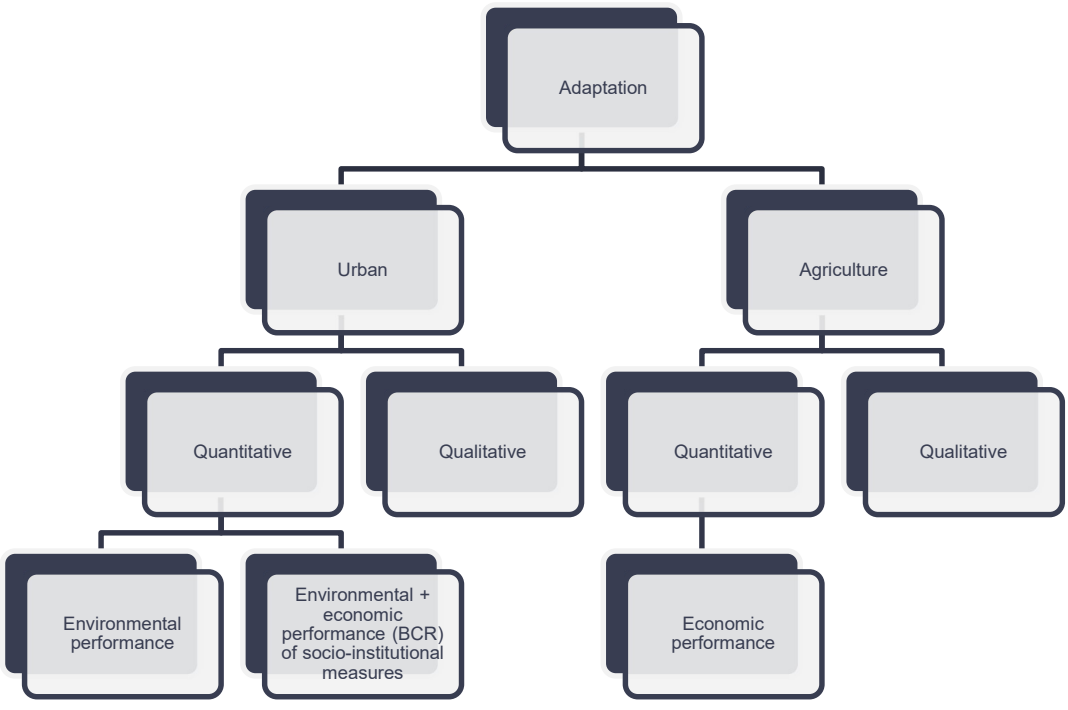


Figure 10. Decision- tree behind the RPVT

4.2.2. Step 2: Vision construction and setting up objectives

At this page (Figure 11) you have to describe the objectives regarding adaptation or resilience for your historic area. An objective can be quantitative or qualitative and describes a desired result that wants or needs to be achieved in the future (See Step 1 and more in particular Step 1.4 from the Resilience Pathway Handbook). The degree of detail depends on how much previous work has been done at historic or urban area. At first stage the settings of these objectives can be ambiguous, but the design of a new pathway can also help to better define more context-oriented objectives.

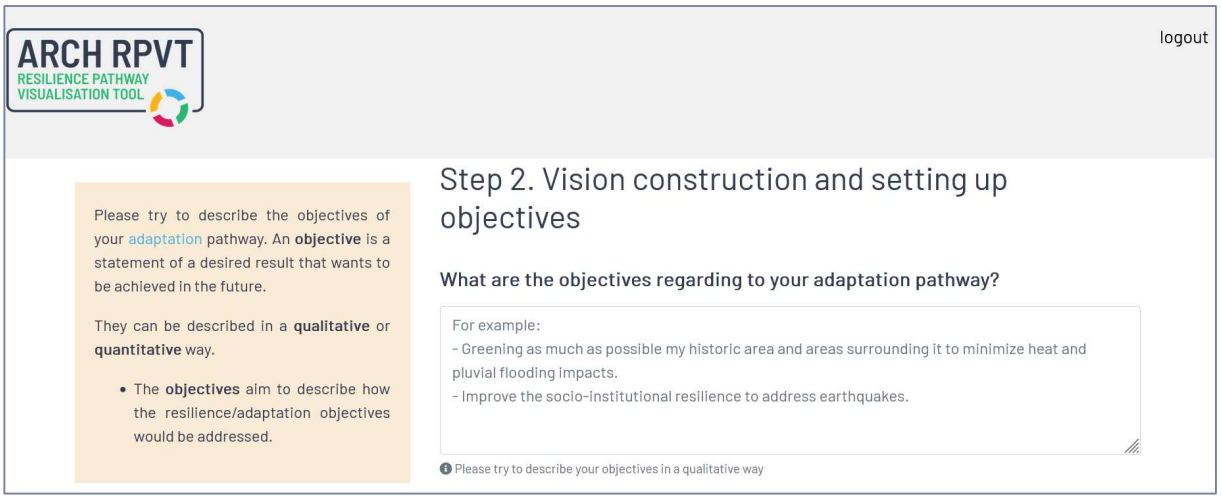


Figure 11. Step 2 page to describe the objectives to be reached

4.2.3. Step 3: Select resilience/adaptation options

At this step the RPVT automatically provides you the list of resilience measures available and applicable for the specific characteristics of your pathway (step 1).

As it is showed in Figure 12, the **central part of this page** provides the environmental effectiveness and economic efficiency of each of the measures (if available). The economic performance is assessed using the *BCR indicator* that considers the benefits of a measure relative to its costs, expressed in monetary terms. Various environmental indicators, which can be selected in Step 1, can be chosen to characterise the measures' effectiveness.

You can re-organize the measures in this central window by ordering them considering their environmental or economic performance. Or look for a specific one by typing the text you are looking for. Close to each measure you can also click on the factsheet link to see in detail the characteristics of the measure.

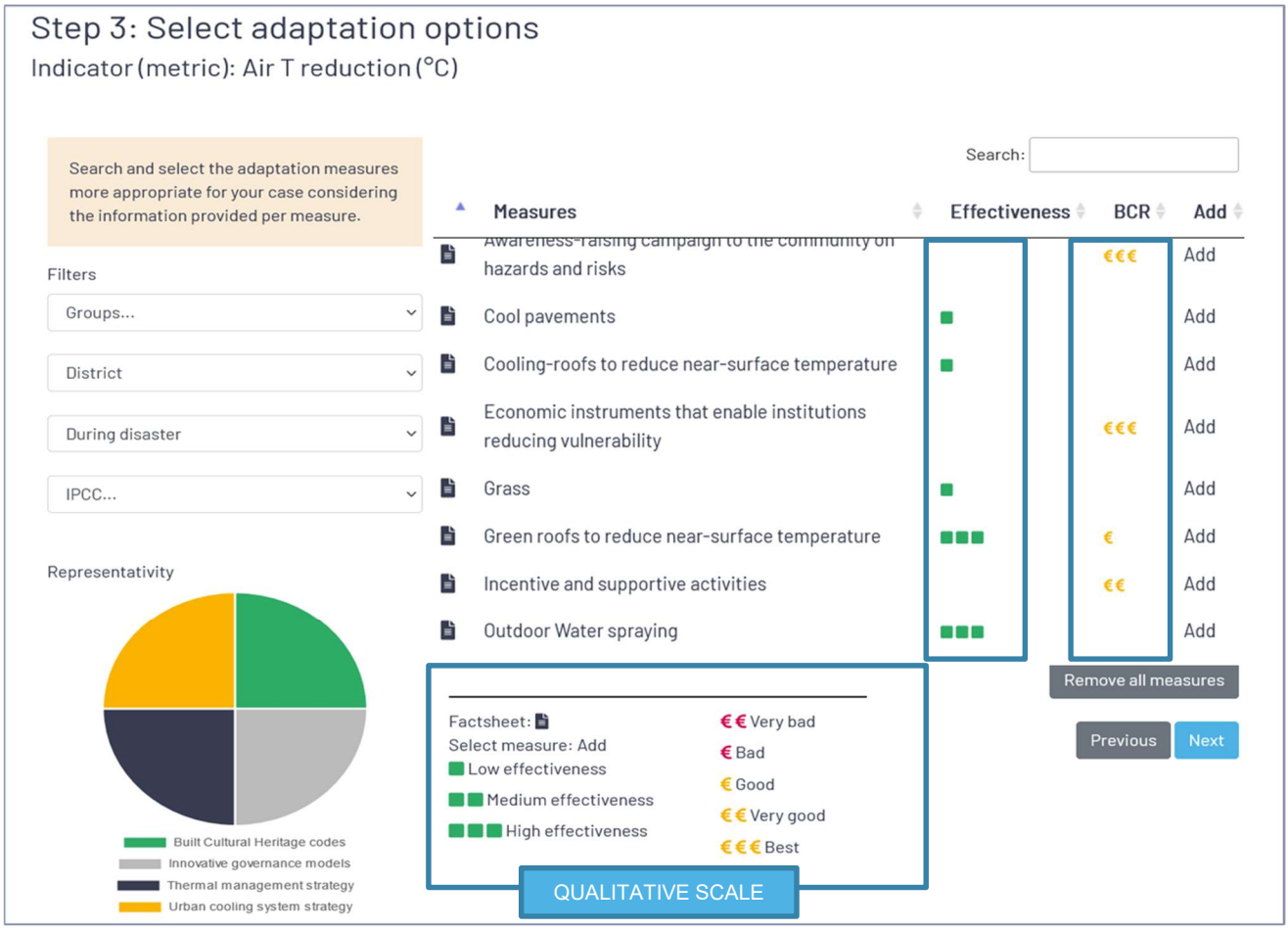


Figure 12. Functions and information provided in Step 2 page

Note that measures have been classified depending on the *average* performance per metric achieved in the analysed case studies following assigned threshold ranges. As environmental and economic performance can depend on the local context it is more desirable to present the performance using qualitative scales. Next tables show the metrics (Tables 1-2) and qualitative scales (Tables 3-8) for each indicator available at the RPVT.

Table 1. Metrics used for heat related environmental indicators at the RPVT

Parameter	Unit
Air Temperature Reduction	ºC
PET (Physiological Equivalent Temperature) reduction	ºC
Indoor air Temperature Reduction	ºC

Table 2. Metrics used for flood related environmental indicators at the RPVT

Parameter	Unit
Flooding area reduction	%

Parameter	Unit
Runoff Reduction	% or cm
Infiltration rate	mm/h

Table 3. Qualitative performance scale for air temperature reduction

Threshold range	Performance
Air Temperature Reduction > 2 ºC	High
1 ºC < Air Temperature Reduction ≤ 2 ºC	Medium
0 ºC < Air Temperature Reduction ≤1 ºC	Low
Air Temperature Reduction = 0	Not effective

Table 4. Qualitative performance scale for PET reduction

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

Table 5. Qualitative performance scale for indoor temperature reduction

Threshold range	Performance
Indoor Temperature reduction > 4 ºC	High
2 ºC < Indoor Temperature reduction ≤ 4ºC	Medium
0 ºC < Indoor Temperature reduction ≤ 2 ºC	Low
Indoor Temperature reduction = 0	Not effective

Table 6. Qualitative performance scale for flooding area reduction

Threshold range	Performance
Flooding area reduction > 50%	High
20% < Flooding area reduction ≤ 50%	Medium
0% < Flooding area reduction ≤ 20%	Low
Flooding area reduction = 0%	Not effective

Table 7. Qualitative performance scale for runoff reduction

Threshold range	Performance
Runoff Reduction > 30%	High
10% < Runoff Reduction ≤ 30%	Medium

0% < Runoff Reduction ≤10%	Low
Runoff Reduction = 0%	Not effective

Table 8. Qualitative performance scale for infiltration rate

Threshold range	Performance
Infiltration rate > 35 mm/h	High
10 mm/h < Infiltration rate ≤ 35 mm/h	Medium
0.5 mm/h < Infiltration rate ≤ 10 mm/h	Low
0 mm/h ≤ Infiltration rate ≤ 0.5 mm/h	Not effective

Table 9. Qualitative performance scale for BCR economic indicator

Threshold range	Performance
BCR > 10	Best
5 ≤ BCR ≤ 10	Very good
1 ≤ BCR < 5	Good
0 ≤ BCR < 1	Bad
BCR <0	Very bad

The **left-hand side of this window** provides you different types of filters to help narrowing down the search for suitable resilience measures, if necessary. If measures have been already identified using the RMI, you can just directly select by clicking the “add” button on the right side of the effectiveness or BCR column. Please, note that in Step 3, only resilience measures with associated effectiveness or efficiency will be shown, unless a qualitative pathway approach has been selected in Step 1.

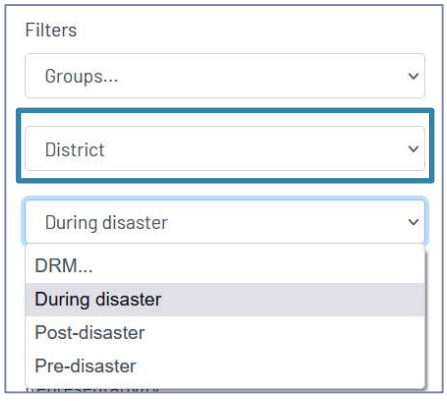


Figure 13. Filters categories

To select the appropriate choice for each filter, click on the filter you are interested on and select one of the listed categories. For example, as seen in Figure 13, the category *District* has

been selected under “Scale” filter. In the same manner, if “DRM[5]” category is selected a list of available options (pre-disaster, during-disaster, post-disaster) are listed and the user can select from them. It has to be highlighted that the more filters are used the more restrictive the search will be. Note that an iterative search can be made until the final selection of desired and suitable measures is achieved. In case there is a need to amend the selection of the filters, there is a way to erase the filter selection by going back to the filter and removing that option.

You can select the desired options within one or more filters, afterwards the list of available measures will appear in the central part of this window (See Figure 14). Click on the “Add” button to add a specific measure into the portfolios of measures or click on “Select all measures” to add all your filtered measures into the portfolio.

Please note that all your selected measures appear in the “Selected measures” panel (at the bottom of the screen). You can go back at any moment by removing any of the previously selected measures or by removing all of them and start again.

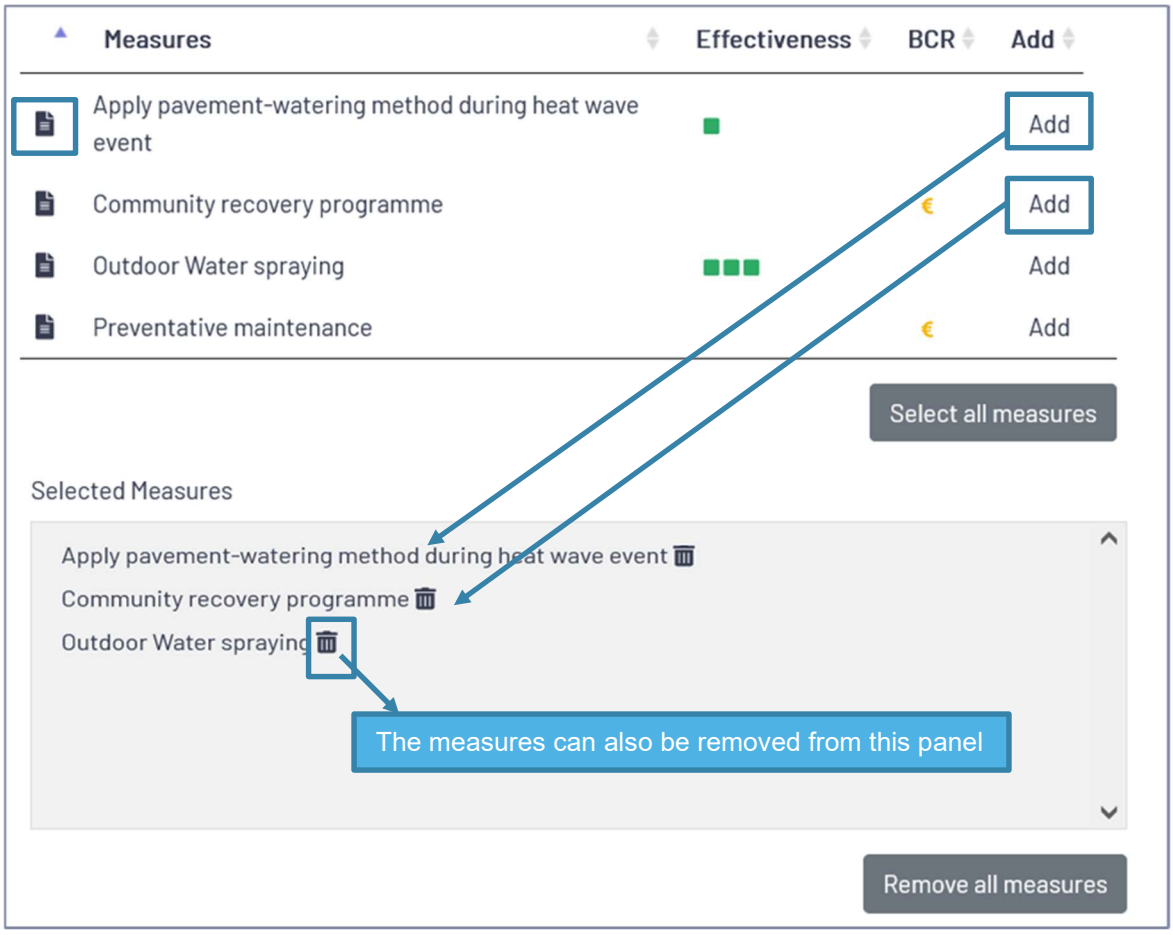


Figure 14. Central part of the window to visualize the factsheet of the measure, select the measure by clicking the “Add” button or remove it by clicking on the “remove” icon.

The last functionality of this window is to provide a graphical information of the representativity of the selected measures (Figure 15) with regard to the group to which they belong (groups

[5] Disaster Risk Management

are explained in the RMI, for further information, please visit the RMI tool or its user guide), so, you can easily visualize the balance of the different type of measures selected. This representation is especially important when a qualitative approach pathway is performed and there is no information available regarding the environmental or economic performance. You can always perform a selection of measures based on stakeholder knowledge and ad-hoc prioritisation exercises, which can be an input on the pathway development process using the RPVT.

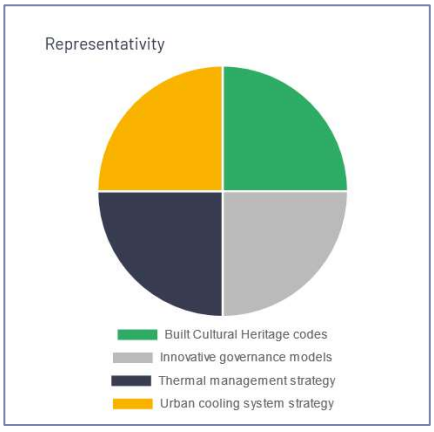


Figure 15. Example of graphical representativity of the selected measures. See also Figure 12, where this part of information appears at the bottom left-hand corner.

For more information on these, go to the RMI or directly click on this link to get access to the list of ARCH groups and subgroups for the urban/ building & structures heritage.

4.2.4. Step 4: Pathway alternatives

This step will support you to build various pathway alternatives[6] in order to benchmark them and help you to identify which group of measures are best to achieve the resilience goals (For further information see step 3.1 from the Resilience Pathway Handbook).

Once you have selected a list of suitable resilience measures there are two different options on how to proceed:

1. **You can manually create a pathway alternative by individual selection of measures** (the approach by which measures are selected are either not included in the RPVT or it is based on stakeholder knowledge). To work on this option, you don't need to set a criterion, you just need to manually select or deselect the measures based on expert criteria and/or the predefined portfolio from the RMI (information provided by the RMI factsheet). This option allows the user to graphically visualize the performance of each individual measure as well as the total pathway alternative performance by using the bar-chart (shown in Figure 16 in the green box) graphical interfaces that appear on the right-hand side of this window.

[6] A pathway alternative is a cluster of resilience measures, similar to a resilience or adaptation strategy

2. **You can create and compare different pathway alternatives based on specific criterion/ia**. To work on this option the user will need to select the criteria settings available on the left-hand side of this window (shown in Figure 16 in the blue box). Depending on the criteria applied, the central part of the window will be filled with the measures that fulfil the criteria previously identified. The user can easily remove or modify the criteria but cannot manually select the measures as they are filtered according to the specified criteria. Similar to previous option, the right-hand side window automatically shows the performance of each pathway alternative that is created.

Figure 16 presents the overall Step 4 page with the different parts of the window. The unique mandatory input requested is the *name* of the pathway alternative. If you create more than one alternative, then you need to add a different name for each pathway alternative.

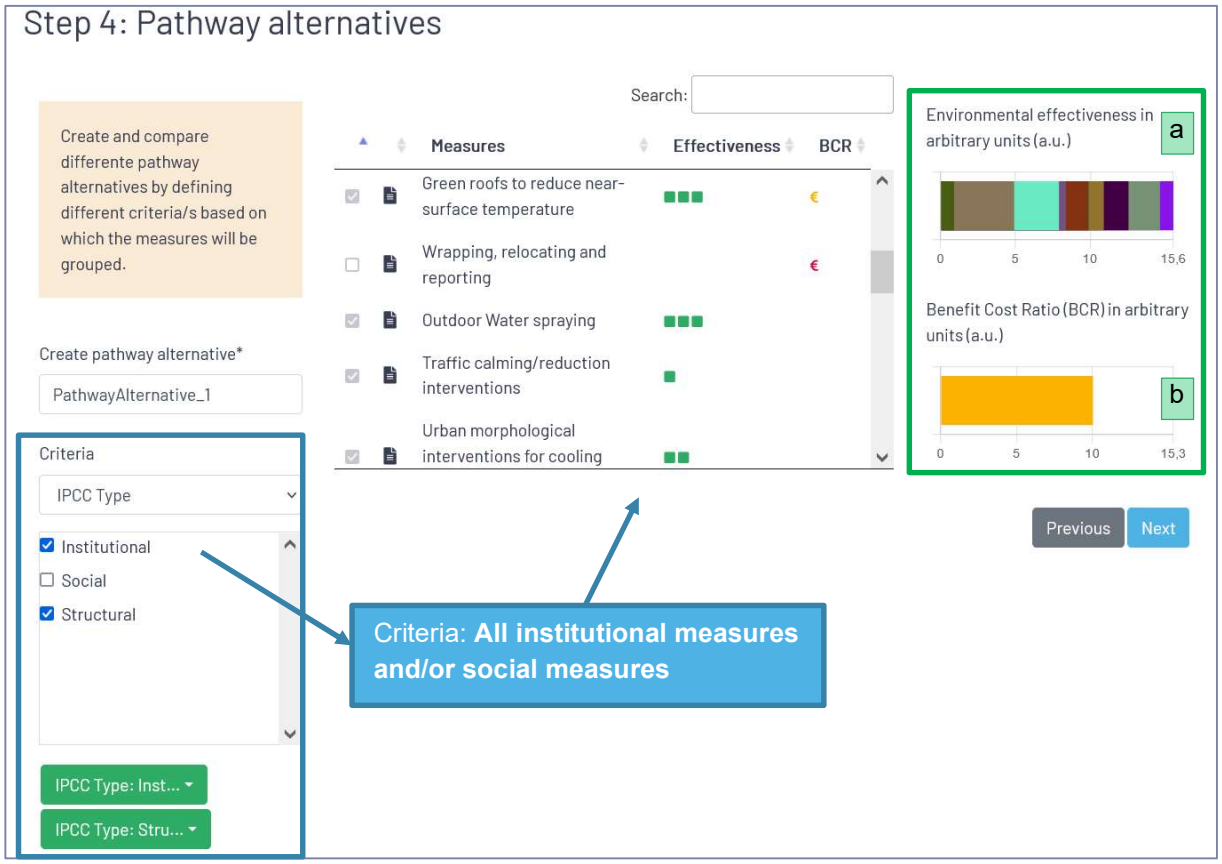


Figure 16. Step 4- page, left-hand side contains the criteria filter window, the central side provides the list of available measures window and right-hand side provides the performance window.

Based on the list of available measures (manually selected or based on a specific criteria) the right-hand side window shows either or both, (i) the physical environmental effectiveness of the pathway alternative (cluster of measures) and (ii) the cumulative economic efficiency of the pathway alternative based on a benefit-cost ratio analysis. See as an example the Figure 16(a) and (b) which allows you to compare different pathways alternatives at glance.

If you want to specify a criterion, click on the "**Criteria**" drop-down input menu and select one of the available categories. Once a category is selected the list of available options for that category are presented. Next, Figure 17-Figure 23 present each category and the description

of the options available for each. A criterion is defined by several categories constraints and based on the established criteria the list of available measures fulfilling that criterion is presented in the central window. Note that each new category settings into the criteria imply more restrictions and therefore less measures will be available.

You can modify the criteria applied by removing any of the restrictions to any of the categories previously established. This information is available at the bottom of left-hand side window (green boxes) so that the user can easily visualize the established criteria.

There is a total of 7 different types of categories to define a criterion:

Group category. You can select any of the groups defined in the RMI. Note that if more than one option is selected the criteria is established by selecting the measures that fulfil any of the selected options.

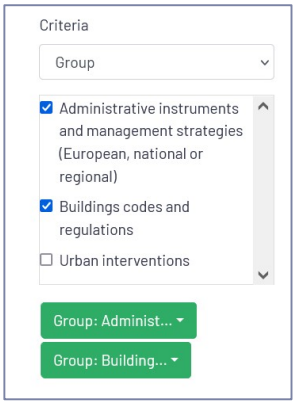


Figure 17. "Group" category

IPCC Type: This category refers to the categories of resilient options defined by the Intergovernmental Panel on Climate Change (IPCC). You can choose from structural, social or institutional. Note that if more than one option is selected the criteria is established by selecting the measures that fulfil any of the options.

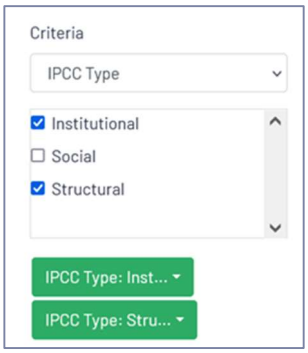


Figure 18. "IPCC Type" category

Spatial Impact: Spatial impact refers to the changes occurred in the distribution or occupation of an area or space due to arrangements made by the application or implementation of the described solution. You can select from major, minor, N/A, None or outstanding options to set a criterion.

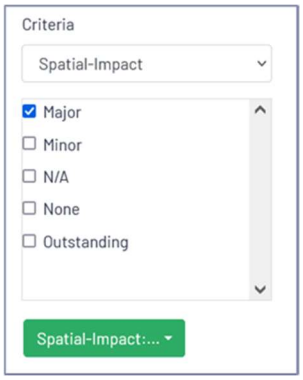


Figure 19. "Spatial Impact" category

Visual Impact: Visual impact refers to the aesthetic or appearance change resulted when applying the described solution. You can select the degree of visual impact, ranging from: *major change*: remarkable *negative* visual effect in the heritage resulted from applying the described solution to *no change (N/A)* where no visible changes can be appreciated in the heritage element to which the solution has been applied or implemented.

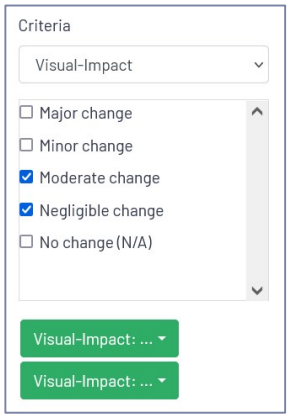


Figure 20. Visual Impact category

Physical Impact: This category refers to the aspects that the solution may influence on the mechanical performance and moisture performance. You can select from *positive impact* : when the physical properties are improved to *negative impact where a* harmful physical damage may occur in the heritage resource or *none impact.*

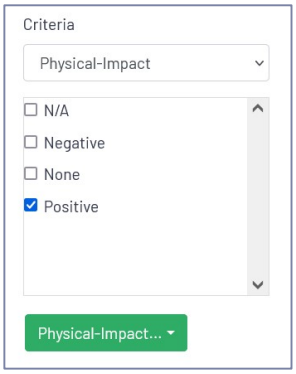


Figure 21.Physical Impact

Contribution to climate change (CC): This category refers to how the solution or implementation of the solution contributes to mitigate climate change, by for example reducing CO_2 emissions. The options available are *yes*, *not* or *not applicable*.

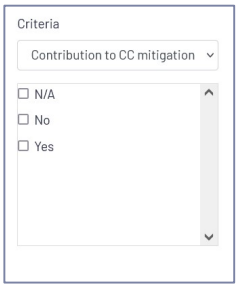


Figure 22. Contribution to CC category

Avoid negative effects: This category refers to possible negative effects of the solution. The options available are the whole list of negative effects that different measures may have. In this case, by selecting in any of the listed negative effects the measures having those negative impacts will be removed from the list.

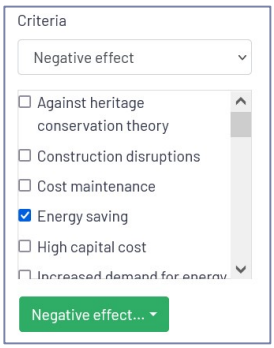
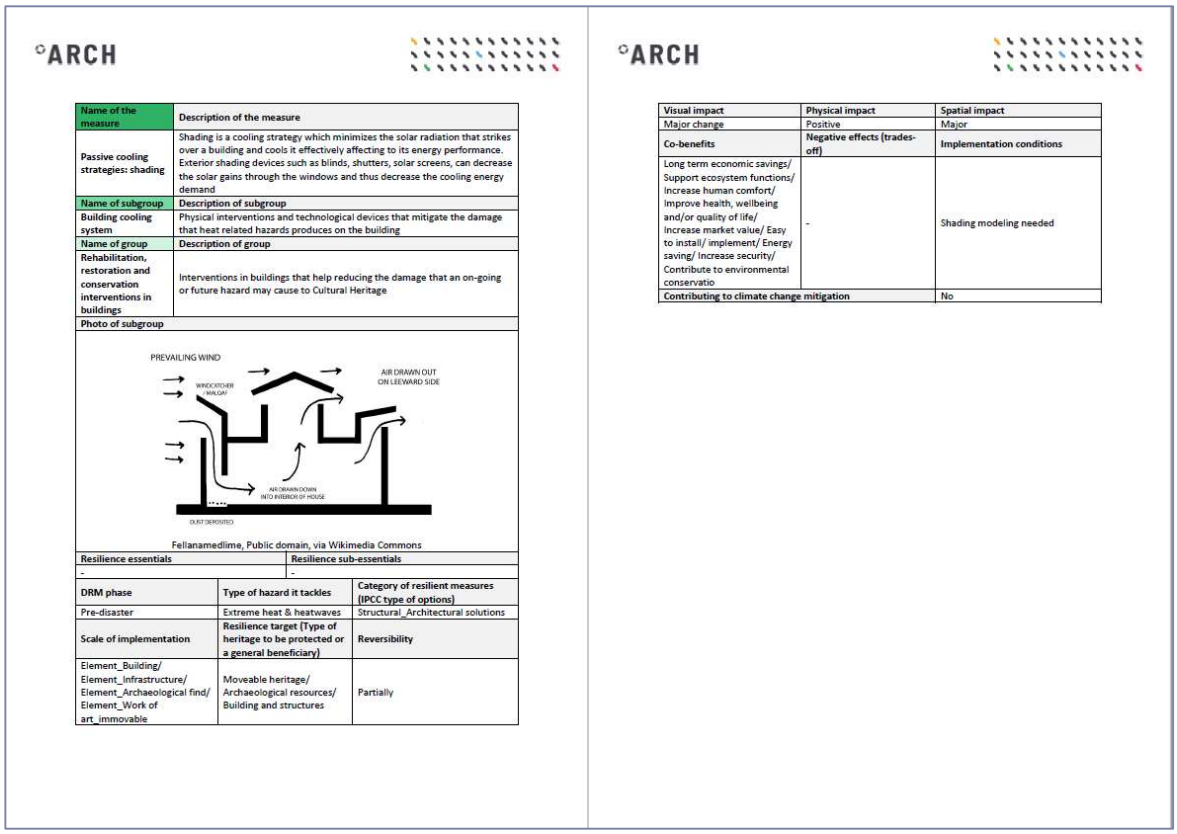


Figure 23. Negative Effects category

Apart of the above criteria categories to gather *clusters of measures* sharing the same criteria, the user can check the detailed information of each of the listed measures by clicking on the "factsheet" button available at the left-hand side of each measure. Next Figure 24 shows an example of the information available for each available measure. In this case, "*Passive cooling stretegies: shading*" adaptation measure has been selected. The factsheets explains how this measure minimizes the solar radiation that strikes over a building and cools it effectively, but additionally it provides more information regarding the measure, such as group and subgroup to which belongs, as well as the type of hazard it tackles, in this case "*Extreme heat & heatwaves*", or scale of implementation, type of heritage to be protected, reversibility, visual

impact, physical impact, spatial impact and the rest of information. Note, this information is stored in the RMI.



ARCH

Name of the measure	Description of the measure
Passive cooling strategies: shading	Shading is a cooling strategy which minimizes the solar radiation that strikes over a building and cools it effectively affecting to its energy performance. Exterior shading devices such as blinds, shutters, solar screens, can decrease the solar gains through the windows and thus decrease the cooling energy demand
Name of subgroup	Description of subgroup
Building cooling system	Physical interventions and technological devices that mitigate the damage that heat related hazards produces on the building
Name of group	Description of group
Rehabilitation, restoration and conservation interventions in buildings	Interventions in buildings that help reducing the damage that an on-going or future hazard may cause to Cultural Heritage
Photo of subgroup	

Fellanamedlime, Public domain, via Wikimedia Commons

Resilience essentials	Resilience sub-essentials
-	-

DRM phase	Type of hazard it tackles	Category of resilient measures (IPCC type of options)
Pre-disaster	Extreme heat & heatwaves	Structural_Architectural solutions
Scale of implementation	Resilience target (Type of heritage to be protected or a general beneficiary)	Reversibility
Element_Building/ Element_Infrastructure/ Element_Archaeological find/ Element_Work of art_immovable	Moveable heritage/ Archaeological resources/ Building and structures	Partially

ARCH

Visual impact	Physical impact	Spatial impact
Major change	Positive	Major
Co-benefits	Negative effects (trades-off)	Implementation conditions
Long term economic savings/ Support ecosystem functions/ Increase human comfort/ Improve health, wellbeing and/or quality of life/ Increase market value/ Easy to install/ implement/ Energy saving/ Increase security/ Contribute to environmental conservatio	-	Shading modeling needed
Contributing to climate change mitigation		No

Figure 24. Example of a downloaded PDF factsheet

In this step, the user can work only with a unique pathway alternative or create several pathways. To do so, click on the button "*Add another Pathway alternative*" 

and a new window will appear to specify new criteria based on which a different cluster of measures will be listed. This option allows you to visualize and compare the effectiveness of each pathway alternative and to select the most appropriate one to continue.

4.2.5. Step 5: Sequencing of resilience measures

Once a pathway alternative has been chosen, this step provides a canvas to support the sequence of resilience measures over time. There are three types of visual representations available depending on the type of pathway and specific objectives:

1. **Qualitative representation**
2. **Quantitative representation based on the environmental effectiveness**
3. **Quantitative representation based on the economic efficiency: Benefit Cost Ratio (BCR) analysis**

Qualitative representation

This type of representation is provided when no metric is chosen by the user (in step 1). The aim of this graphical representation is to offer a visual way to plan different type of measures over time.

To start this pathway representation, you just need to set the *timeline (start and end year)* of the different possible scenarios: *"small change scenario", "significant change scenario" and "worst case scenario"* that will be part of your pathway representation. Next figure (Figure 25) shows you the "by default" values for each scenario. To change these values, click on the input text and set any other year. These values can also be modified later on by the user as conditions evolve or new knowledge is available. These dates should therefore be indicative as it is important to have the necessary flexibility to act and deploy new measures when needed.

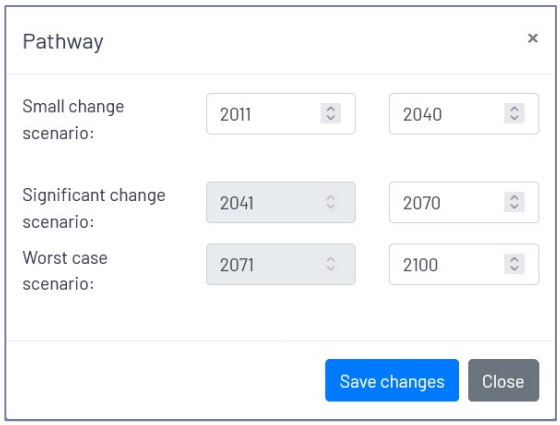


Figure 25. Definition of the timeline of the reference period per each scenario

Next, you only need to click on any of the available measures to sequence/plan it into the scheduled timeline. The RPVT will request through a pop-up window (Figure 26) the *start/end year* based on which the measure will be scheduled in the canvas. Being the first measure, there is no previous measure to select from.

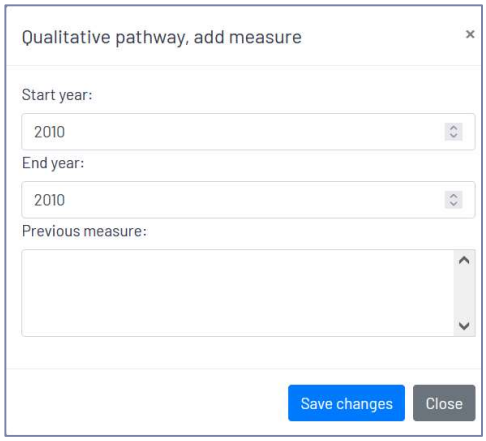


Figure 26. First measure of a Qualitative pathway

From now on, once you select a new measure to be scheduled in the canvas, you repeat the same action as before, apart from that to set the *start/end year.* In addition, you need to specify the previous measure to which this new measure follow. Figure 27 shows an example of how measures can be scheduled over different years.

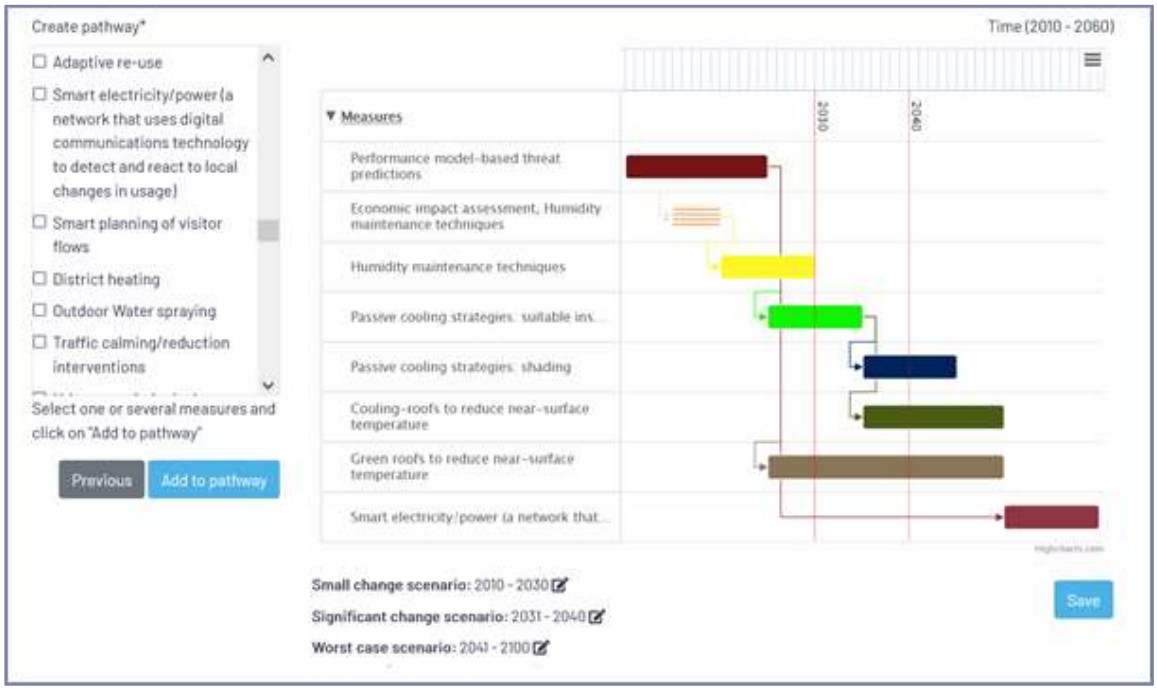


Figure 27. Example of qualitative pathway

The user can modify or remove any of the planned measures by directly clicking on the canvas and selecting it. Also, the timelines of each of the reference periods can be modified at any moment.

Please note, that more than one measure can be deployed simultaneously (e.g. economic impact assessment and humidity maintenance techniques). These measures will be shown as striped lines. When names are very long, these will not be completely shown. In order to see the full name, the user needs to leave the mouse over the name for few seconds and a new box with the full name will appear as shown in Figure 28.

Figure 28. Long name measures in the canvas

Quantitative representation based on the physical performance.

This representation allows to graphically represent and plan different types of options taking into account the environmental physical performance of the measures considering a physical metric (previously chosen, in step 1).

To start this pathway representation, click on one of the listed measures. Just afterwards, the RPVT requests your three inputs parameters (see Figure 29) that allow you to characterize the measure in your specific context. You will need to enter the location where this measure will be implemented, the exact number of square meters to be implemented, as well as the scenario in which the measure is planned to be implemented. These “small change scenario”, “significant change scenario” and “worst case scenario” options aim to represent the intensity or frequency of the hazard. They are linked to different temporal periods (that can be pre-configured), the farther in time, the more intense or frequent the hazard would be.

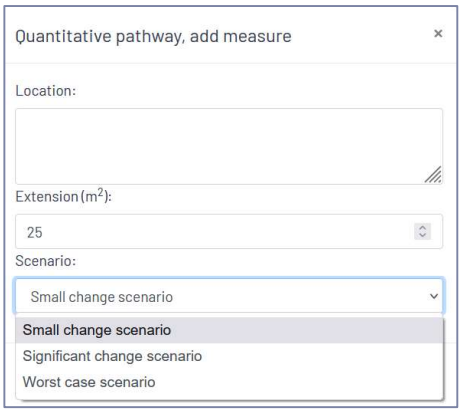


Figure 29. Requested parameters for a new measure in a quantitative pathway

Once you click on “Save changes”, the measure is placed into the canvas, and you can select a new measure and repeat the previous process to configure the rest of the measures. Each measure is configured accordingly with the specific needs and objectives to be reached. Next figure (Figure 30) shows the graphical representation of several planned measures over the canvas. As it can be observed, this window offers two important parameters to the user: the cumulative square meters where resilience measures have been deployed and the performance assigned to the difference areas.

The user can modify or remove any of the planned measures by clicking on directly on the canvas and selecting the measure to be modified or removed.

To save the changes on this pathway, click on “Save” button. If later on, you continue adding new measures over this pathway, remember to press again the “Save” button to save last changes. Note that different pathways can be stored in the database, so that you can visualize different possibilities.

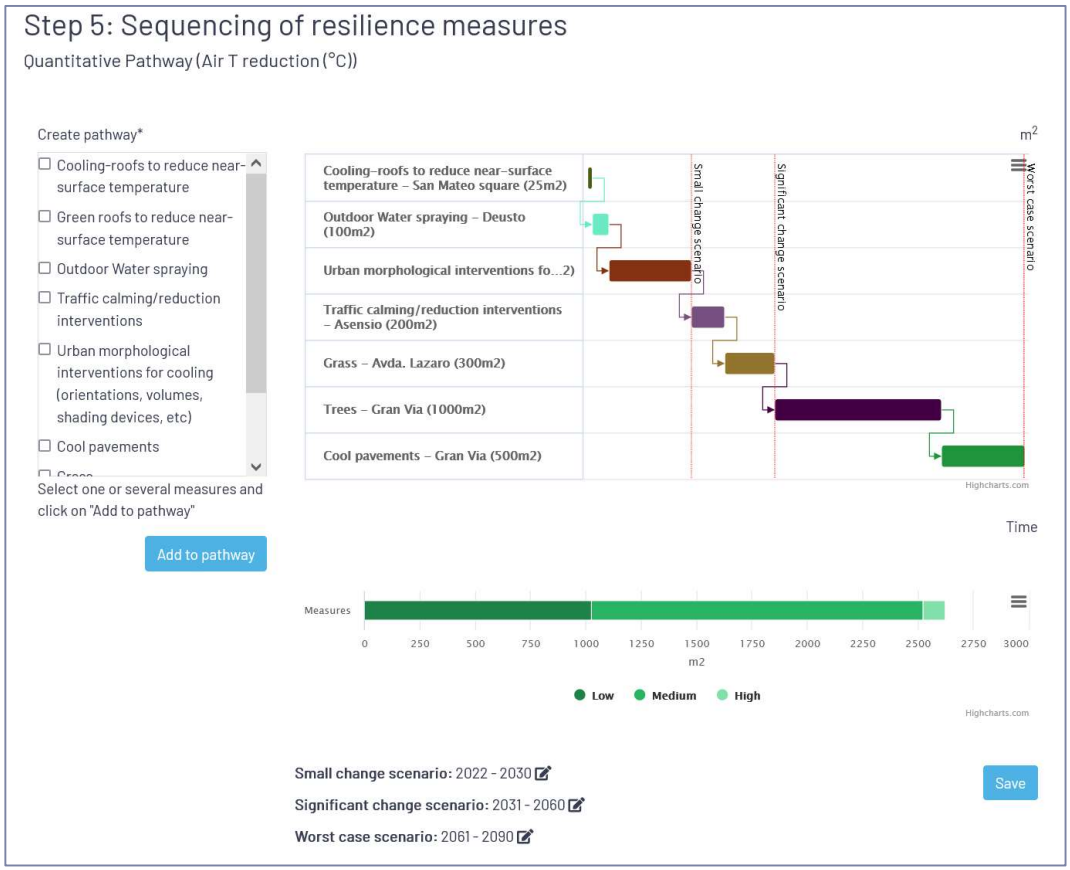


Figure 30. Example of quantitative pathway

Quantitative representation based on the BCR analysis

This type of representation is provided by the RPVT when the metric chosen is the BCR indicator. Similar to the previous representations, to start this pathway, you just need to set the *timeline (start and end year)* of the different scenarios: *"small changes scenario", "Significant changes scenario" and "Worst case scenario"*. Next figure (Figure 31) shows an example of dates per scenario, but these dates are only tentative to plan as it is important to have the necessary flexibility to act and deploy new measures when needed. But these dates can be changed very easily, by clicking on the input text and setting any other year.

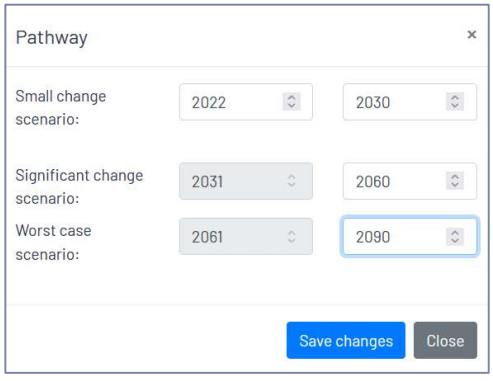


Figure 31. Example of start and end dates per scenario

First, click on “Save changes”, to start the sequencing of measures into the canvas. Next click on one of the listed measures (on the left-hand side part of the window) and click on “Add to pathway” to enter that measure into the roadmap, after that you will only need to select in which of the possible scenarios you are willing to implement the measure *“small changes scenario”, “Significant changes scenario” and “Worst case scenario”*, by selecting on one of them and clicking on “Save changes”. The measure will be automatically placed into the canvas, and you will easily visualize its economic performance based on the BCR indicator.

You can repeat exactly the same for the rest of the measures. Next figure (Figure 32) shows the graphical representation of several planned measures over the canvas.

Figure 32. Example of quantitative pathway based on BCR

Similar to the previous canvas representation, you can modify or remove any of the planned measures by clicking on directly on the canvas and selecting the measure to be modified or removed, and to save the changes, click on “Save” button. If later on, you continue adding new measures over this pathway, remember to press again the “Save” button to save last changes.

5. Use cases of the RPVT

5.1. Use case 1: Improve social and institutional resilience for seismic risk

You would like to improve both social and institutional resilience for better management of seismic risk

You firstly need to set the main characteristics of this pathway by providing the requested input parameters. As showed in Figure 33, you just need to select an *urban* type of pathway and *earthquake* as hazard. As you can see in Figure 34, the RPVT automatically provides you the unique approach available for this type of pathway ("*resilience*"), and the "BCR" (benefit-cost-ratio) indicator is selected by default.

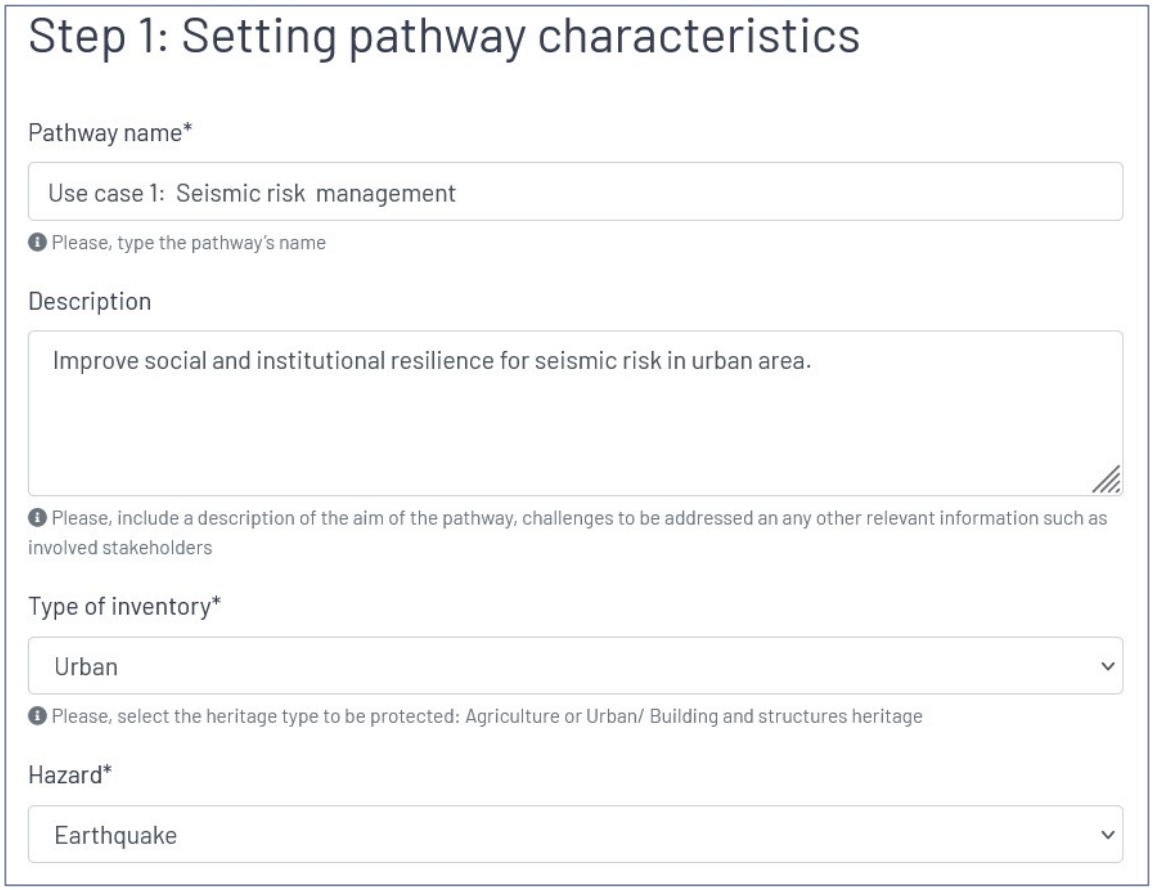


Figure 33. Setting the characteristics for the seismic risk case based on BCR analysis (I)

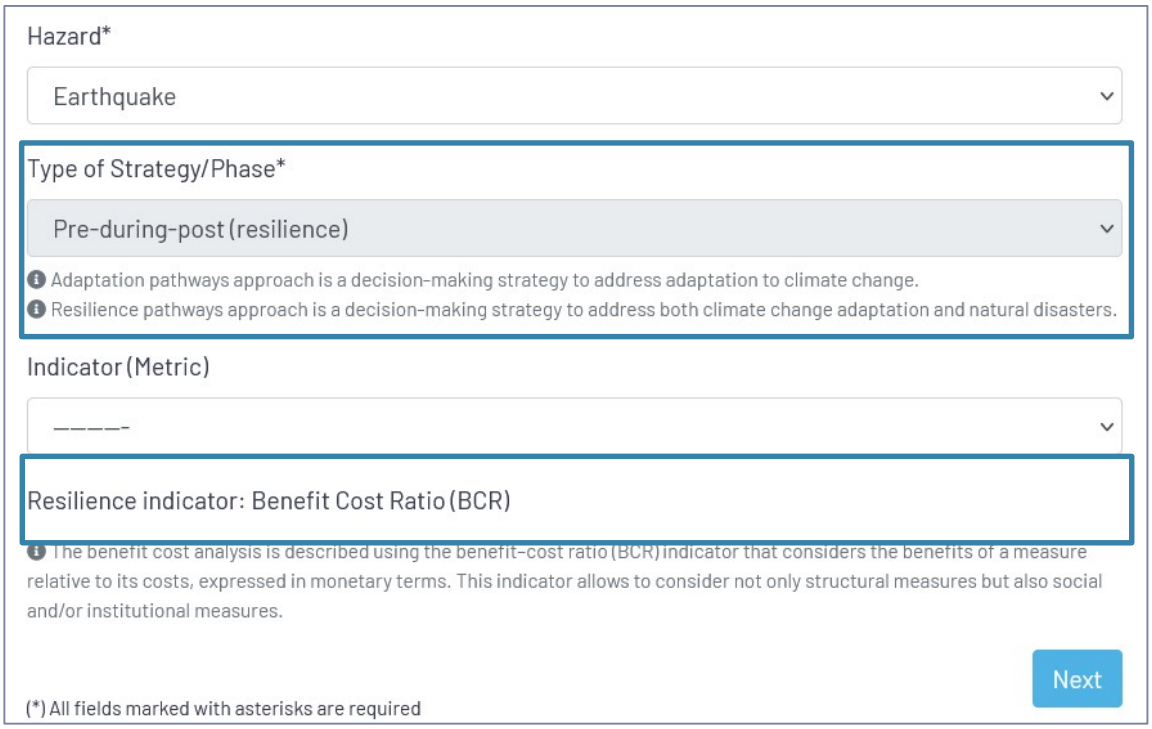


Figure 34. Setting the characteristics for the seismic risk case based on BCR analysis (II)

Click on “Next” button to enter into Step 2 (Figure 35) where the objectives and aim of the pathway have to be described.

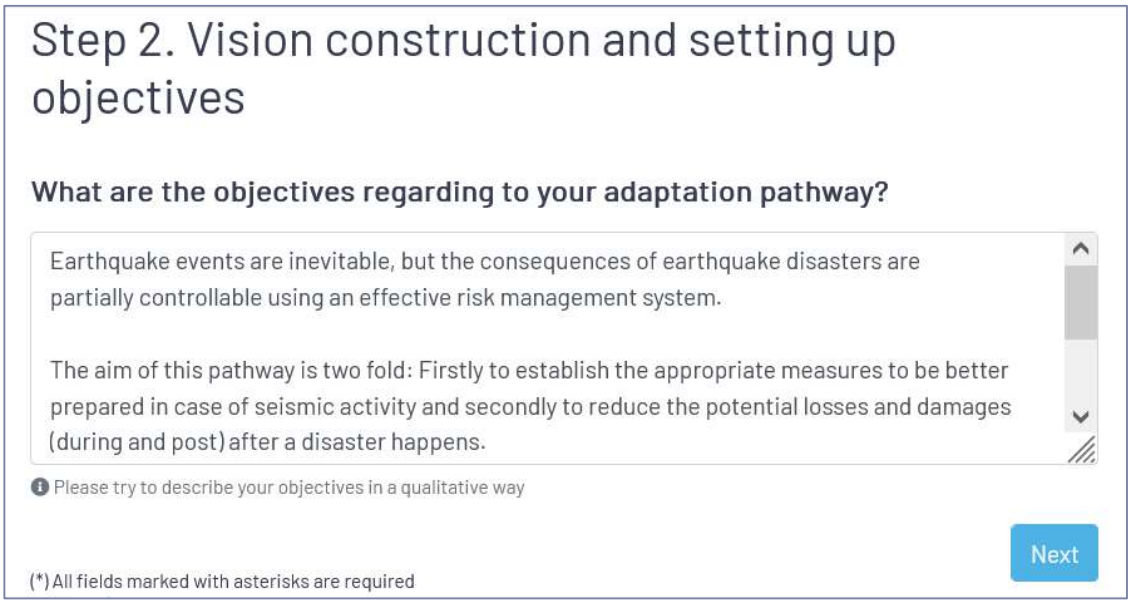


Figure 35. Description of the aim and objectives for this pathway

Click on “Next” button to enter into Step 3. The Step 3 window (Figure 36) provides the list of measures available together with the economic efficiency of each measure (as you can see, only measures for which BCR has been gathered) based on a 5-ranged scale.

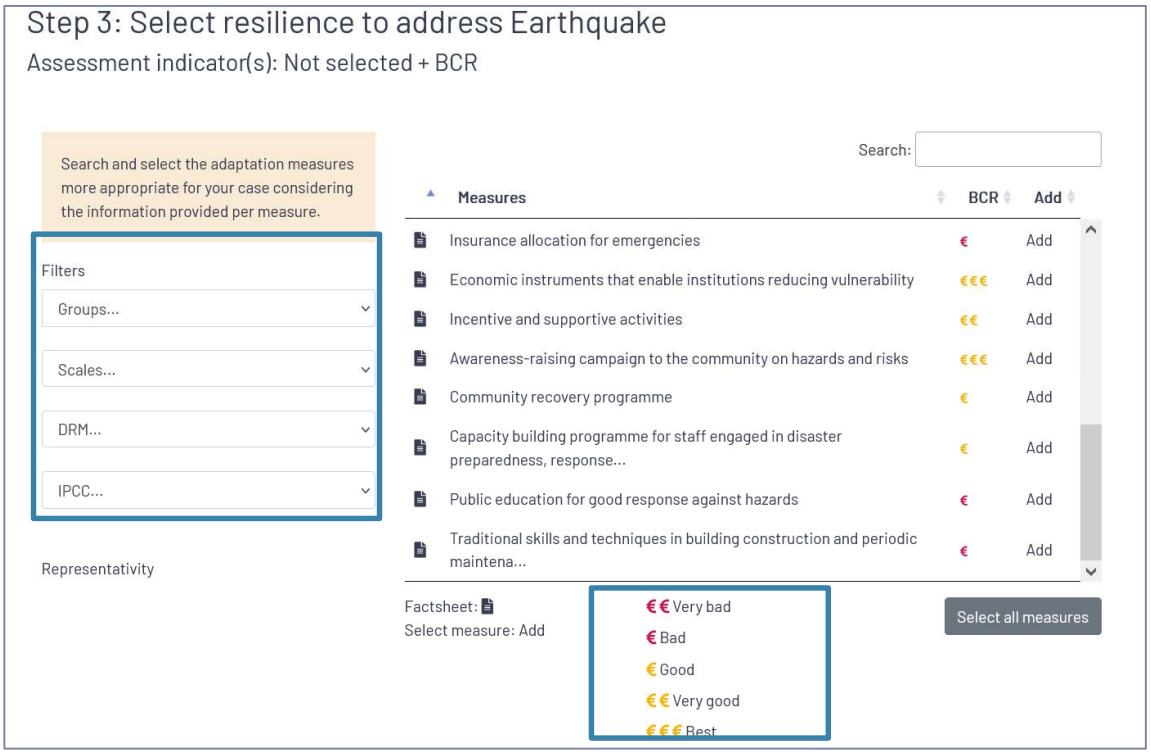


Figure 36. List of available measures of seismic risk management

At this step, you can set different *filters* to search for different types of measures. Since in this case you are only interested in the social and institutional measures, these two filters are applied by selecting these two options in the IPCC category, See Figure 37and Figure 38, where those filters are set, and the available measures for each filter are showed.

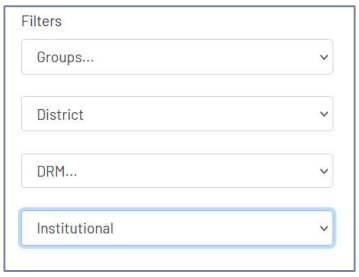


Figure 37. Filter-I. Institutional measures

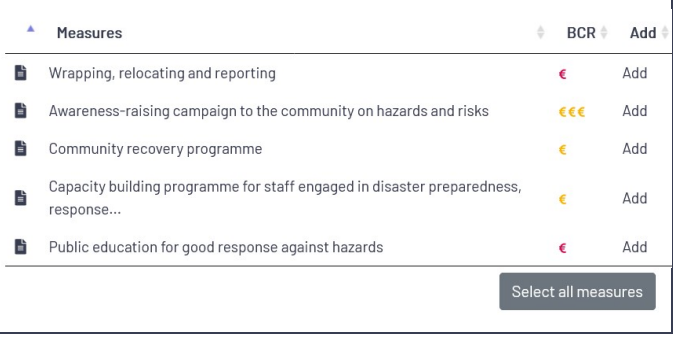


Figure 38. Filter-II. Social measures

Once the different available measures are listed on the left-hand side, you can click on the "*Select all measures*" button to add all filtered measures into the portfolio of measures for the next step.

As the user is interested in *pre-, during and post-disaster*, the DRM filter is not used in this case, but could also be used to restrict the portfolio of measures to any of these phases in any other case. Meanwhile, the left-hand side of the window displays the representativity of each measure, by showing the subgroup of measure to which they belong. This also allows the user to react by removing or adding additional measures not well represented or balanced. See next Figure 39, with different representativity charts considering different measures.

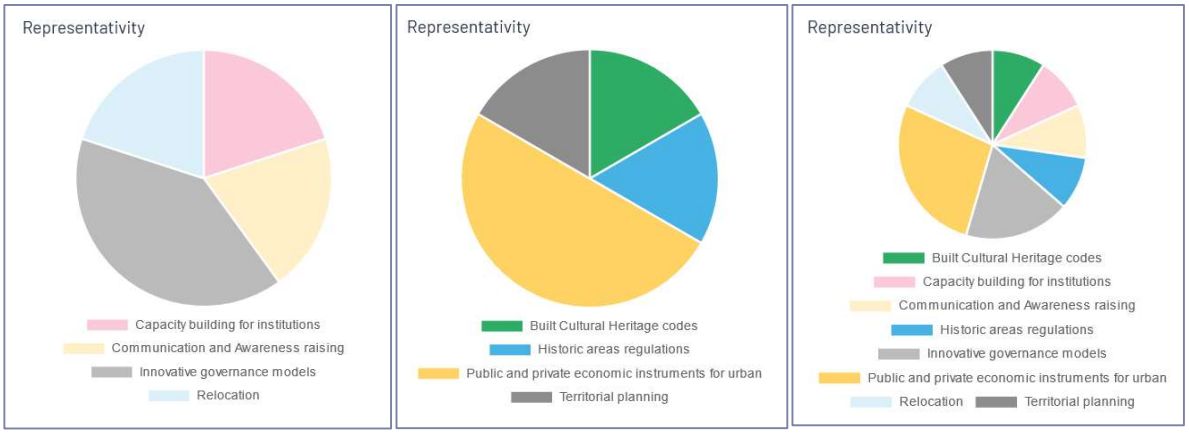


Figure 39. Representativity of the social measures (a) and representativity of the institutional measures (b) and social + institutional measures representativity

Click on "Next" button to enter into Step 4, where the central part of this window provides the selected measures in previous step. In this step 4 you are allowed to benchmark different pathways alternatives by considering different combinations of measures based on a specified criterion. In this case (Figure 40, Figure 42) the user creates two pathway alternatives by naming them as Alternative 1 and Alternative 2 to compare the bundle BCR effectiveness.

Figure 40. Pathway alternative 1 – where only administrative instruments are considered, – (left) total BCR of measures considered

Figure 41. Pathway alternative 2. Where all except administrative instruments are considered – (left) total BCR of measures considered

At this step, you can see at glance that administrative instruments are best option. So, you can click on the “Next” button of any of the created alternatives to design the pathway of that alternative.

In the next window – Step 5 (Figure 42), you are able to see all selected measures on the left-hand side of the window, that you can select to drop it into the canvas.

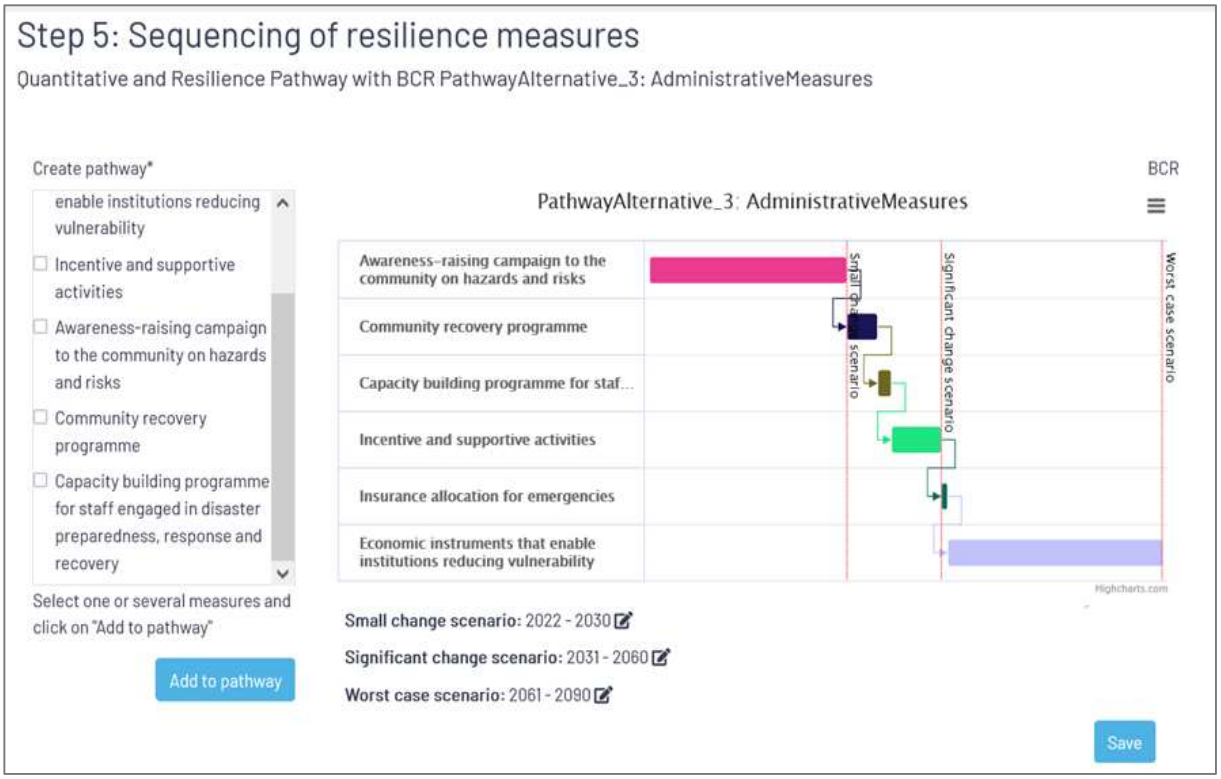


Figure 42. Pathway created to prepare the city to seismic risk events considering administrative instruments only

By adding the measures into the canvas, you can easily create a quantitative roadmap representation and easily visualize the economic efficiency of each based on the BCR analysis.

You can adapt or modify this pathway in this step, but you can also go back to the previous step and select additional measures to be included in this roadmap in case you are interested in doing so, for example by adding other type of measures.

In the previous canvas the timeline of the *"small changes scenario", "Significant Changes scenario" and "Worst case scenario"*, are linked to 2022-2030, 2031-2060 and 2061-2090, but you can configure and change at any moment these *timelines (start and end year)* of the different scenarios by clicking on the icon close to each scenario. Then a new window will appear to change these values (Figure 43).

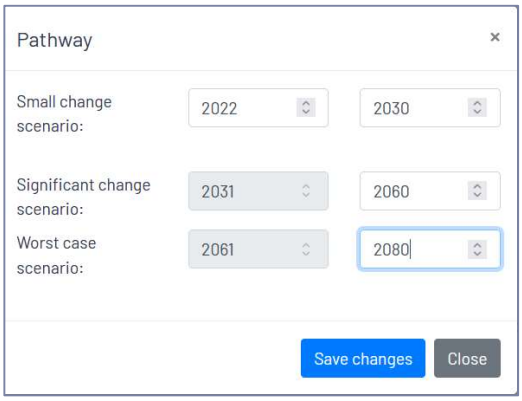


Figure 43. Pop-up window to modify the time periods linked to each scenario

5.2. Use Case 2: Improve resilience in agricultural management

I would like to increase both social and institutional resilience by developing agricultural resilient communities and improving the water management techniques. Which subgroup of measures would be appropriate for this purpose? How to create a roadmap to best organize these measures considering a qualitative approach?

Firstly, the user needs to set the main characteristics of this pathway, such as the name of the pathway "*Use case 2: Multihazard Agricultural Management*", as well as the type of pathway. In this case, as the user is interested in a multi-hazard and qualitative approach, these options are selected in step1 (See Figure 44 below). As you can see below, in this case, the type of strategy is automatically set to *adaptation,* as for agriculture type of heritage resilience approach is not considered. Last selection is to set no metric, as in this case we are interested in a qualitative analysis.

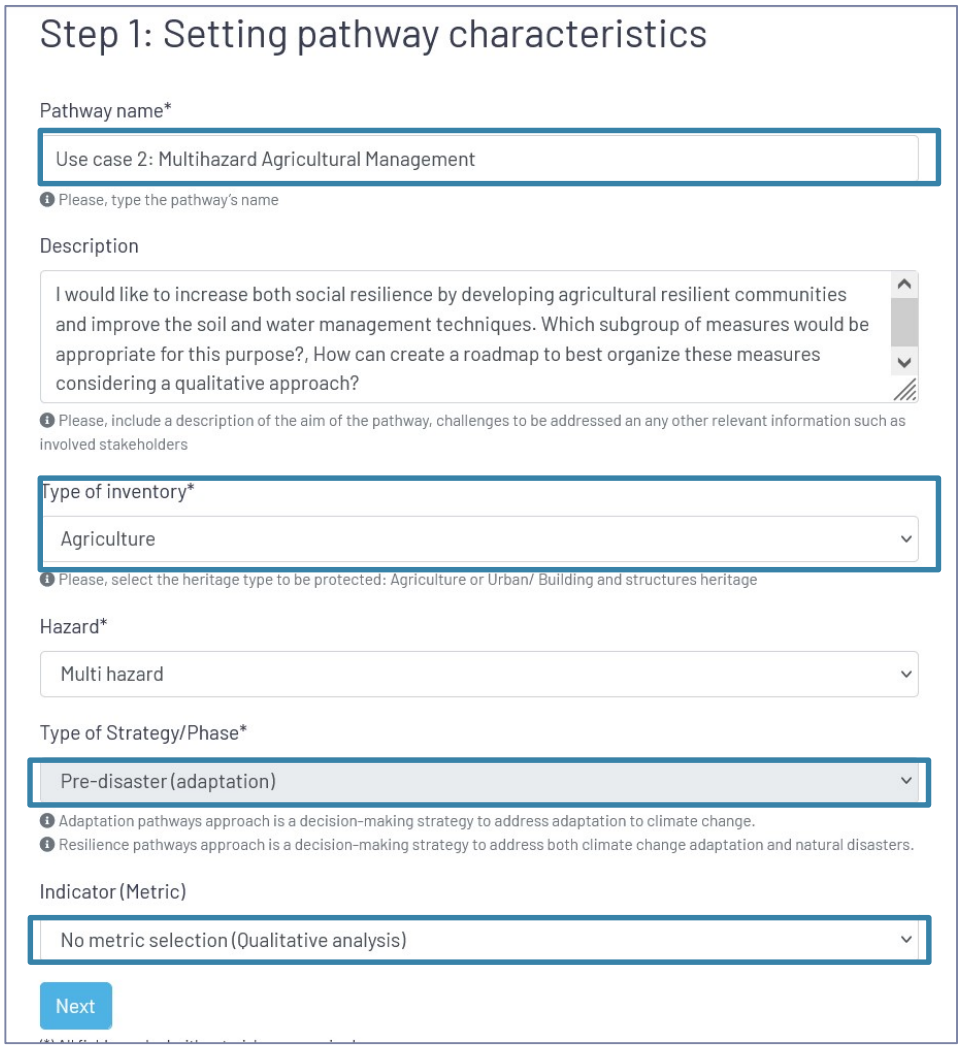


Figure 44- Use case 2 - Setting the pathways characteristics of Use Case 2

Click on "Next" button to continue the process and specify the specific objectives to be achieved as well as any other aim by other stakeholders.

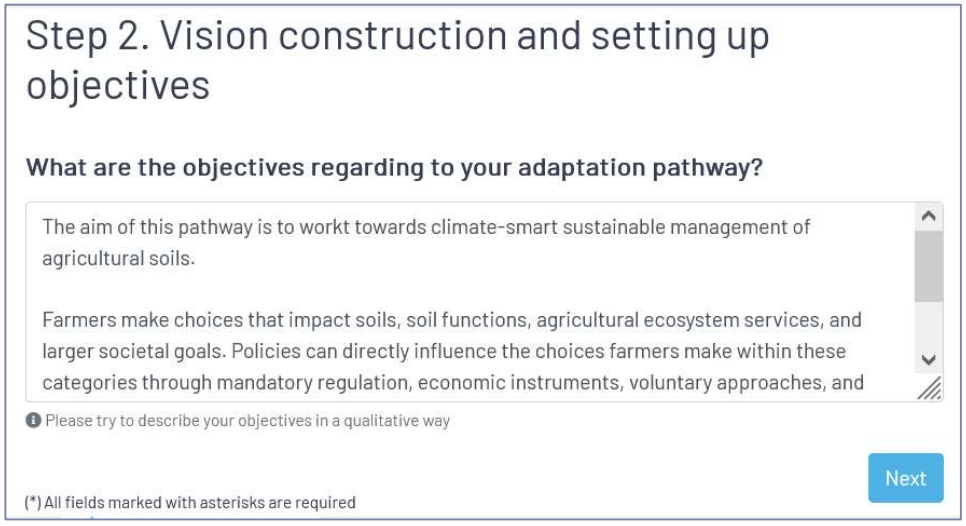


Figure 45. Description of the aim and objectives for this pathway

By clicking on “Next” button the RPVT process continues in Step 3 (Figure 46), this window provides the list of all available options, a total of 30 possible options that can be taken for multi-hazard adaptation.

To facilitate your final selection, you can search by filtering (Figure 46 (a)) considering the type of group, the implementation scale or the reversibility.

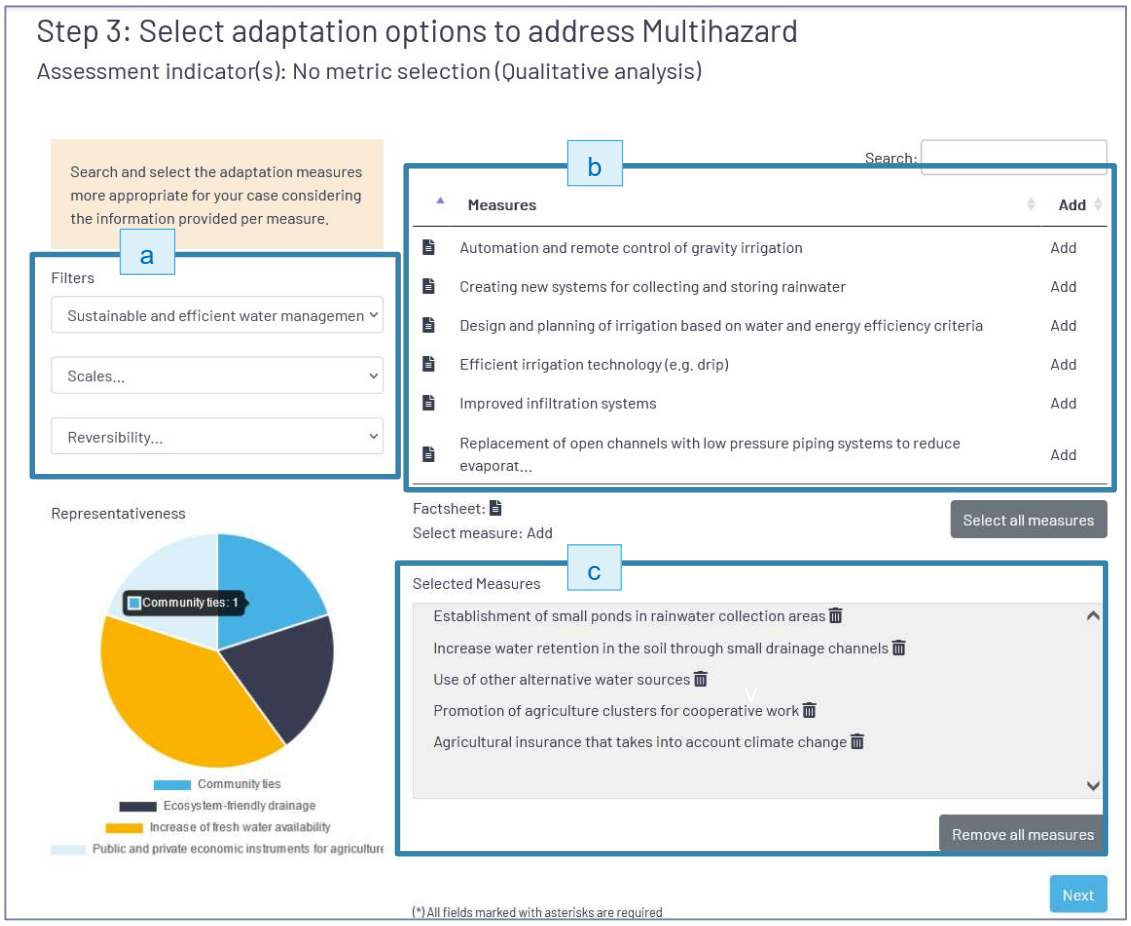


Figure 46. List of available groups for an agricultural type of pathway.

By selecting the “*Developing Resilient Communities”* group filter, the central window (Figure 46 (b)) provides the list of available measures. A similar response happens when selecting *the “Administrative instruments”, “Forecasting, monitoring and Early Warning System”* and *“Sustainable and efficient water management” groups.* For each filter category, the user can select all or select specific adaptation measures based on previous expert knowledge as no additional information is provided in this qualitative pathway design. The measures added are listed in the window below (Figure 46 (c)). They can be removed by clicking the bin icon 🗑 .

If no additional changes are needed, click “Next” to enter into the Step 4 to generate different alternatives. This step allows to create different pathways alternatives (clusters of measures) In this specific case, the user creates two alternatives (See Figure 47 (a) and (b)) to visualize on one side the social and structural measures, and the institutional and structural measures

on the other. The right-hand side window (c) provides information of the subgroups to which the measures belong.

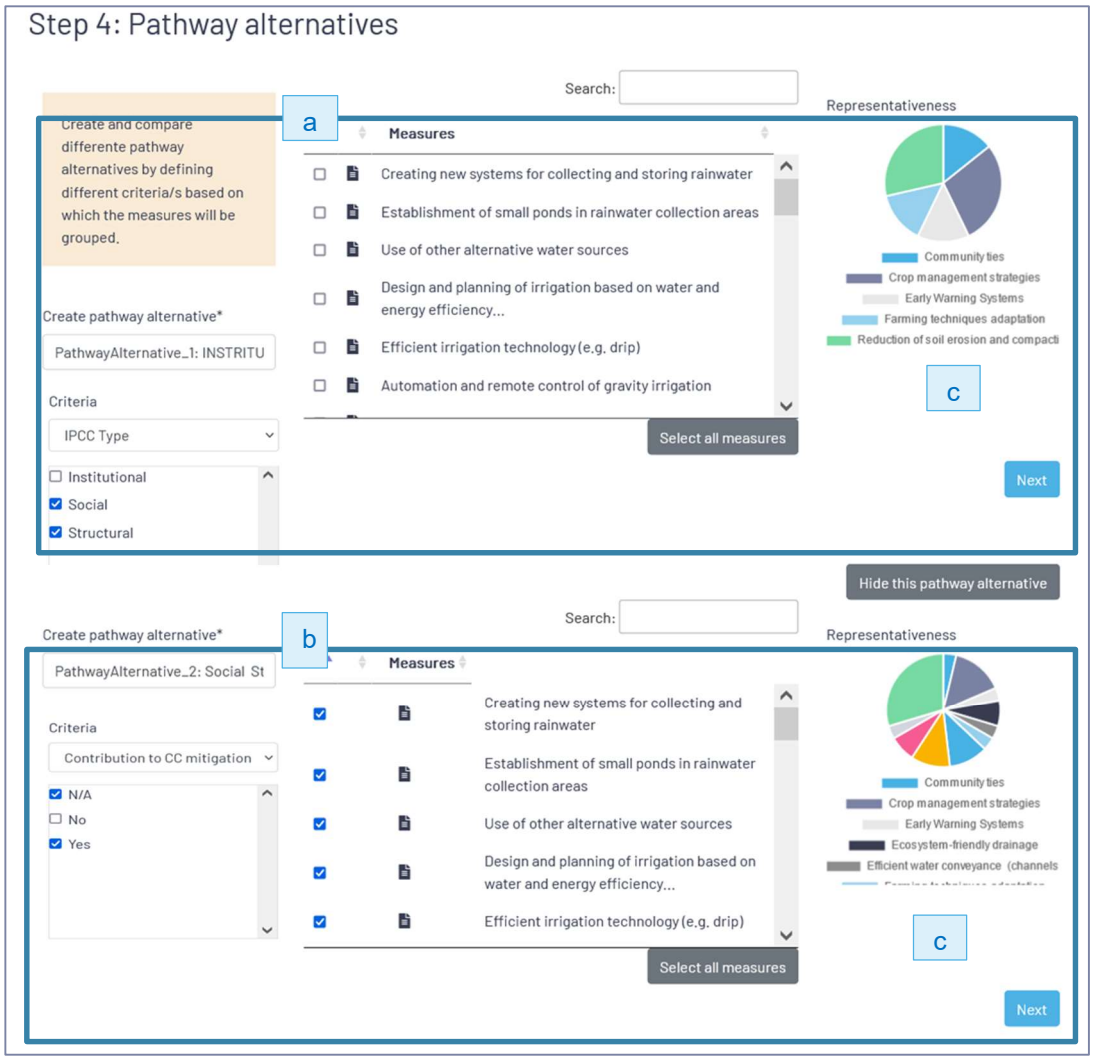


Figure 47. Pathway Alternative 1 (a) configured by this pathway considering Social or Structural measures and Pathway Alternative 2 (b) configured by this pathway considering Institutional or Structural measures contributing to CC mitigation or N/A

In this case, when the qualitative approach is chosen, the criteria to create the pathways alternatives can be based on expert judgment, multicriteria analysis or stakeholders' participatory workshops.

Once an alternative is valid for you, click on the "Next" button, behind the alternative selected. Then the RPVT drives you to the last step where the pathway can be disinged for the selected pathway alternative.

Next figure (

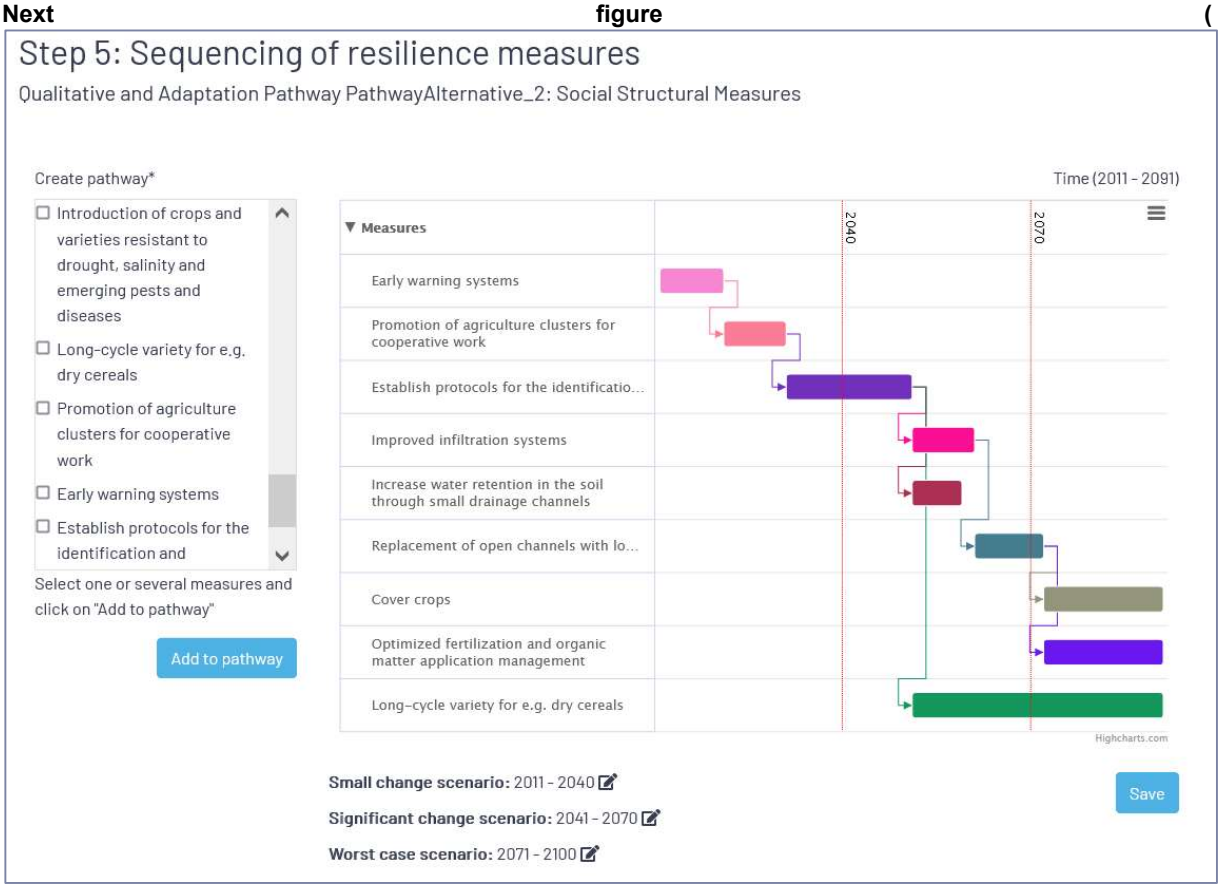


Figure 48) shows an example of pathway created for the next timelines linked to different possible scenarios: small change scenario [2011-2040], significant change scenario [2041-2070], worst case scenario [2071-2100]. The different options can be sequentially added, modified or removed.

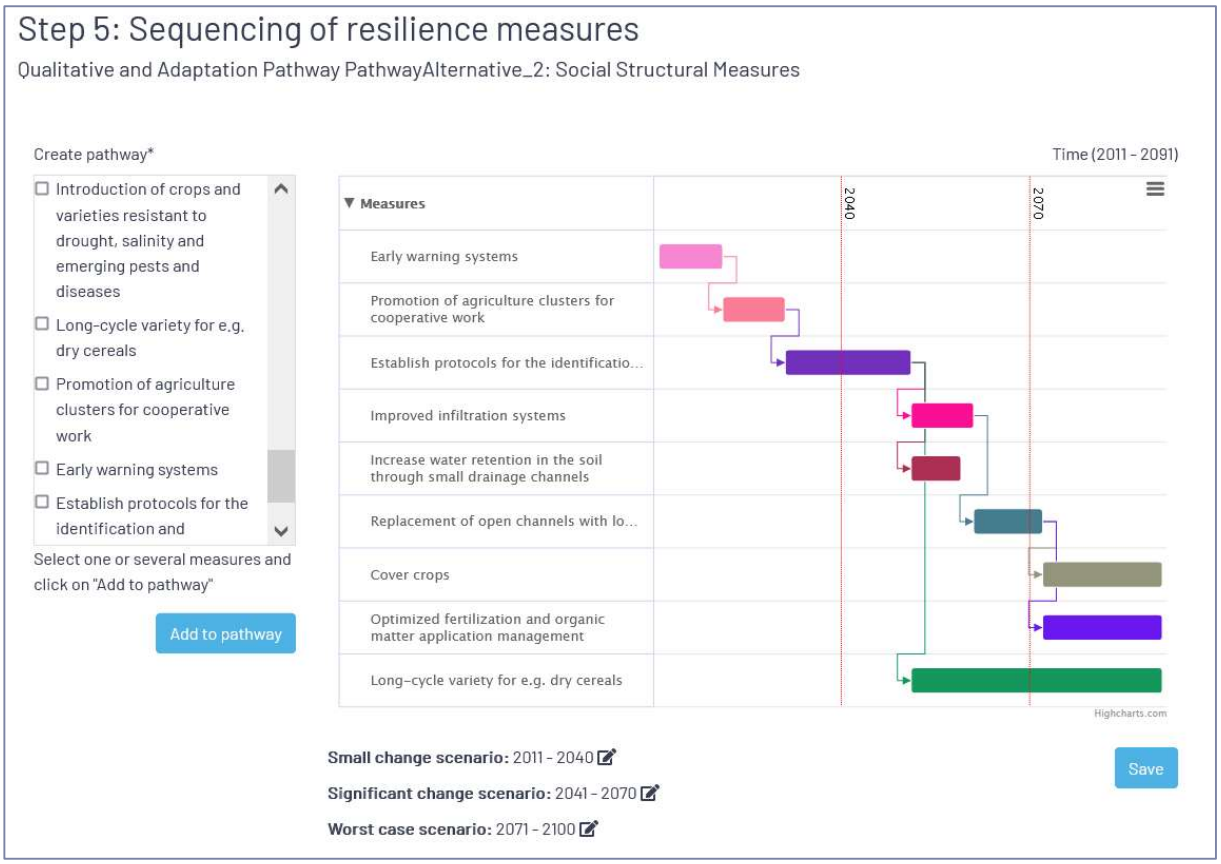


Figure 48. Example of pathway visualization

5.3. Use Case 3: Urban heat management

I would like to know which measures can be applied to better adapt my city to extreme heat events. I would also like to explore how to develop a comprehensive long-term plan to reduce the thermal discomfort and how to incorporate relevant sectoral legislation, particularly for new and existing buildings, transport, and urban planning.

This use case focuses on the analysis on how to improve the thermal comfort in a urban context, therefore you need to select (Figure 49) heat (b), as hazard and PET (c) (Physiological Equivalent Temperature) as the indicator to measure the biometeorological assessment of the thermal environment to assess how different possible measures can be used to reduce the thermal discomfort in an urban context (a). Note that in this case, the settings don't include the option to complement the environmental performance-based pathway with a benefit cost analysis (d). So, in the next windows only structural measures will be considered. If additional social and/or institutional measures want to be considered, then this option has to be modified.

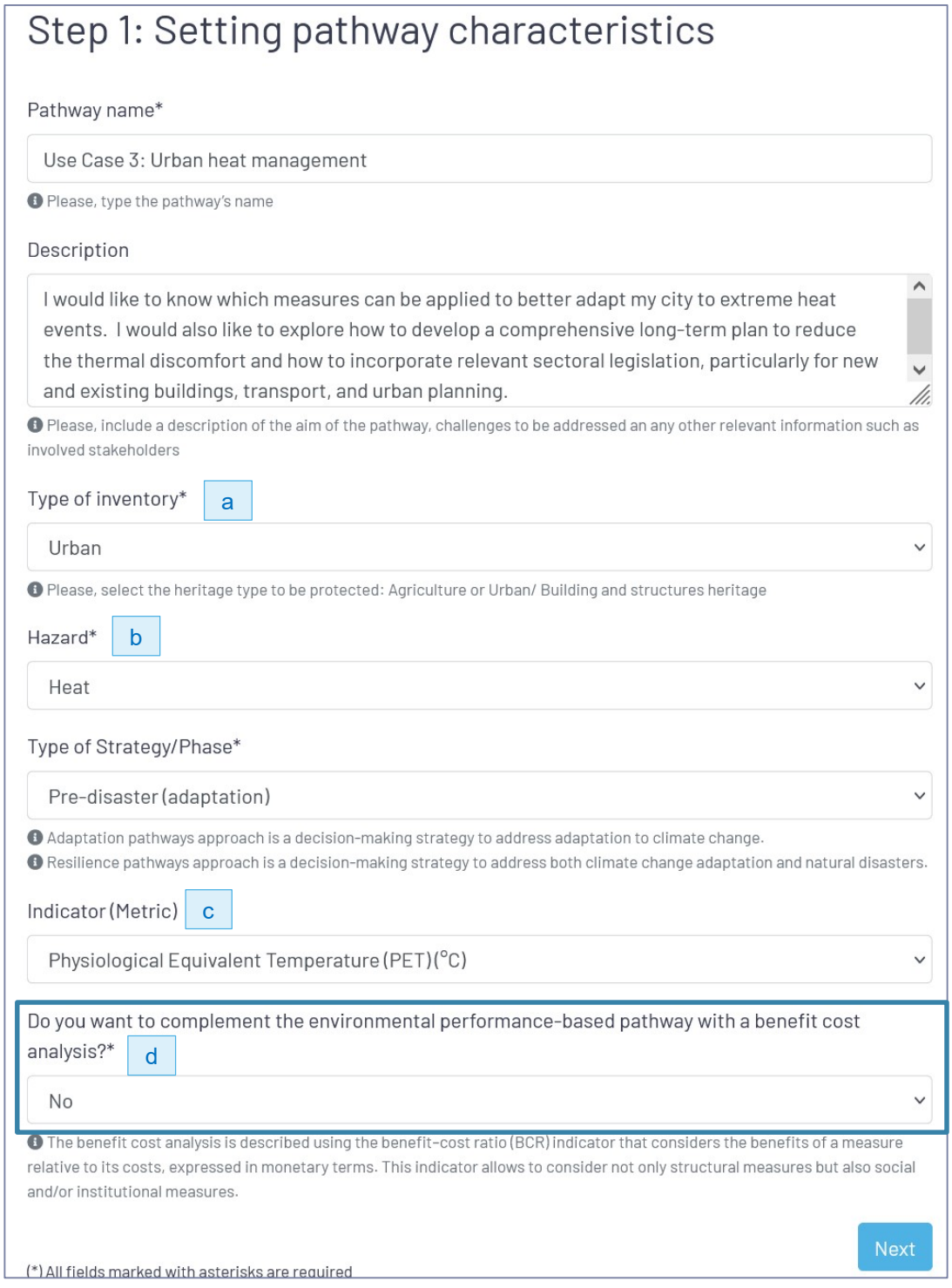


Figure 49. Settings for the Use case 3. Urban heat management

By clicking on the "Next" button the RPVT leads you to the Step 2 (Figure 50), where the aim and objectives of this pathway are described.

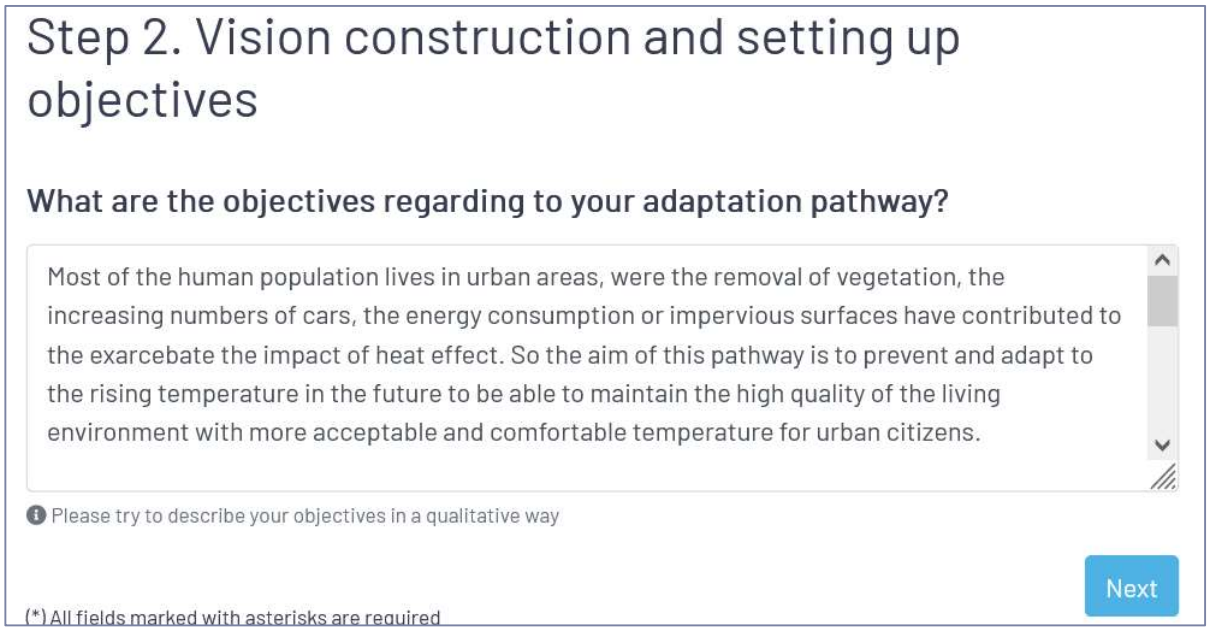


Figure 50. Description of the aim and objectives for this pathway

Click on Next to enter into the next step, where the list of available measures will be showed (Figure 53). This window allows you to use different filters to search and compare measures' performance. As it can be observed in the Figure 53, the benefit cost ratio indicator is provided per measure if the information is available in the knowledge database. If it is not, the information doesn't appear.

As it can be observed in the group filter (Figure 51), the available measures belong to two different categories, the urban interventions and the building interventions. At this pathway urban interventions are more relevant, but as there is also interested to know about other building interventions both categories are chosen.

Figure 51 Group filter categories available

There is also the possibility to filter the measures per type of scale (Figure 52), so in this case both district and element are selected to filter and select the appropriate measures.

Figure 52. Filter categories available for scales.

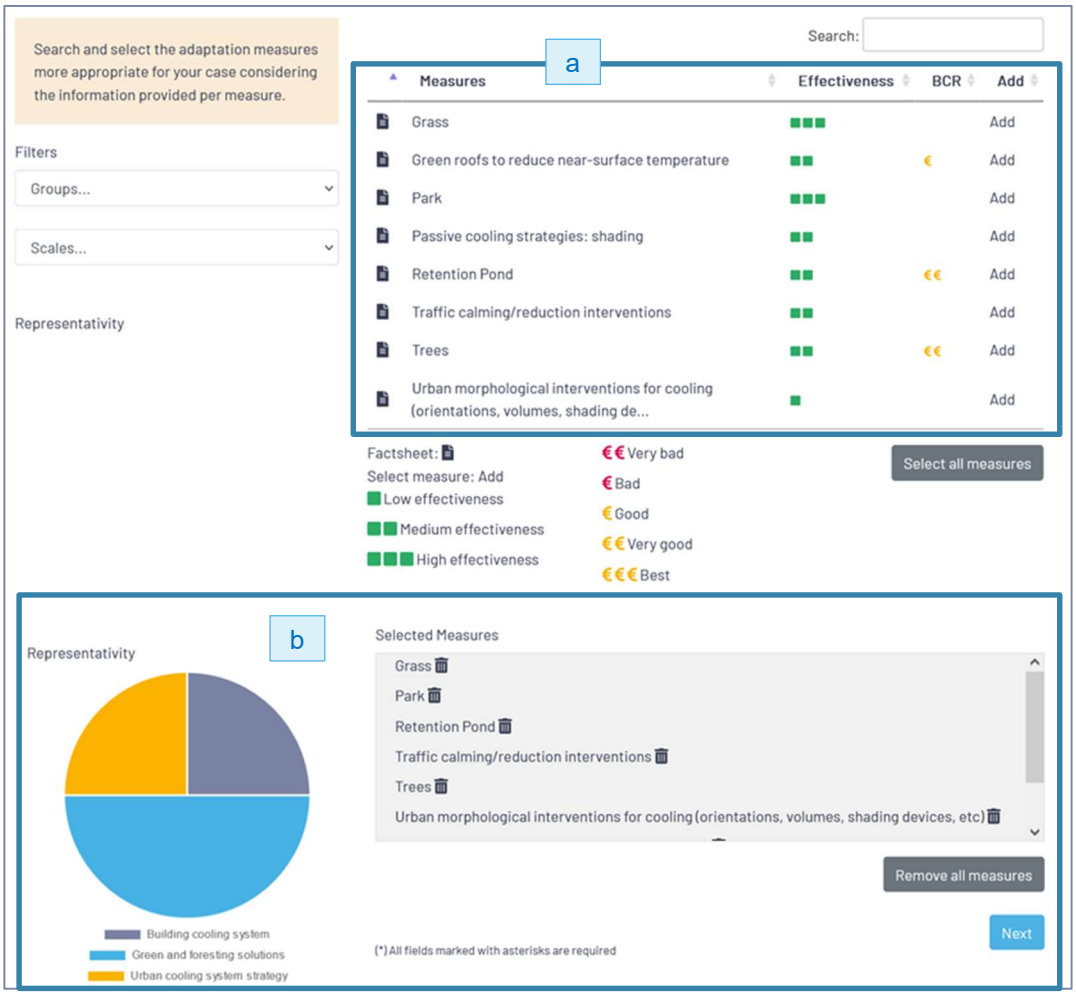


Figure 53. (a) List of available measures with performance assessment available at the RPVT and (b) List of selected measures and their sub-group representativity

Once the measures are selected, press “Next” button to go to the next step.

In Step 4 (Figure 54and Figure 55) different pathways alternatives are created to compare the effectiveness of each.

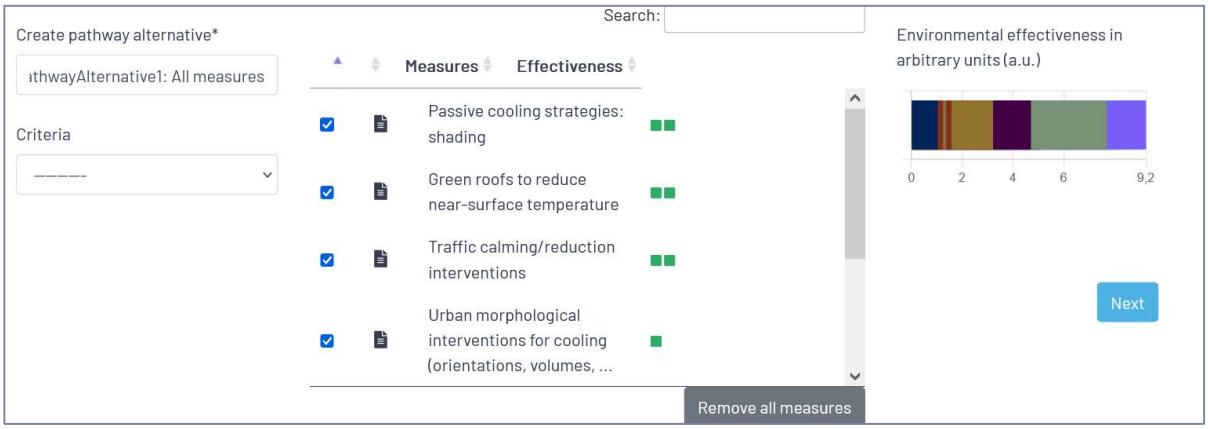


Figure 54. Pathway Alternative 1. All measures manually selected.

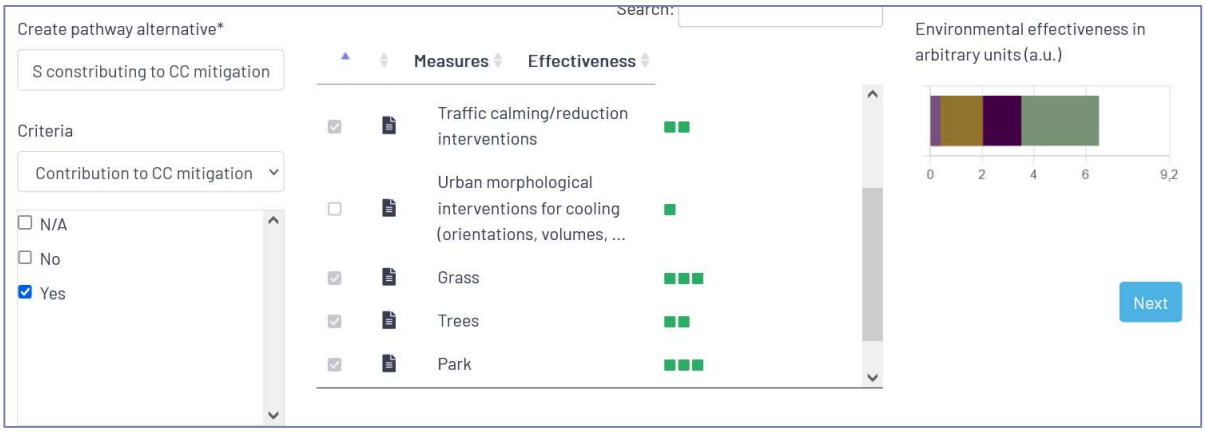


Figure 55. Pathway Alternative 2. Only measures that contribute to CC mitigation are selected.

Once an alternative is chosen, click on Next button to start the pathway design.

Next Figure 56 visualizes an example of pathway where different measures have been parametrized according to the urban context to create a plan of urban appropriate interventions. The bottom bar char allows to visualize how the different interventions allow to improve the thermal comfort in the implemented square meters. In this case, the planned interventions allow to improve at low performance 1500 square meters, at medium performance on a slightly larger area, and high performance at over 2000 square meters.

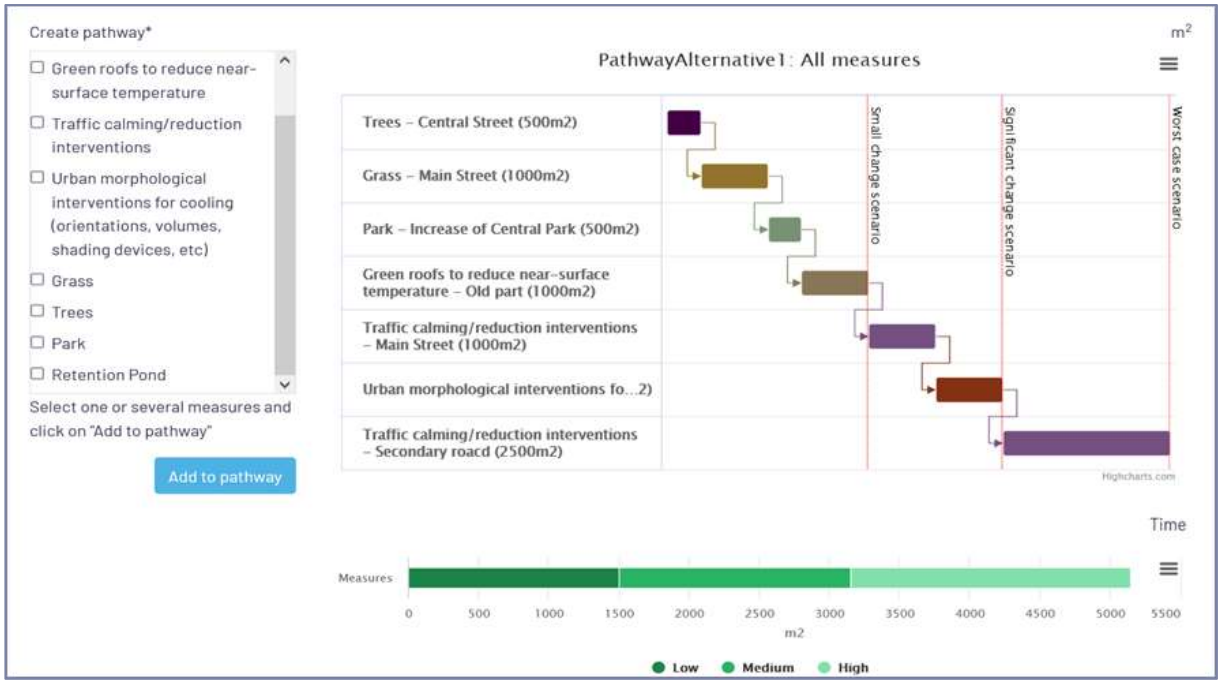


Figure 56. Example of pathway design done for Use case 3

As it can be observed in the figure below, the different scenarios are set considering the timeline periods are established from 2021 to 2080, considering 20 years per period. These settings can be change at any moment by clicking on the icon . Next pop-up window (Figure 57) will appear to enter new dates.

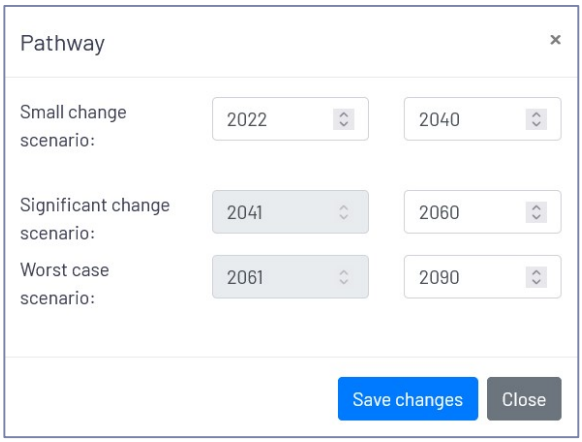


Figure 57. Settings for the future periods established to design the pathway

5.4. Use case 4: Urban flood management

The torrential rainstorms and flash floods create flooding events, with serious impacts for cities and their surroundings. These impacts may happen on cultural heritage sites including historic buildings or infrastructures, town sites, important archaeological sites or works of monumental sculpture or painting. Given the reality of climate change, these flooding disasters will increase so it is important to be prepared to mitigate the consequences of this type of events.

This use case focuses on a resilient approach on a urban context and therefore is important to set in the Step1 (Figure 58), these settings (a) urban, (b) Flood hazard and (c) resilience approach, which automatically imply that the BCR indicator is considered (e). Additionally, the RPVT in this step allows you to select another physical metric to assess the performance, so in this case the metric chosen is the *infiltration rate (mm/h) (d).*

There are different indicators and metrics available to address floods, depending on the chosen indicator (metric) different measures will be available. Note that the tool assessment is based on a literature review of more than 150 papers, 200 case studies and more than 1000 effectiveness assessments that have been revised and validated during the ARCH project.

Note also, that a resilience pathway can also be designed considering only the BCR indicator and no physical metric.

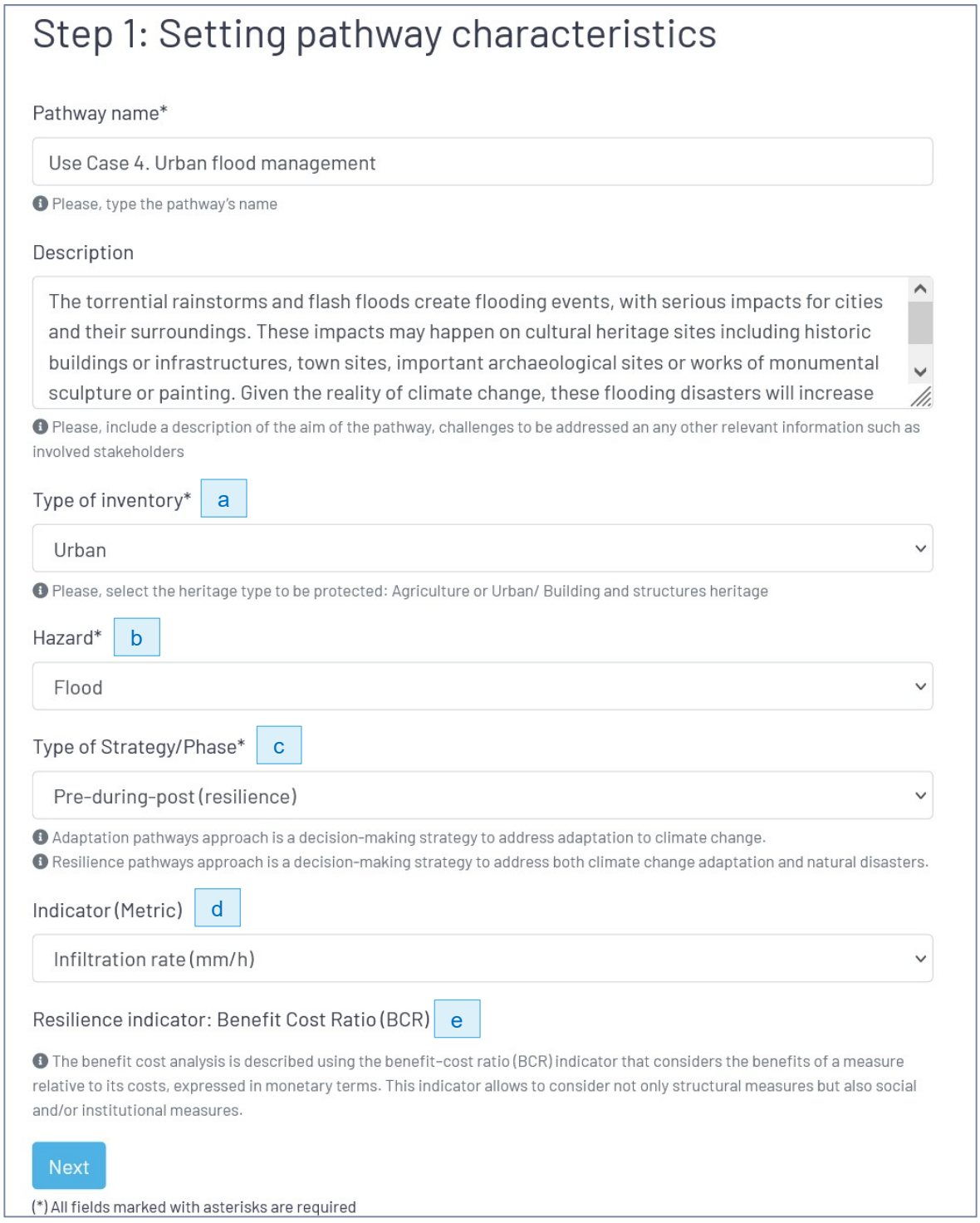


Figure 58. Settings for the Use case 4. Urban flood resilient management

Click “Next” button to enter into Step 2 (Figure 59) where the main objectives of this pathway are described, as well as activities needed to design this pathway with other stakeholders.

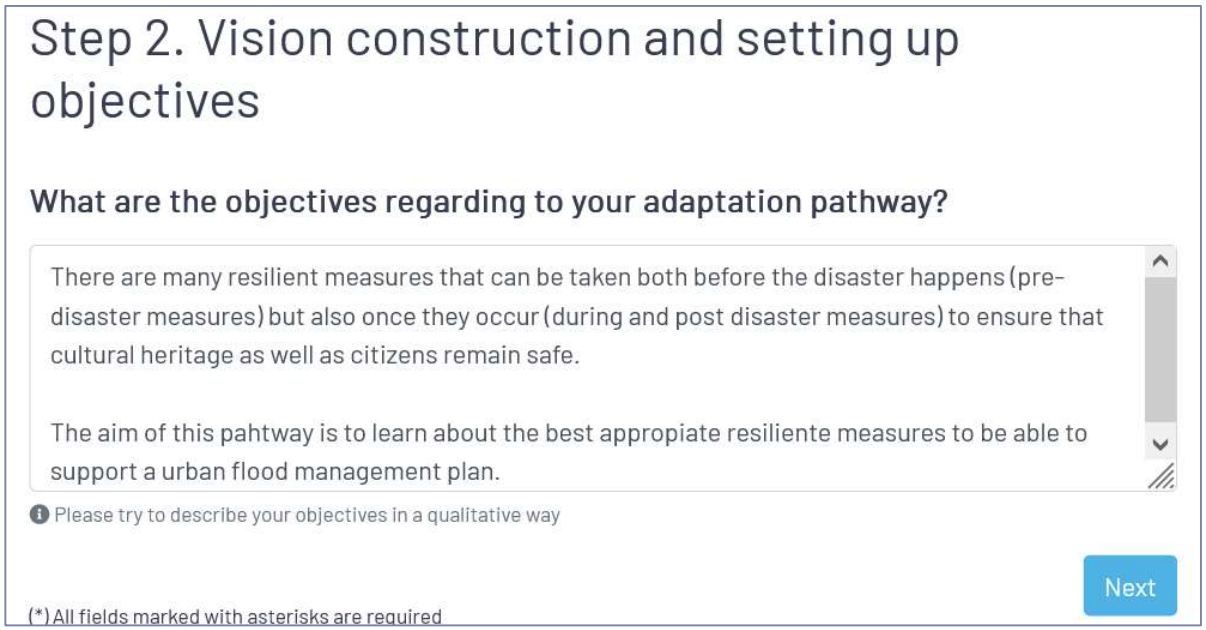


Figure 59. Description of the aim and objectives for this pathway

Next step provides the list of available measures in the RPVT knowledge base. See figure below (Figure 60) where the physical effectiveness is provided for the measures that have effectiveness on "*infiltration rate*" as well as other available measures for flood management from which benefit cost ratio indicator is available in the RPVT knowledge base. In some cases, both indicators are available, in others only the physical indicator or BCR is available.

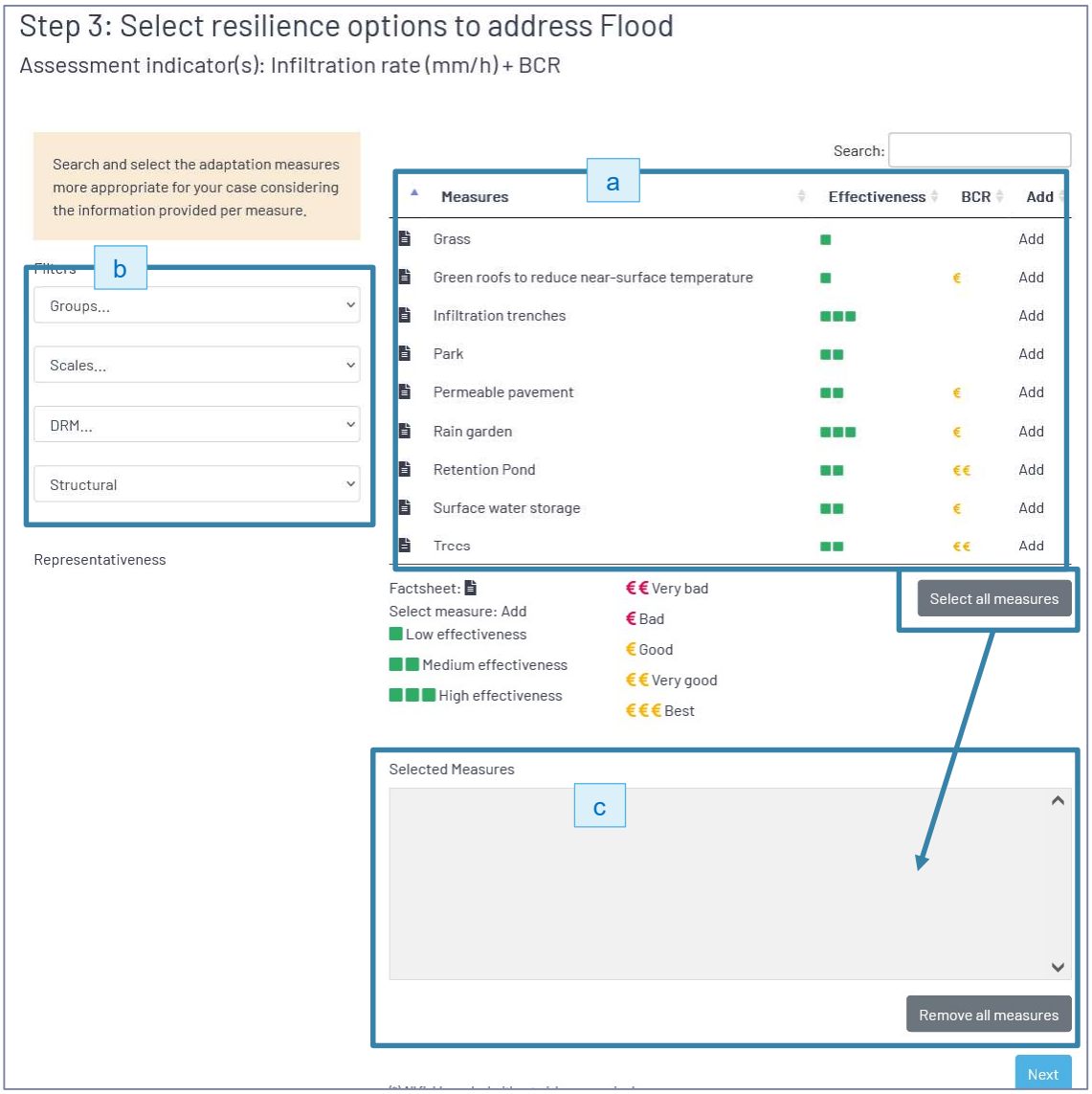


Figure 60. List of available resilience measures to address flood effectiveness, considering both physical performance over infiltration rate and BCR indicator

This window allows to search for specific measures based on the filter categories available (Figure 60 - b). In this case, as you have selected the resilience approach, apart from the group filter there is also a DRM filter, where you can filter considering pre-disaster, during and post disaster measures. Two additional filters are also available to select the scale of implementation of the measure, and the type of measure based on the IPCC classification.

So, the user, firstly apply the IPCC type to filter (Figure 60(b)) the structural measures, once they are showed in the central panel (Figure 60(a)) by pressing the “Select all measure” button they are added into the selected measures panel ((Figure 60(c)))

The next figure shows how the window looks like once the measures are selected.

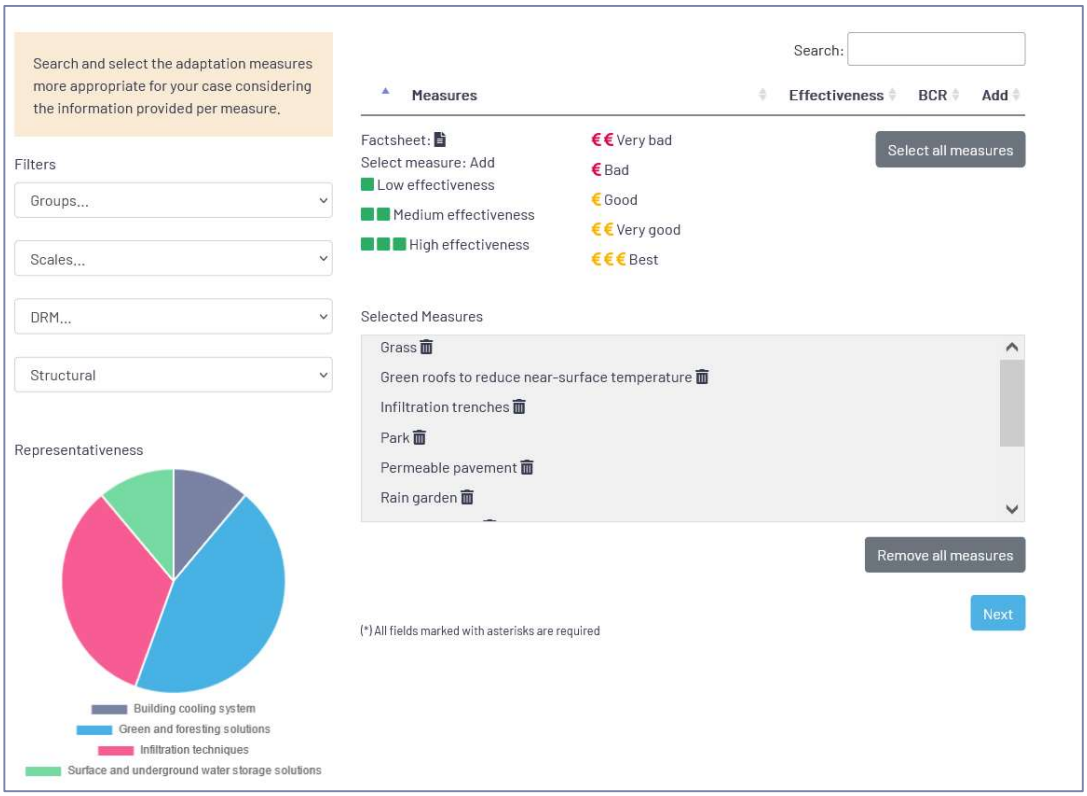


Figure 61. List of structural measures added into the Selected Measures panel, as well as the representativity chart of the selected measures.

Following, the user manually selects from the rest of social and institutional measures available the ones with good, very good or best BCR economic assessment. The ones with bad BCR values are not selected and click on “Next” to continue.

In step 4, the user can create different alternatives, in this case the option with all measures is taken.

Figure 62. All measures are taken as pathway alternative

Finally click on “Next” to continue and design the pathway. In this case as there is a resilience pathway two panels appear, one to design the preparation phase, and another panel to prepare de during and post-disaster phase.

Next figure shows an example of pathway designed considering the BCR assessment.

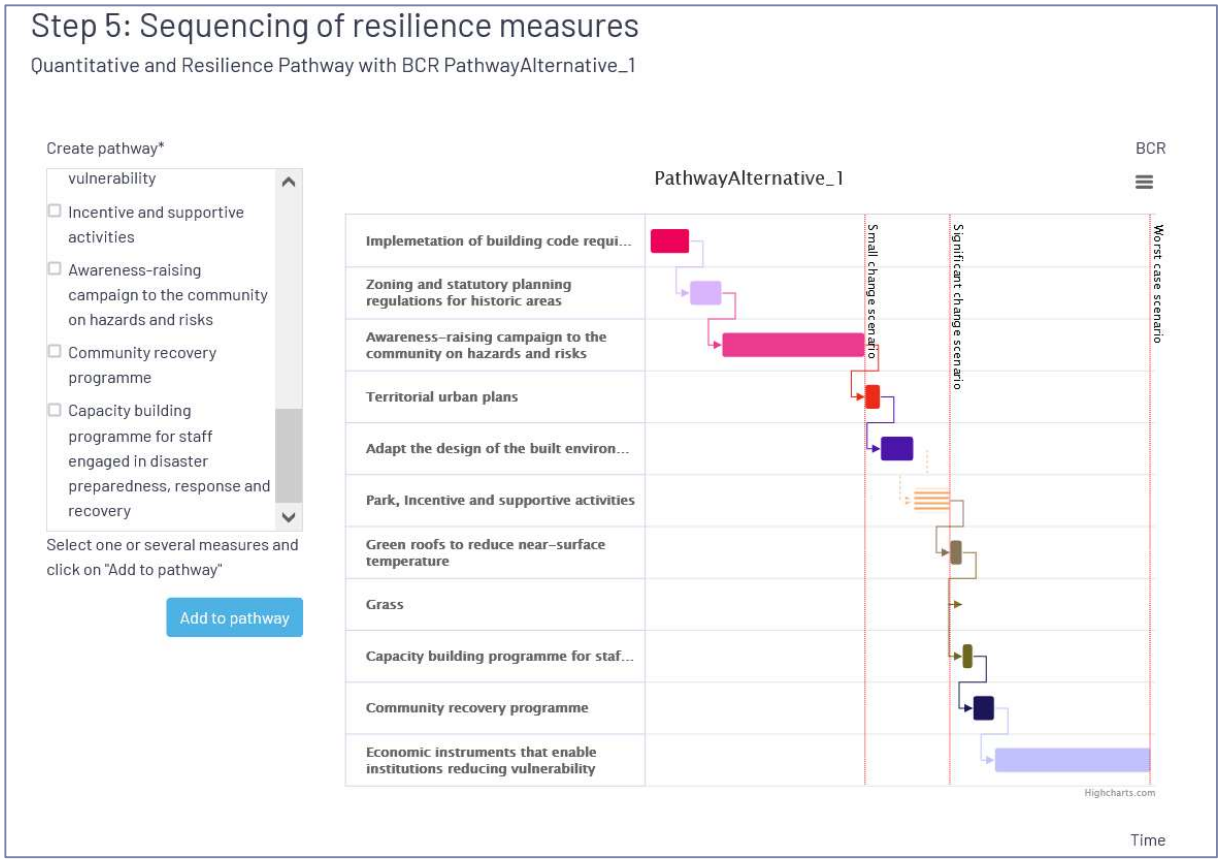


Figure 63. Example of pathway considering BCR assessment of social and institutional measures