D1.4 CLARITY CSIS v2

WP1 – CO-CREATION

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Disclaimer

Figure 1: CLARITY Disclaimer

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CLARITY Project Overview

Urban areas and traffic infrastructure linking such areas are highly vulnerable to climate change. Smart use of existing climate intelligence can increase urban resilience and generate added value for businesses and society at large. Based on the results of FP7 climate change, future internet and crisis preparedness projects (SUDPLAN, ENVIROFI, CRISMA) with an average TRL of 4-5 and following an agile and user-centred design process, end-users, purveyors and providers of climate intelligence will co-create an integrated Climate Services Information System (CSIS) to integrate resilience into urban infrastructure.

As a result, CLARITY will provide an operational eco-system of cloud-based climate services to calculate and present the expected effects of CC-induced and -amplified hazards at the level of risk, vulnerability and impact functions. CLARITY will offer what-If decision support functions to investigate the effects of adaptation measures and risk reduction options in the specific project context and allow the comparison of alternative strategies. Four demonstration cases will showcase CLARITY climate services in different climatic, regional, infrastructure and hazard contexts in Italy, Sweden, Austria and Spain; focusing on the planning and implementation of urban infrastructure development projects.

CLARITY will provide the practical means to include the effects of CC hazards and possible adaptation and risk management strategies into planning and implementation of such projects, focusing on increasing CC resilience. Decision makers involved in these projects will be empowered to perform climate proof and adaptive planning of adaptation and risk reduction options.

Abbreviations and Glossary

A complete glossary of all CLARITY terms and abbreviations can be found in the public document "CLARITY Glossary" available at https://cat.clarity-h2020.eu/glossary/main.

Table 1: CLARITY abbreviations.

Abbreviation/ Acronym	DEFINITION
CA	Consortium Agreement
CKAN	Comprehensive Kerbal Archive Network
CLARITY	Integrated Climate Adaptation Service Tools for Improving Resilience Measure
CS	Climate Service
CSIS	CLARITY Climate Services Information System
DC	Demonstration Case
DoA	Description of the Actions (Annex 1 to the Grant Agreement)
EC	European Commission
EU-GL	Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient (Document)
GeoJSON	geographical JavaScript Object Notation
GeoTIFF	Geographic Tagged Image File Format
GML	Geography Markup Language
JSON	JavaScript Object Notation
OGC	Open Geospatial Consortium
RDBMS	Relational Database Management System
WFS	Web Feature Service
WMS	Web Map Service
WMTS	Web Map Tile Service
WP	Work Package
TOC	Table of Content
WP	Work Package

Executive Summary

The objective of WP1 is to involve practitioners, suppliers, purveyors and technology providers, scientists and potential end users (customers) in the climate service co-creation and deliver the CLARITY CSIS software and workflows in support of the climate-resilience planning.

Task T1.3 Climate Services Co-creation is responsible for integrating the WP3 (datasets and models) and WP4 (software) outputs and implement the CLARITY CSIS for use in WP2 demonstrators and in line with the user stories (requirements) from task T1.2 Climate Service Requirements.

As such, the present report describes the second version of the CSIS prototype implementation (i.e., deliverable D1.4 CLARITY CSIS v2, marked as OTHER in the DoA). This new version goes beyond the original Naples demonstrator case study, being now possible for the end-user to perform a basic screening study in more than 500 European cities for which there is available data (mostly obtained from the European Environmental Agency (Urban Atlas dataset).

1 Introduction

The introduction chapter defines the purpose and intended audience of deliverable "D1.4 CLARITY CSIS v2" and briefly explains its structure.

1.1 Purpose of this document

Deliverable "D1.4 CLARITY CSIS v2" represents the current status of the second implementation prototype of the CLARITY CSIS. As such, being software, the deliverable is considered as "OTHER" in the DoA. Nevertheless, the present document provides a high-level description of the main features implemented so far with respect to the:

- CLARITY User Stories and Test Cases compiled as part of task T1.2 "Climate Service Requirements" - stored in the online catalogue[1] established by the project- which were derived from the input collected from the four Demonstration Cases, the EU-GL guideline, partners' ideas and workshops outcomes related to the envisioned and were presented in deliverables D1.1 "Initial workshops and the CLARITY development environment" and its follow-up document "D1.2 Database of initial CLARITY CSIS user stories and test cases".
- Mock-ups derived from the above deliverables (i.e., D1.1 and D1.2), which describe in a visual manner the conceptualization of CLARITY CSIS used by partners (and more particularly the involved developers) as the common ground for understanding what needs to be implemented how (the mock-ups focus mainly in the frontend but also in the underlying implications in terms of features and data structures/contents required by the system).
- The datasets collected in WP2 (deliverable D2.2 Catalogue of data sources and sample datasets) for the four project demonstrator cases – used as basis for developing the the CSIS prototype – and
- The CLARITY data package specification, which acts as "glue" enabling the interrelation of the various pieces of information (and its related data models) that are necessary at each step of the CLARITY (EU-GL) methodology (implemented by means of the CSIS).

Further detailed information concerning implementation status of each of the specific components can be found in WP4, deliverable "D4.4 Technology support report v2"

1.2 Intended audience

The target readers of this document are mainly the stakeholders of the four CLARITY Demonstration Cases in WP2 "Demonstration & Validation" that represent the Climate Service Customer perspective and the purveyors and climate data providers that represent the Climate Service Supplier perspective in the overall co-creation process; as well as CLARITY technical partners in charge of the Climate Service integration and development in WP1 "Co-Creation" and WP4 "Technology Support".

[1] http://cat.clarity-h2020.eu

1.3 Document structure

The structure of the document and the relationships between the different chapters is as follows:

Chapter 1 (this chapter) introduces the document and explains the overall purpose of this document and its relation to other work packages and deliverables.

Chapter 2 presents the state of CSIS specification in a visual manner, showcasing the different features implemented (in relation to the initially defined User Stories and mockups but also with new features/changes that were introduced through github tickets on https://github.com/clarity-h2020 and enhance the earlier requirements and specifications).

Chapter 3 presents the reference modelling workflow used to process the data required by the DCs, and it also lists the datasets prepared for the +500 European cities for which there is data available and finally introduces the CLARITY data package specification.

Chapter 4 presents the list of components currently being implemented and deployed that make part of the first CSIS prototype.

Chapter 5 provides the conclusions.

Chapter 6 lists the references and bibliography used in this document.

Chapter 7 provides two annexes providing full details on the CLARITY data package specification as well as a working example of the data package being prepared for Naples demonstrator.

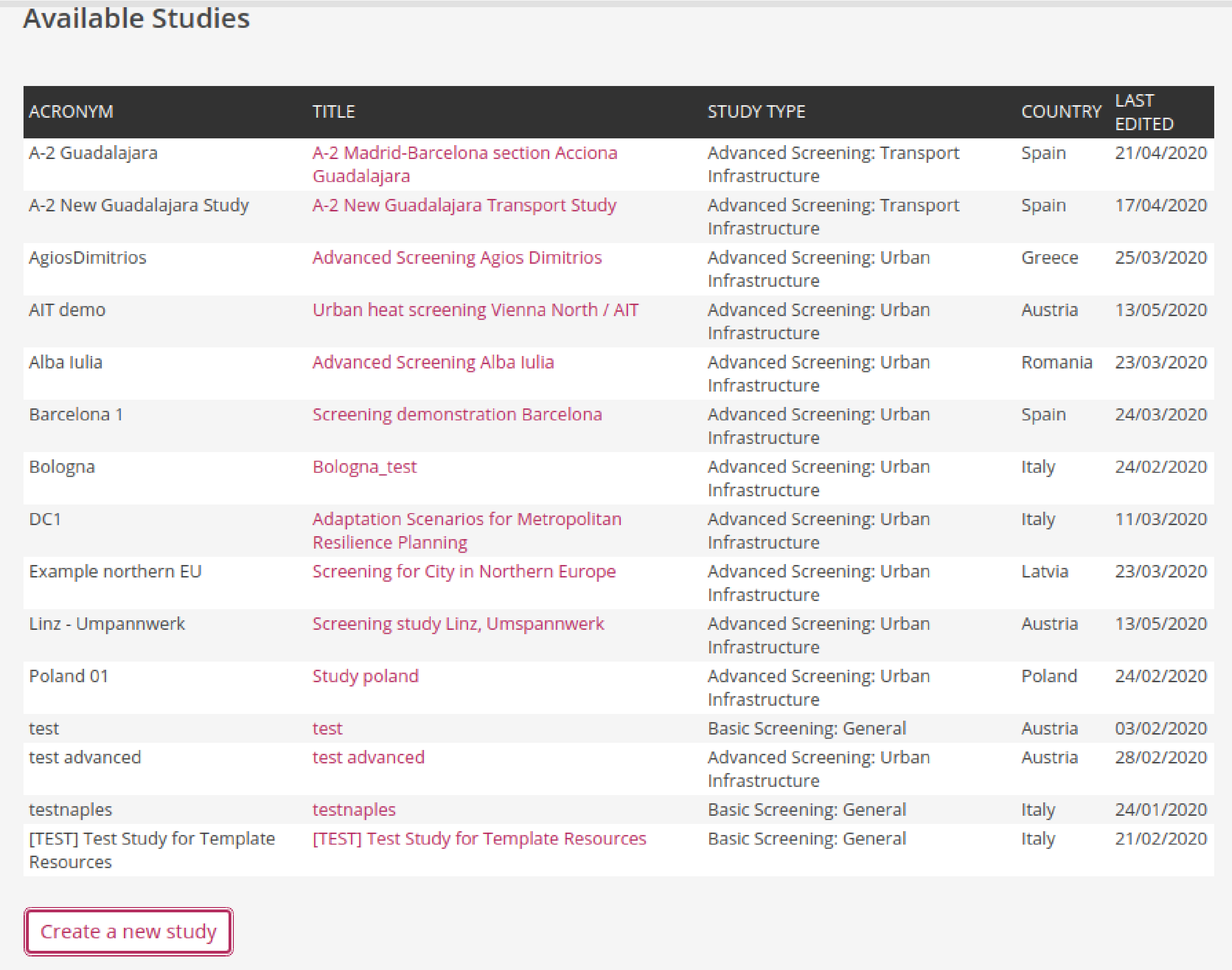
2 CSIS Prototype

CSIS prototype is developed based on the user requirements that were initially described in the form of the User Stories and later refined in a co-creation process and in the form of the mock-ups.

The prototype is accessible at https://csis.myclimateservice.eu. Please, note that a user account is needed in order to test it.

A detailed description of the CSIS architecture, components and their related technologies can be found in deliverables D4.1 Technology support plan and D4.2 CSIS Architecture. In addition, deliverable D4.4 Technology support report v2 provides further details on the present implementation status of each component.

A commented list of screenshots of the CSIS features is shown hereafter. First screenshot page (**Fehler! Verweisquelle konnte nicht gefunden werden.**) shows the overview of the projects that have been previously defined in the CSIS.



Available Studies

ACRONYM	TITLE	STUDY TYPE	COUNTRY	LAST EDITED
A-2 Guadalajara	A-2 Madrid-Barcelona section Acciona Guadalajara	Advanced Screening: Transport Infrastructure	Spain	21/04/2020
A-2 New Guadalajara Study	A-2 New Guadalajara Transport Study	Advanced Screening: Transport Infrastructure	Spain	17/04/2020
AgiosDimitrios	Advanced Screening Agios Dimitrios	Advanced Screening: Urban Infrastructure	Greece	25/03/2020
AIT demo	Urban heat screening Vienna North / AIT	Advanced Screening: Urban Infrastructure	Austria	13/05/2020
Alba Iulia	Advanced Screening Alba Iulia	Advanced Screening: Urban Infrastructure	Romania	23/03/2020
Barcelona 1	Screening demonstration Barcelona	Advanced Screening: Urban Infrastructure	Spain	24/03/2020
Bologna	Bologna_test	Advanced Screening: Urban Infrastructure	Italy	24/02/2020
DC1	Adaptation Scenarios for Metropolitan Resilience Planning	Advanced Screening: Urban Infrastructure	Italy	11/03/2020
Example northern EU	Screening for City in Northern Europe	Advanced Screening: Urban Infrastructure	Latvia	23/03/2020
Linz - Umpannwerk	Screening study Linz, Umspannwerk	Advanced Screening: Urban Infrastructure	Austria	13/05/2020
Poland 01	Study poland	Advanced Screening: Urban Infrastructure	Poland	24/02/2020
test	test	Basic Screening: General	Austria	03/02/2020
test advanced	test advanced	Advanced Screening: Urban Infrastructure	Austria	28/02/2020
testnaples	testnaples	Basic Screening: General	Italy	24/01/2020
[TEST] Test Study for Template Resources	[TEST] Test Study for Template Resources	Basic Screening: General	Italy	21/02/2020

Create a new study

Figure 2: CSIS studies homepage

Two options are available on this page: (1) *View* the final report of the study (any user); and (2) *Delete* the study (study owners). Possibility to clone a study is disabled due to technical difficulties encountered with the cloned studies.

2.1 Study types and workflows

CSIS studies can be of different types, and each type can have different workflows consisting of “steps” and sub-steps. Each step corresponds with one step in the CLARTIY methodology, which is based on an updated version of the EU Non-paper Guidelines for Project Managers (EU-GL). Each sub-step corresponds with one specific view at this data, such as “data description”, “table view” or “map view”

Which steps and sub-steps are available in the study and what they do can be easily configured through “study templates”. Several study templates have been defined for different types of studies, most notably the “Basic screening”, “Advanced Screening: Urban Infrastructure”, “ Advanced Screening: Traffic Infrastructure” and the “Expert: Urban infrastructure”. Main characteristics of these study types are presented in the TABLE

Table 2: CLARITY abbreviations.

Study Type	Description
Basic screening	Allows the users to compare the existing hazard and exposure data sets and explore the vulnerabilities and adaptation options anywhere in Europe. Over 20 hazard indices are provided for several periods and future climate scenarios. However, the hazard resolution is limited to 12x12 km^2, which isn’t enough to capture the urban climate variations. No impact calculations are performed, but the comparison of the hazard intensity with positions of the elements at risk can be used as a proxy for risk/impact.
Advanced Screening: Urban Infrastructure	Allows the user to perform on the fly calculation of local hazards, exposure and impact on the fly for a selection of European cities and regions where the relevant input data is available. The resolution is 500x500m^2, which is enough to capture the urban climate variations. However, the calculation is limited to “heat urban islands” use case, with “flooding” still in development. Like in the basic screening, the Advanced screening – Urban infrastructure also allows the users to explore the characteristics of the main adaptation options anywhere in Europe. An additional step for assessing the impact of adaptation options is still in development. More information on Advanced Screening: Urban Infrastructure is provided in section 2.2.
Advanced Screening: Traffic Infrastructure	Allows the user to perform the advanced screening for the traffic infrastructure. Currently limited to Spain, the extension to the rest of the Europe is in development. This screening is conceptually similar to the Advanced Screening: Urban Infrastructure but targets a different type of infrastructure and a different group of users. It is also very different in terms of the technology used and showcases how the (HML5) software can be embedded in the CSIS workflow. More information on Advanced Screening: Traffic Infrastructure is provided in section.
Expert: Urban infrastructure	Similarly to the “basic screening”, this workflow relies on pre-made data sets and no calculations are performed on the fly. However, the expert study relies on data packages that were specifically made for this study and therefore no a-priory assumptions are made on the available steps or data. Typically, such data packages provide high resolution data for a limited study area. They may also provide data corresponding to hazards, elements at risk, impacts and impacts of the adaptation options that aren’t available in the screening data packages. Main use case for the “Expert: Urban infrastructure” study type is therefore preparing one or more reports on a previously conducted expert study.

The simple screening workflow is available in the whole Europe, whereas the advanced urban screening process can be carried out in more than 450 European urban areas for which the necessary data is available. Finally, the traffic infrastructure screening is available in a whole Europe but provides higher level of service in Spain than elsewhere due to availability of the specific data.

"Advanced Urban infrastructure screening" and the "Advanced screening: Traffic infrastructure" workflows are presented hereafter.

2.2 Advanced Screening: Urban Infrastructure workflow

2.2.1 Study step

Each study starts with a "Study" step. This step is common to all study types and provides relevant information regarding the study's nature and methodology. This section is split into several tabs, the first of which is the "Introduction" tab (Figure 3). This tab offers an introduction to the (updated) EU-GL methodology. "Change description" button allows the users to change or adapt the introduction or replace it entirely with texts that are more relevant for the study at hand if they wish to do so.

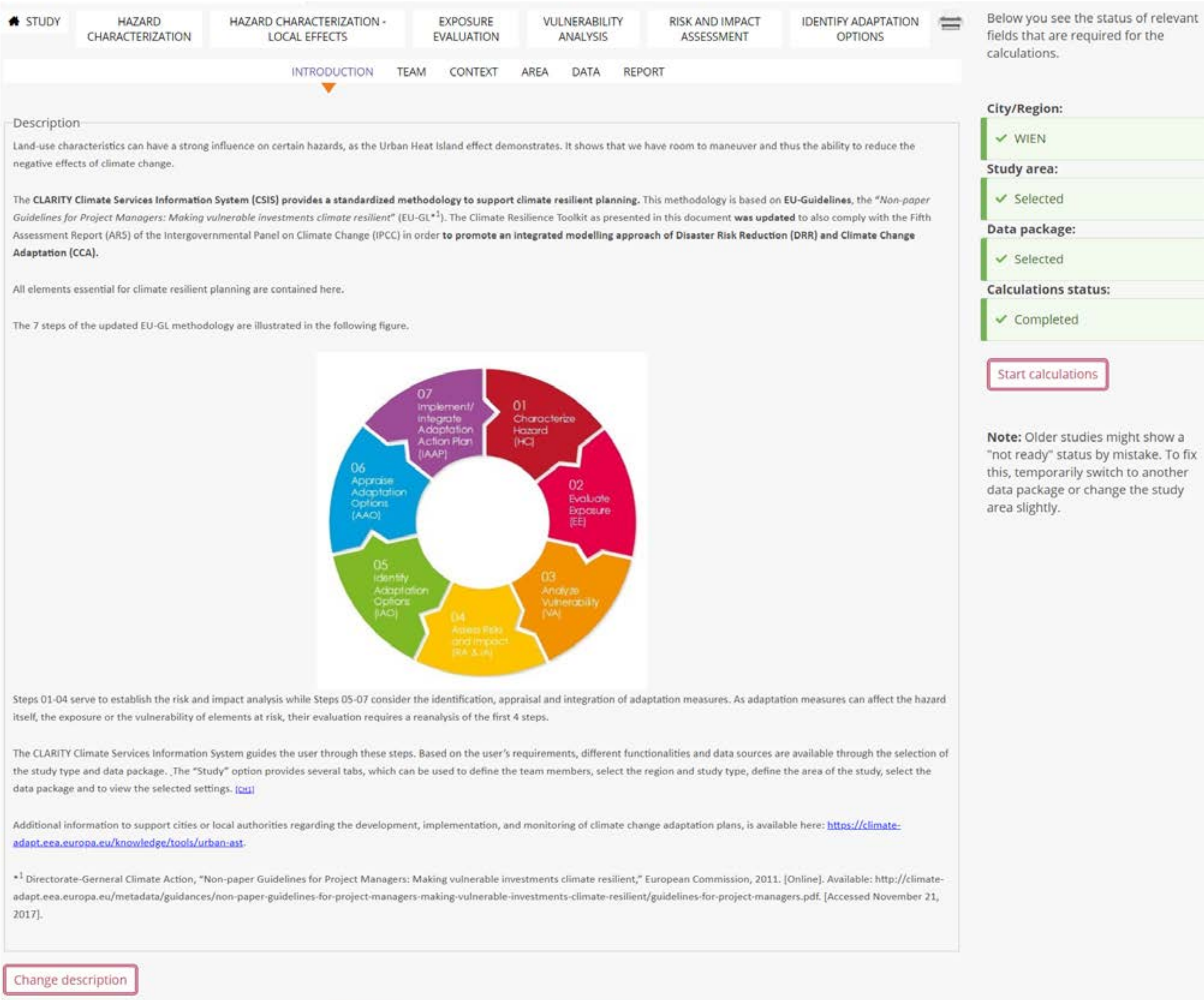


Figure 3: Study -Introduction

Right-hand side of Figure 3 also presents the "Study checklist". This checklist is shown in all tabs of the Study step and depicts the status of project initialization. Figure 3 presents the final state, when all the relevant information is entered, all steps turn green and calculations can be initiated. Initial, with checklist steps coloured in yellow to indicate that information is missing is depicted in Figure 5.

The **Team tab** (Figure 4: Study - Team) depicts the participants involved in preparing the study. Depending on their role, team members may be allowed to view unpublished studies, edit, re-calculate or even delete the study. A participant's role can be selected when they are added as a member. Team members can be added, removed and their roles changed at any time.

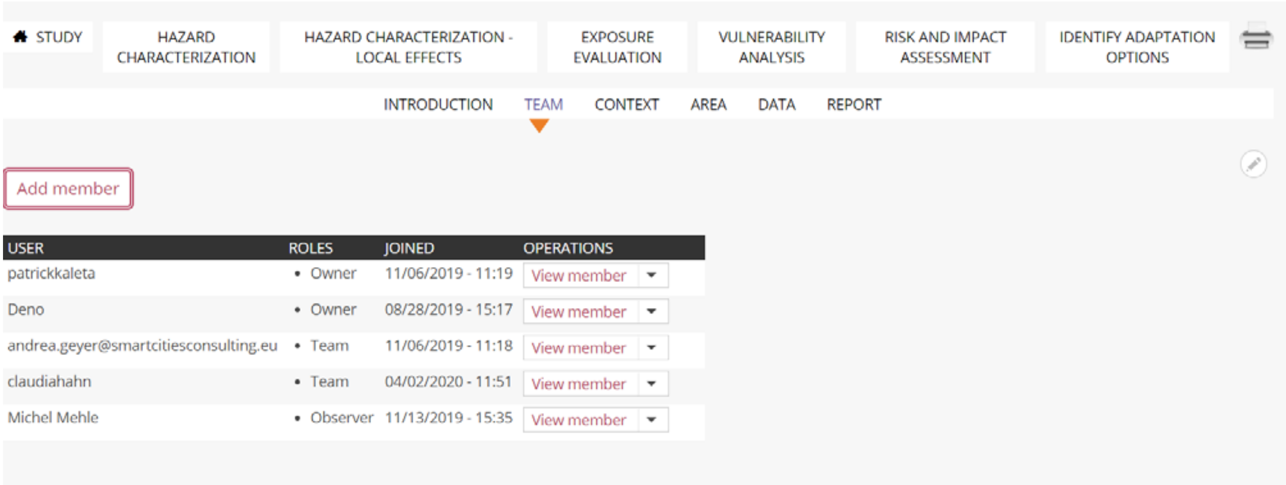


Figure 4: Study - Team

The **Context and area tabs** provide contextual information about the project and allow for more detailed customization of the study. In the context tab (Figure 5, Figure 6) the user is able to add information about the study, such as short name, study goal, country and city where the project will be/is being developed. This section also allows for the creation of study scenarios, within which a time period (historical or future), an emission scenario and frequency of hazard occurrence are selectable. Several study scenarios can be added, which allows for a comparison between e.g. historical data and future projections.

At the time of writing, it is still the possible to choose if the study scenario should be presented with or without adaption options. This option will be removed in the final release when a possibility to explore the effects of adaptation options for *all* study scenarios is fully implemented.

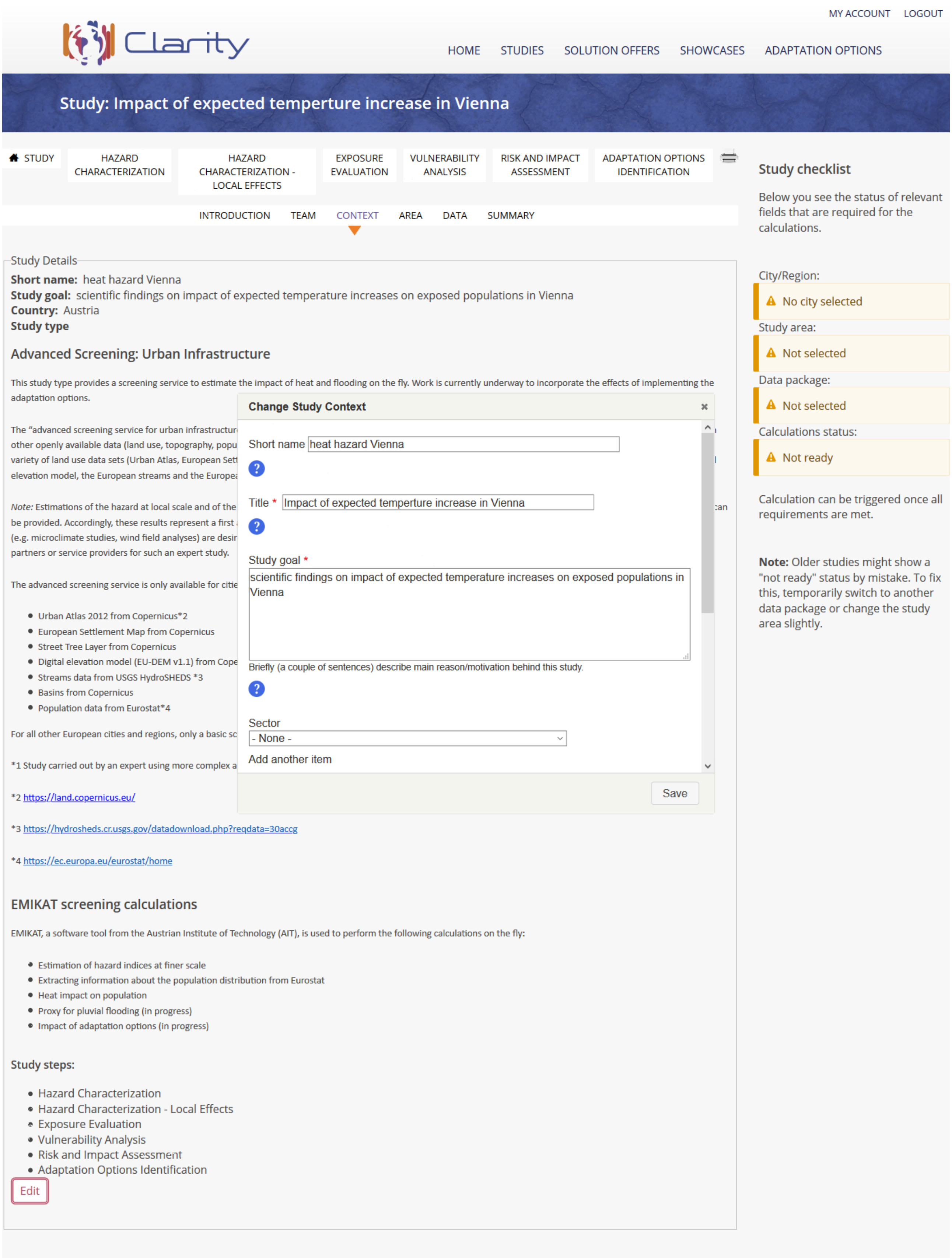


Figure 5: Study - Context (form)

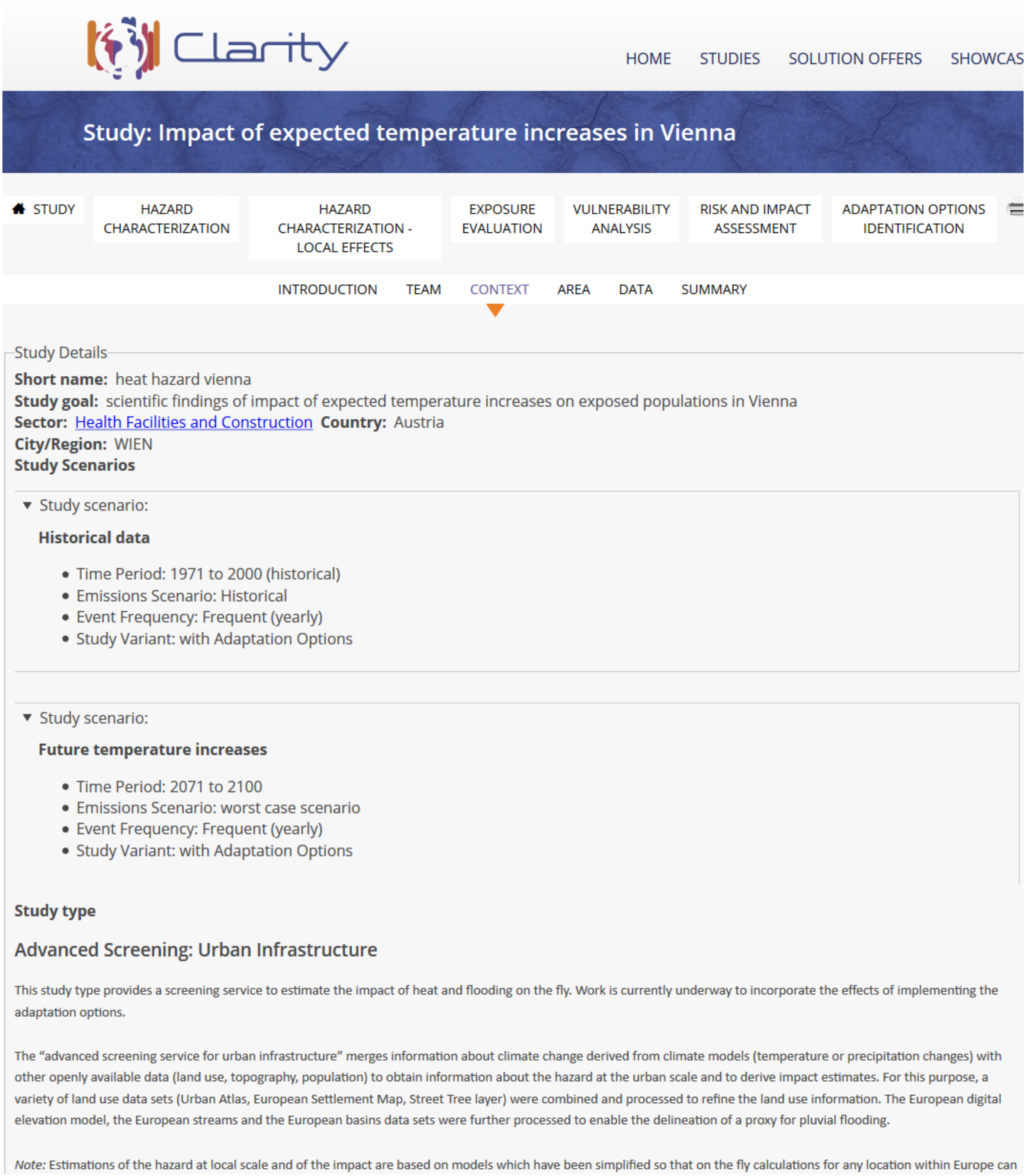


Figure 6: Study – Context form completed

Next tab in the Study step is called **“Area”.** Here, the user is presented with a map displaying the area where the study can be performed (in purple, see Figure 7) and asked to define the actual study area of interest (red rectangle, see Figure 8). “Include in report” button allows the user to add the map to the project report, together with a title and explanatory text. “Include in report” buttons appear on many parts of the system and always work in the same way.

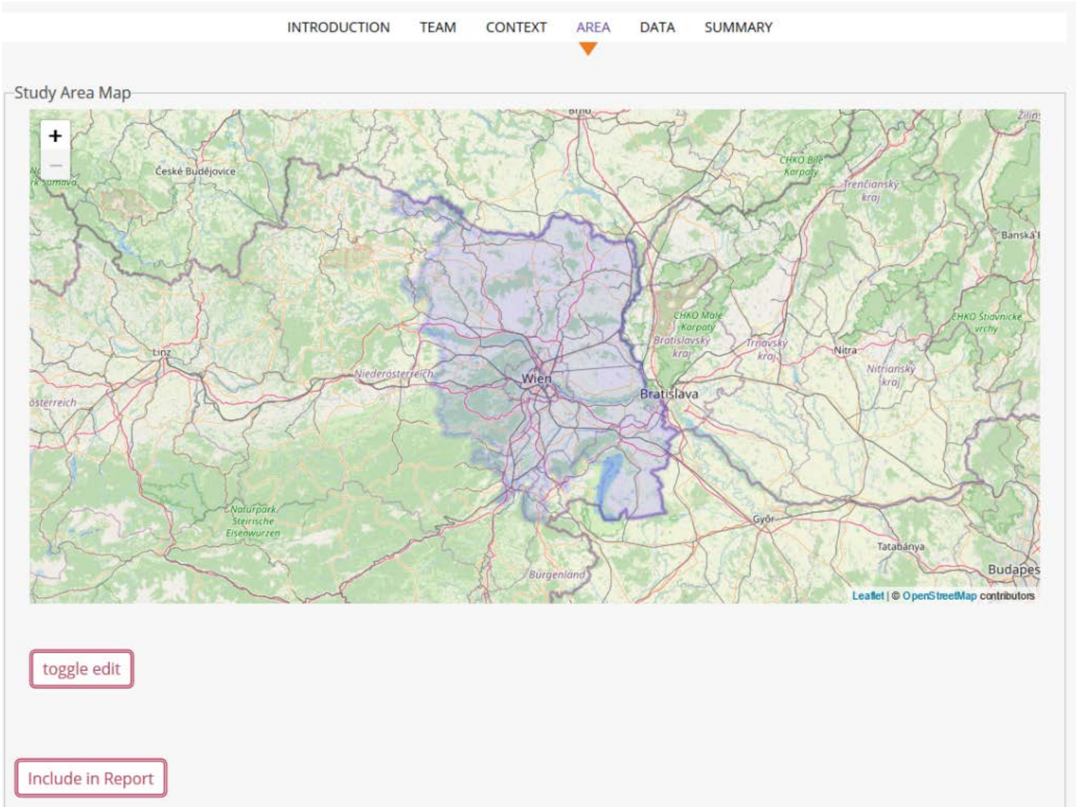


Figure 7: Study – Area boundary

Figure 8: Study – Specified Study Area

Data that is necessary for screening calculation is only available within the purple shaded area of the map. Therefore, the system will only accept study areas that at least partially overlap with this area. Moreover, the maximal allowed area is currently limited to $500km^2$, to keep the calculations short and avoid overloading the backend server.

Once the study area is selected, user needs to switch to the **“Data” tab** (Figure 9) and select the data package to be used for calculations. Data packages differ in area coverage, resolution, choice of hazards, elements at risk, validation options, etc. Only one of the currently defined data packages is compatible with the Advanced Screening: Urban Infrastructure study type, the pan-European data package. Thus, choosing a data package is trivial for this study type. Now that all sections are completed, calculation can (and should) be started. Calculations typically take 25-20 min and the progress is presented on the screen.

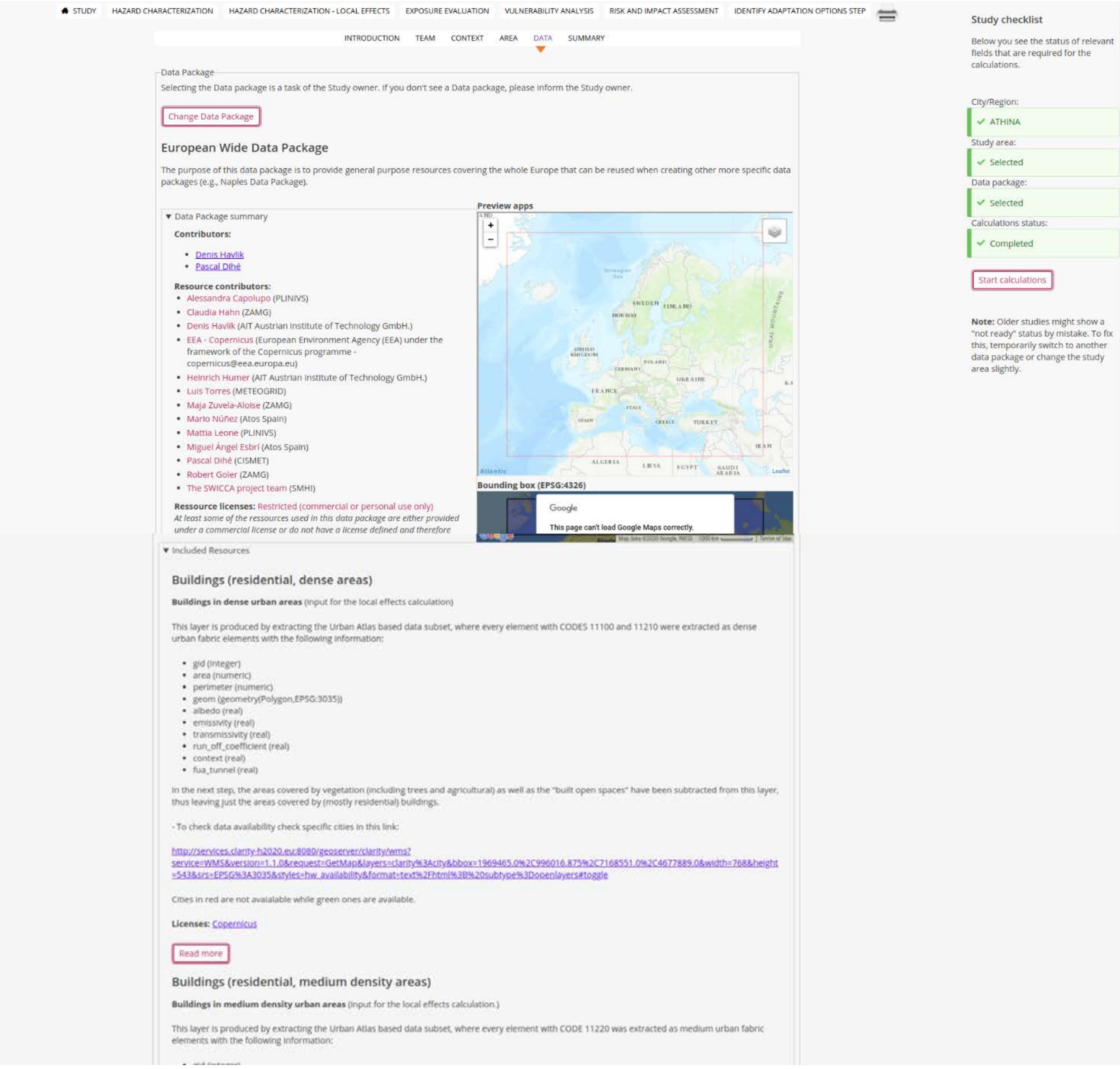


Figure 9: Study – Data Package

The **"Report" tab** (Figure 10) is the last tab in this section. It functions as a preview of the complete study report and depicts all the information entered in the previous tabs, as well as the information related to other study sections.

Some supplementary/explanatory comments can be added to the embedded map previously selected in the area tab. This tab also offers the possibility of downloading the report as a pdf.

The downloadable pdf is the finalized study report. Each completed section when creating the study generates another section within the report. This report summarizes all the calculations and findings of the system and can serve as a supporting statement or evidence in any argument revolving around the issue

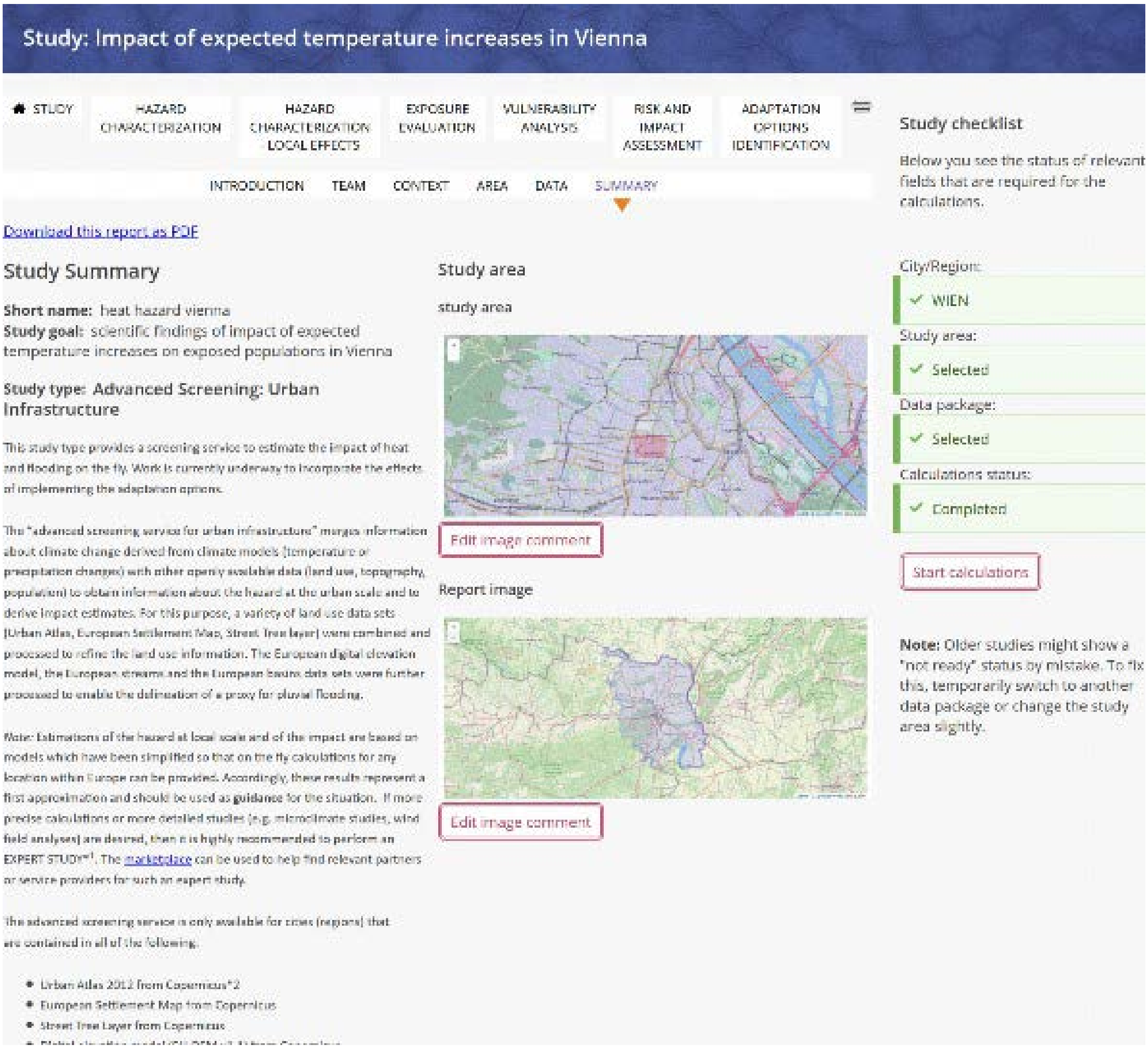


Figure 10: Study- Report

2.2.2 Hazard Characterization (HC) step

In order to develop an adaption strategy for the study created, the user should work through a few more sections, the first of which is "Hazard Characterization" (Figure 11). This section, as well as all of the following steps, starts with the "Introduction" and ends with the "Summary"[2]. This ensures that: (1) users do not have to read through the methodology before starting to use the tool, and (2) immediately understand how the report is built and what is included in it.

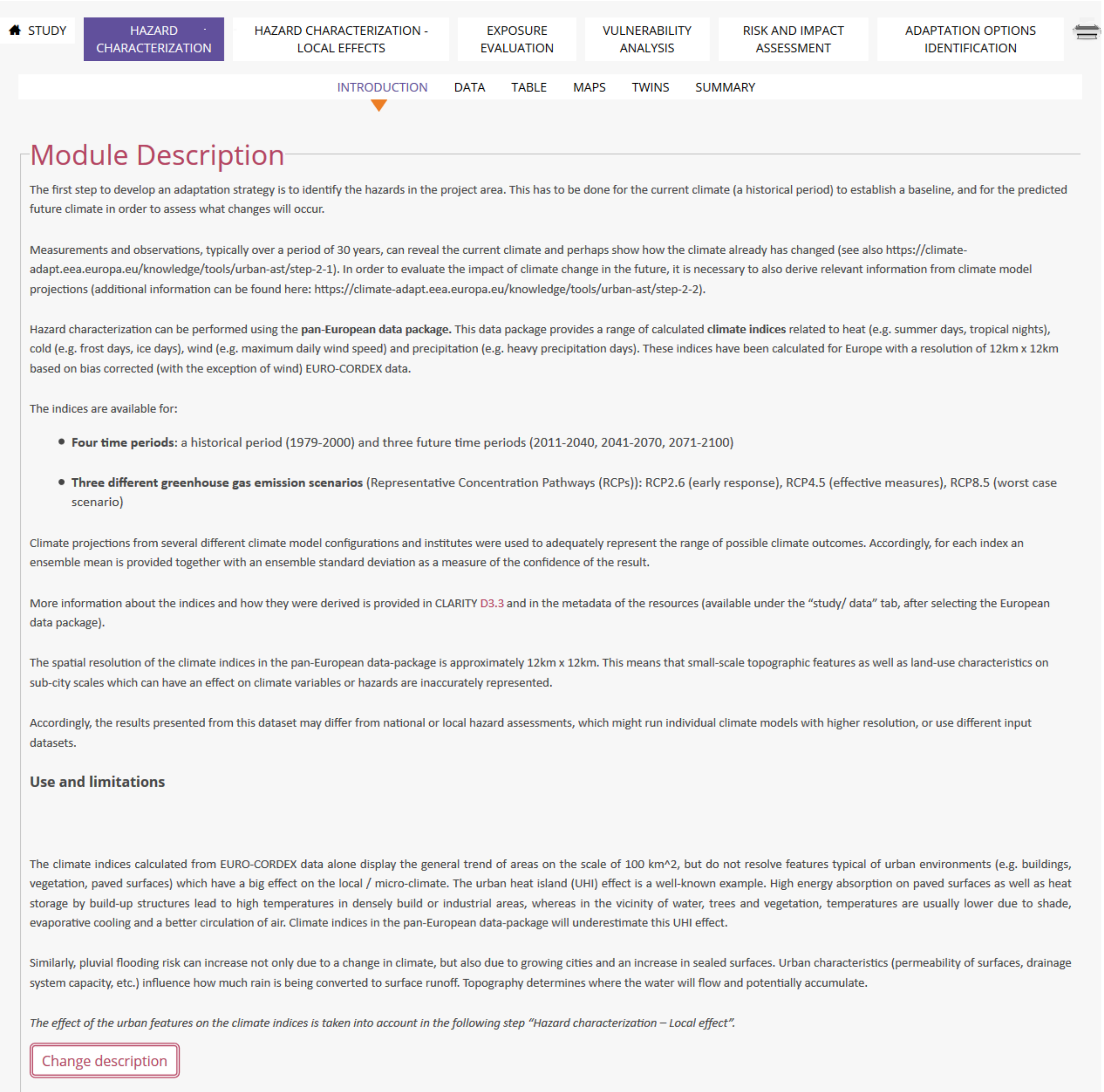


Figure 11: Hazard Characterization – Introduction

[2] Summary tab will be renamed into "Report chapter" in the final version of the workflow.

The next tab in the Hazard characterization step is “Data”. Here, the users are able to view which hazard-related indices are used in the data package, what they represent, how accurate the data is etc

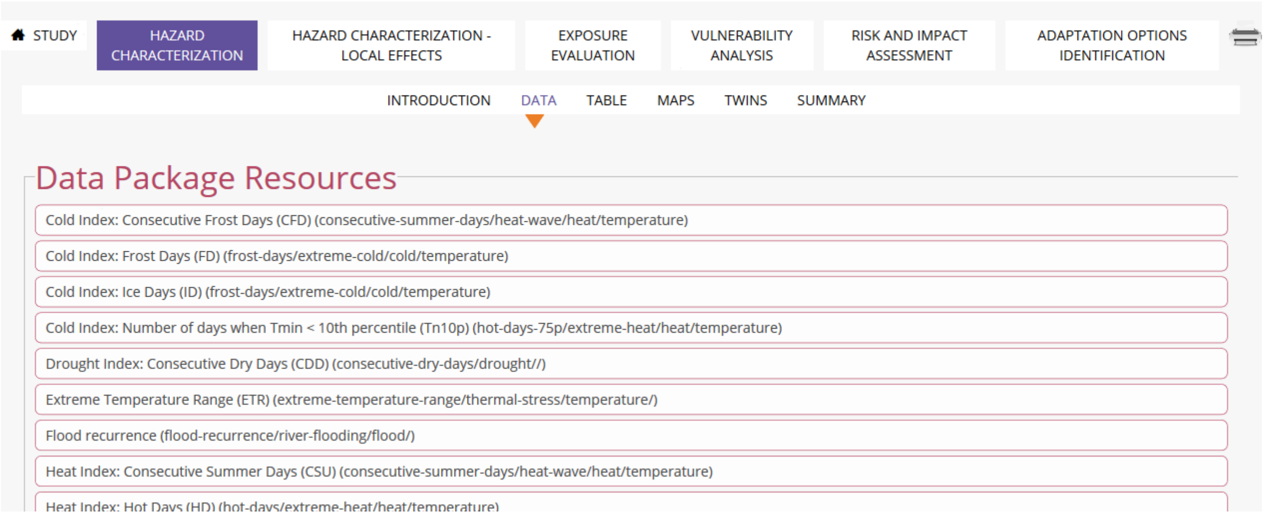


Figure 12: Hazard Characterization- Data (list of resources in the data package)

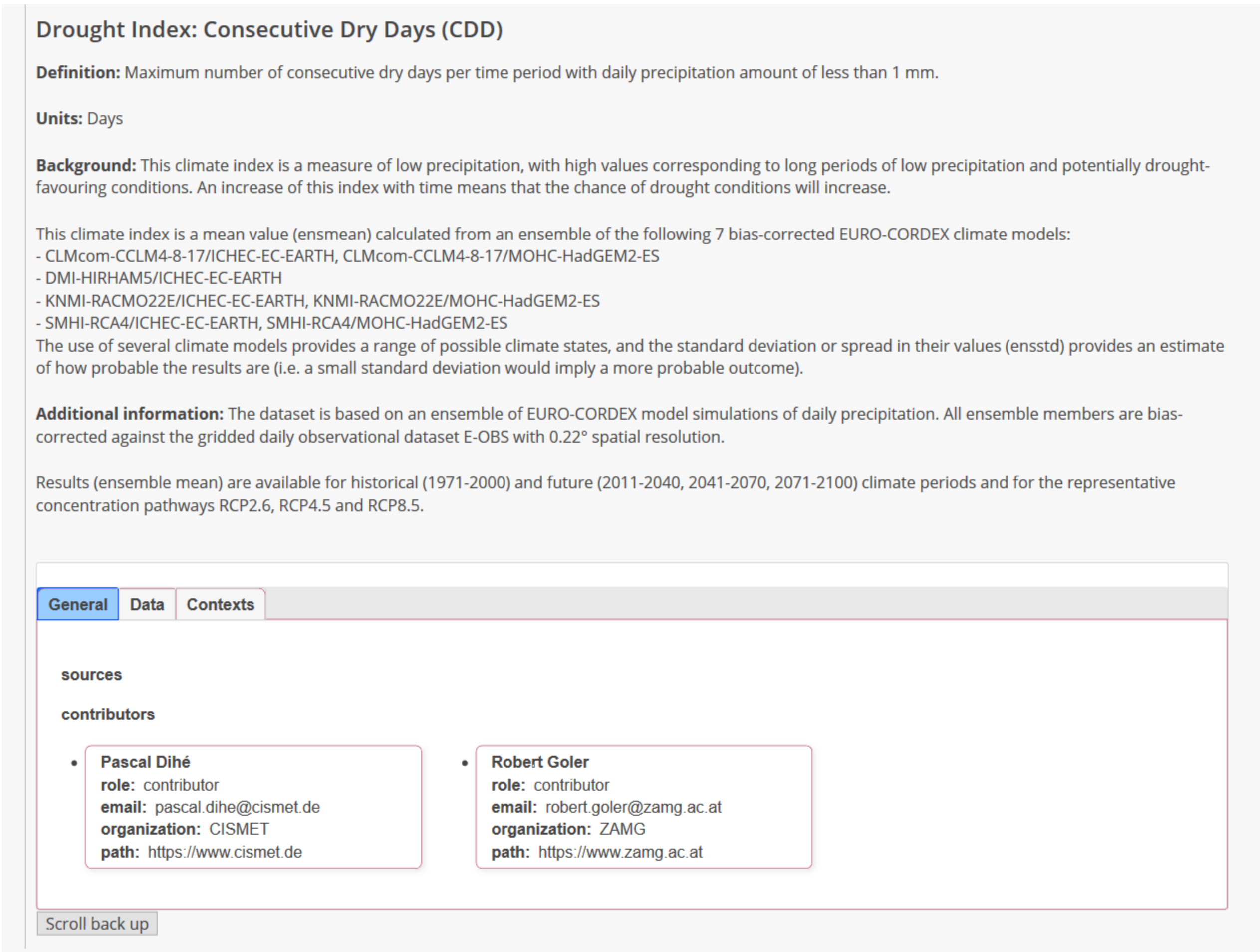


Figure 13: Hazard Characterization - Data (data package resource description)

The “Table” tab depicts the first study results for heat wave and heavy rainfall hazards. The user has the possibility to inspect how the data for the whole study area changes for different combinations of the emission scenarios and time periods considered in the present study, as well as to download the data in various formats as well as to add it to the study report.

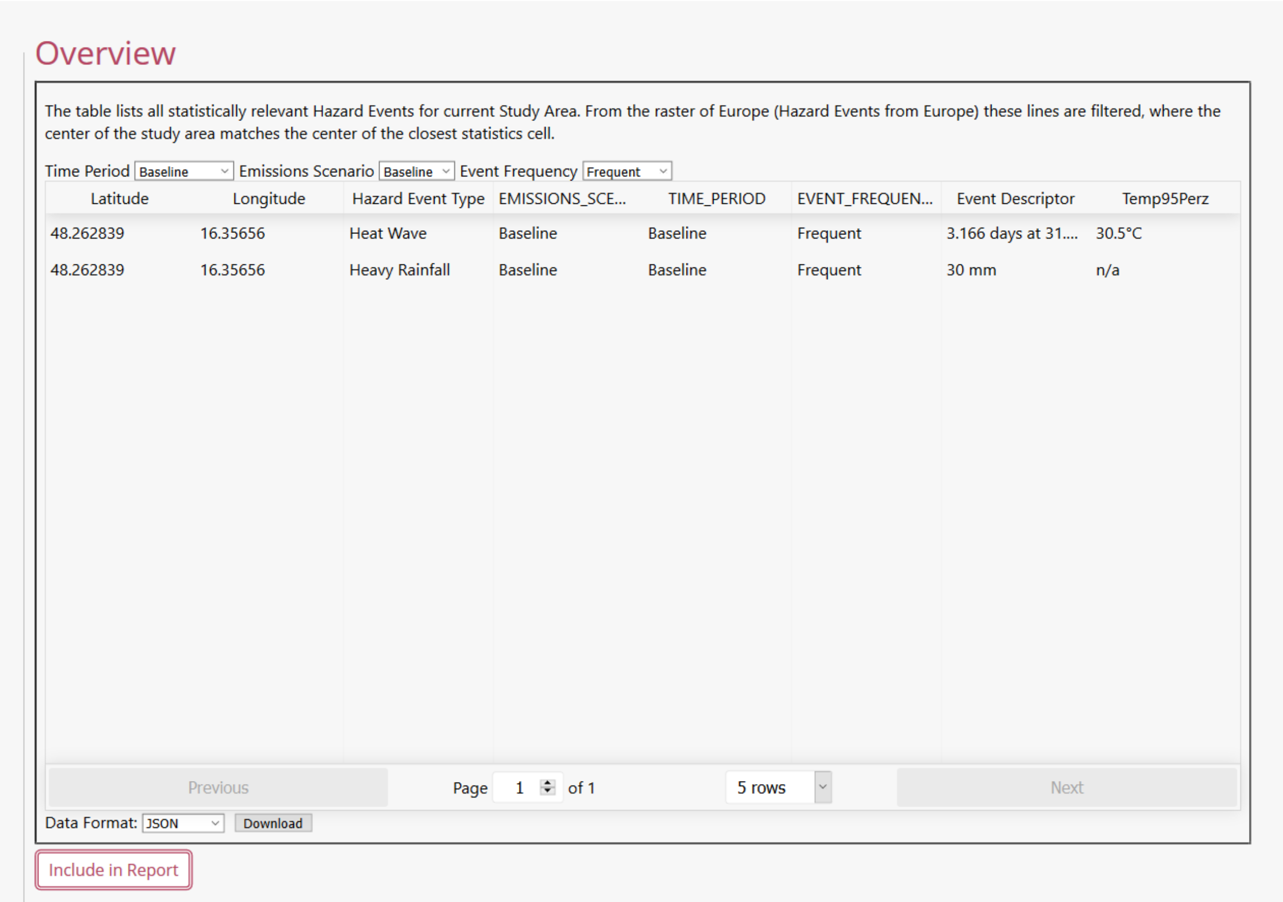


Figure 14: Hazard Characterization – Table tab

This tab is a bit confusing to new users, since the “event description” is somewhat cryptic and because it presents the results of the screening calculation, whereas the rest of the hazard characterization step presents the pre-calculated hazard data. We have decided to keep it at its current position (for now), because this data is considered important part of the study by our experts and no other place within the workflow is better suited for presenting it.

The “Maps” tab allows the users to explore map views of different hazard indices. A total of 21 indices is available, all of them covering the whole Europe and at a 12km^2 scale. These indies are a result of the ensemble calculation and presented as ensemble mean value and standard deviation for a variety of time periods and emission scenarios.

Some important features of this map view are illustrated in Figure 15, which presents ensemble mean (left) and the standard deviation (right) for the number of hot days in Vienna:

1. Two maps are shown side-by side. Both maps show the same area and the user can decide what is shown on each of them independently.
2. Due to coarse resolution, usually no variation can be seen at the urban scale. This view should be used primarily to at a bigger scale and to compare the values for different scenarios.
3. Actual values of the indices are revealed on the mouse click.

4. Standard variation of the ensemble calculation is a measure of reliability of the prediction and should be assessed to understand the significance of the model prediction.

Annotated map snapshots can (and should) be included in the report. This principle applies to all map views.

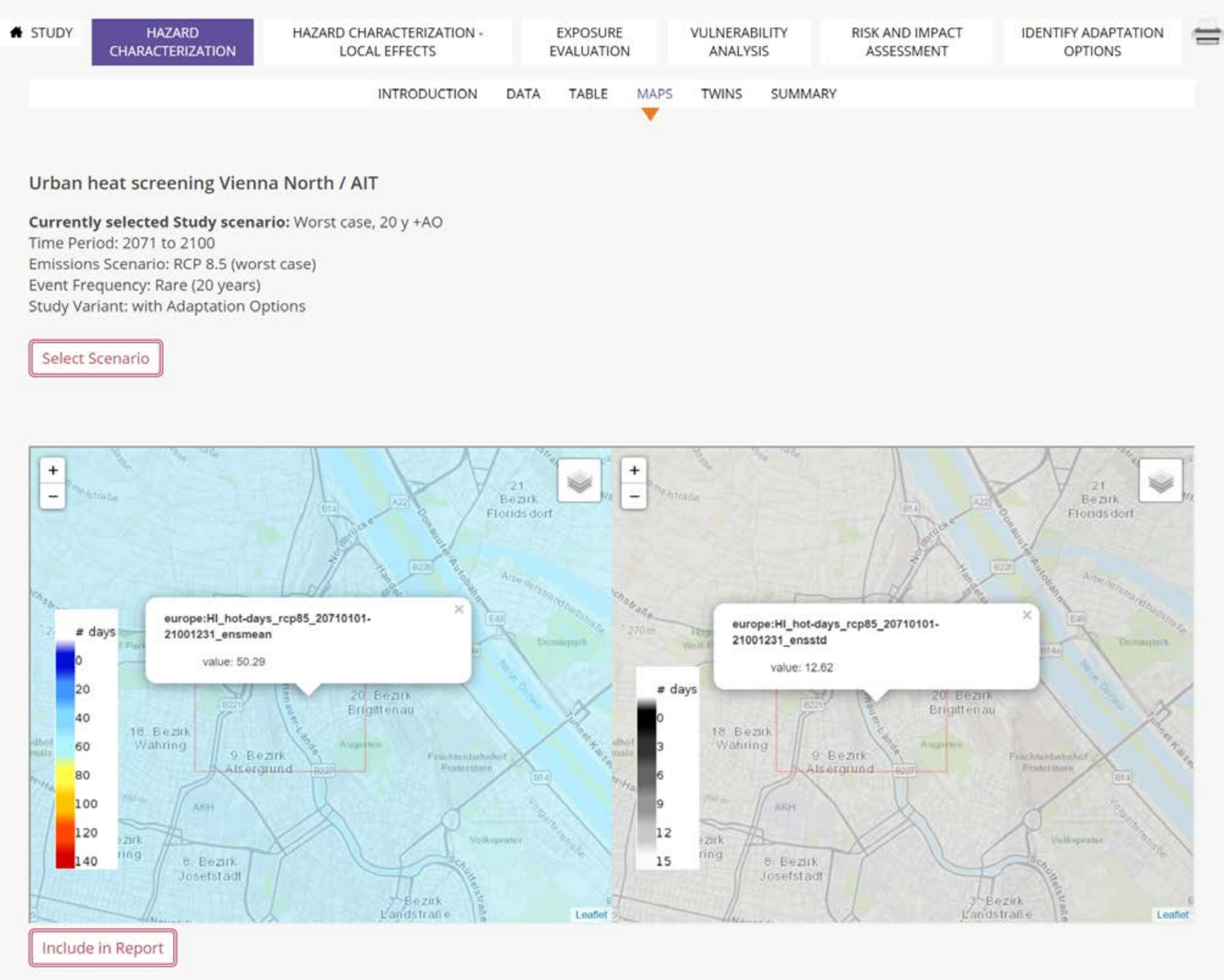


Figure 15: Hazard Characterization – Maps

At a city scale, no variation of the hazard will be seen in the study area due to coarse resolution of the hazard maps, but the users can zoom in and out and customize which overlay they would like to see. *Moreover, estimating the values of indices from the colour codes is difficult and error prone. Actual numeric values are revealed on a mouse click and should be used instead.*

Finally, the "Twins" tab allows the user to discover concrete examples of various hazard events and include them in the report. This can be used to illustrate the meaning of the numerical values provides in the study (Figure 16).

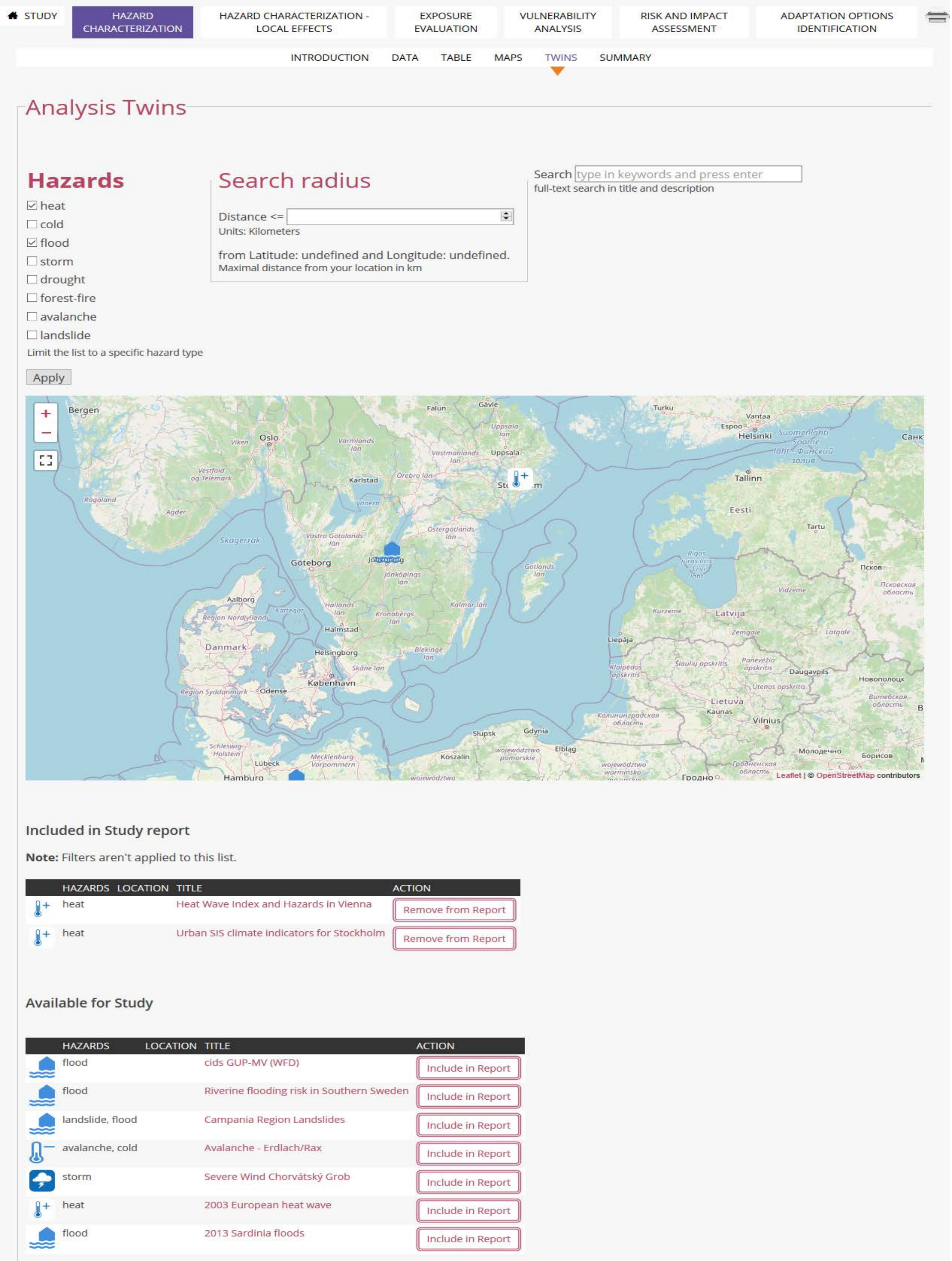


Figure 16: Hazard Characterization– Twins

The last tab is a preview of the report section corresponding to this step and sums up all the information entered in different tabs. All included maps, tables and twin studies are presented and can be edited, sort and deleted.

2.2.3 Hazard Characterization – Local Effects step

Next step in the advanced urban screening study is called "Hazard characterization: local effects". Here, the result of an automated microclimate simulation in the study area is shown – effectively resulting in higher resolution hazard indices (see "D3.3 Science support report v2" for details).

This step does not exist in EU-GL but was introduced for practical reasons, to differentiate between a large number of pre-calculated indices that are available at 12x12km^2 resolution for the whole Europe and the smaller number of indices that are calculated at a fly for the study area and at a 500x500m^2 resolution. All indices available in this step are either related to flooding or to heat hazard.

It must be noted that the "Hazard Characterization – Local Effects" indices are provided for specific future hazard events, e.g. "6 consecutive days > 30°C max temperature heat wave" and for three distinct return period probabilities: "frequent" (yearly), "occasional" (once in 5y) and "rare" (once in 20 years). Please keep in mind that CLARITY definition of common, occasional and rare events is different from ones used by e.g. hydrologists or earthquake experts.

As aforementioned, this section/step has a very similar set-up compared to the "hazard characterization", with an introduction tab (Figure 17), a data tab (Figure 18), a table tab (Figure 19), a maps tab (Figure 20) and a section summary/report (Figure 21). Merely the twins tab has been disabled to avoid duplication.

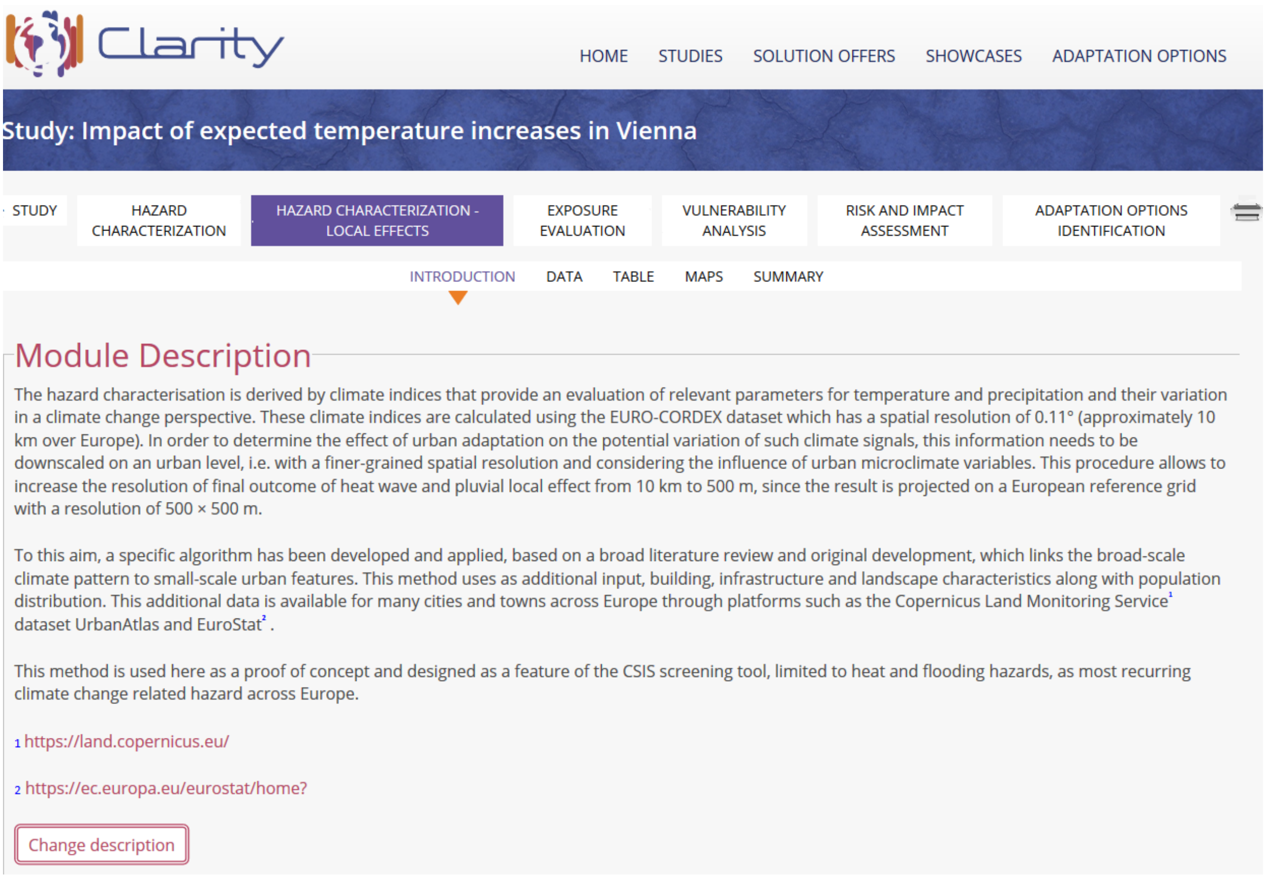


Figure 17: Hazard Characterization – Local Effects – Introduction

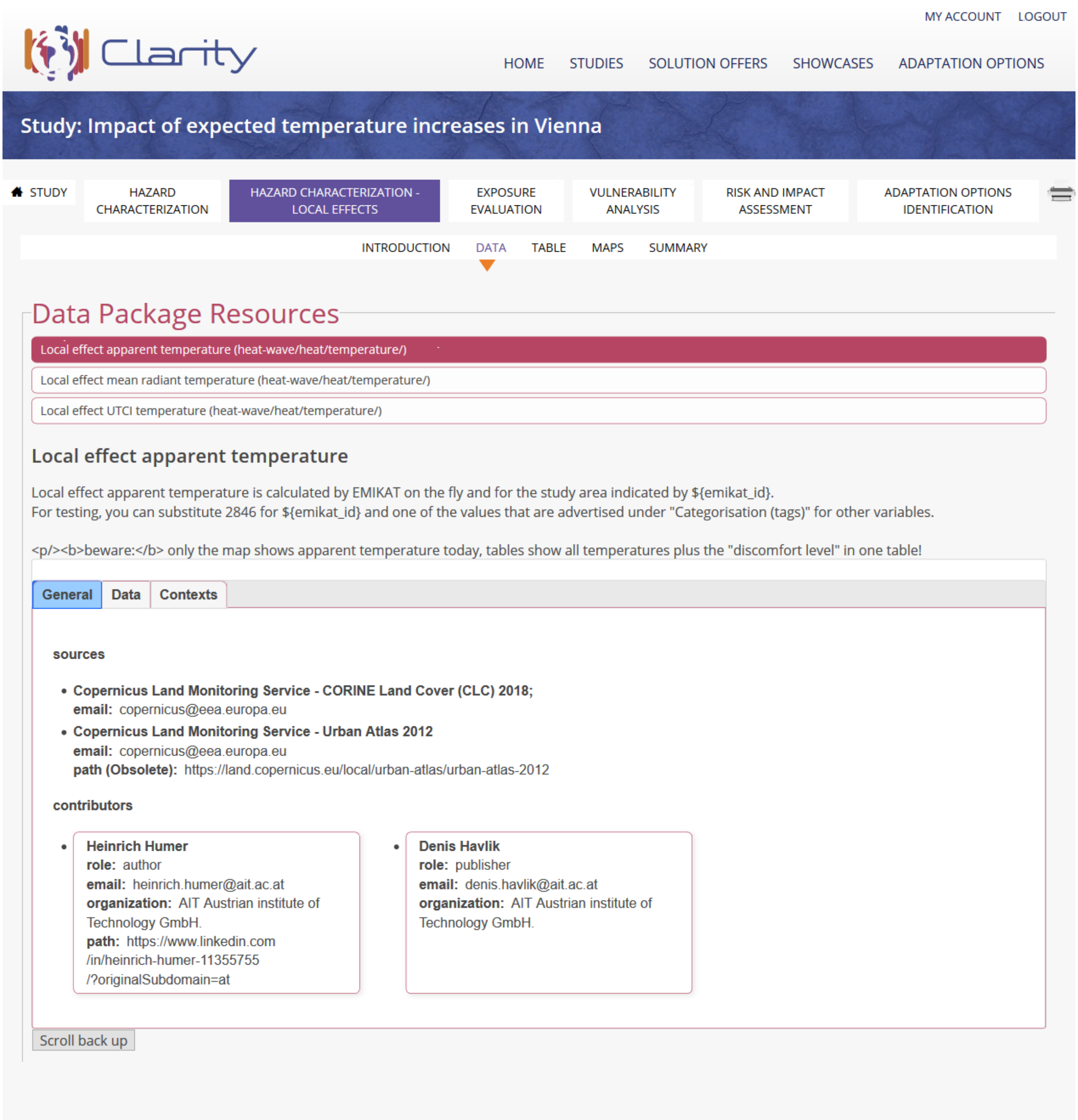


Figure 18: Hazard Characterization - Local Effects - Data (list of resources in the data package)

Compared to previous step, both the table (Figure 19) and the maps tab (Figure 20) provide a far more data variation at urban scale.

In fact, the table is often so long that including it in a report may be overkill. However, the table is very interesting as a tool for exploring the data by sorting it online and by exporting it and analysing it offline.

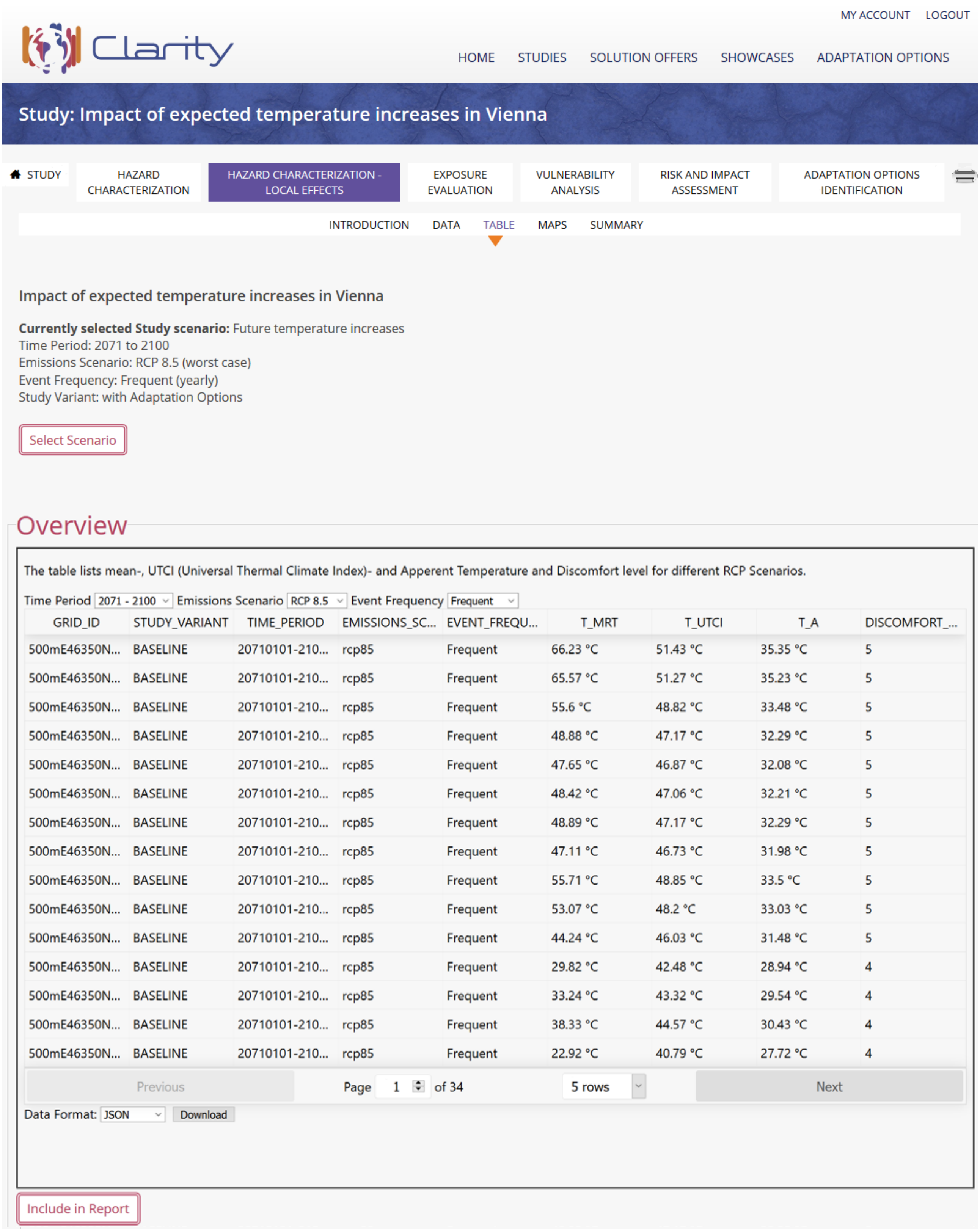


Figure 19: Hazard Characterization – Local Effects – Table

Likewise, the hazard local effect maps (Figure 20) provides clear variation of the indices values at the urban scale, which is the main reason for implementation of the advanced screening workflow. Map widget works in the same way as the one provided in the hazard characterization step (Figure 15), except that the data presented in this step is at a higher spatial resolution.

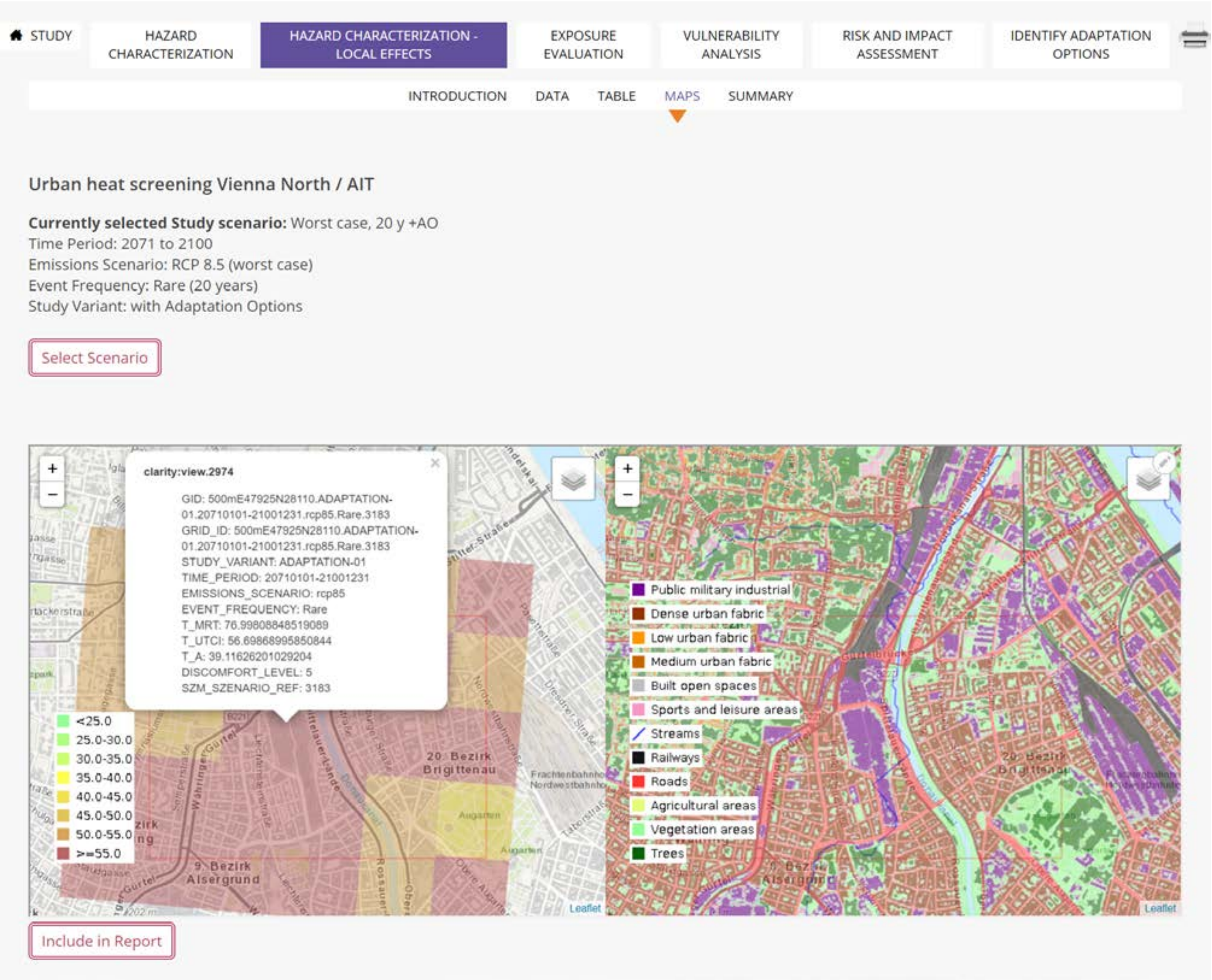


Figure 20: Hazard Characterization – Local Effects – Maps (left: Universal Thermal Climate Index; right: CLARITY land cover layers)

As illustrated in Figure 20, local hazard temperature indices mainly correlate to the type of land cover, with green and water areas providing a cooling effect and dense urban areas resulting in excess heat. In addition, the model also accounts for the height differences between different parts of the city.

Section summary/report (Figure 21) is the same as in all other steps. It provides the step summary and all the tables and maps that were attached to the report by the user.

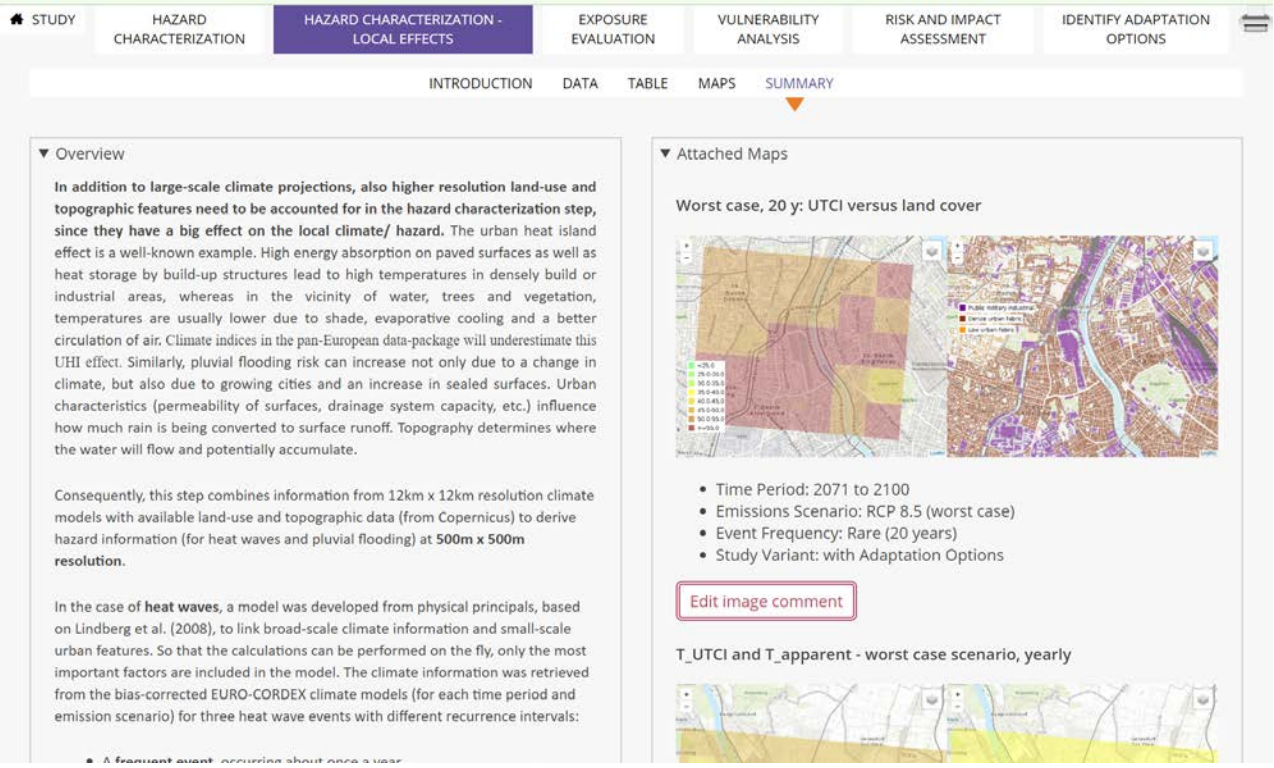


Figure 21: Hazard Characterization – Local Effects – Summary

2.2.4 Exposure Evaluation (EE) step

Once the hazard characterization in the project area has been assessed, the next step is to evaluate the exposure of elements considered to be at risk to climate hazards (e.g. population, buildings, infrastructures, etc.), at the project location(s). The exposure is a quantitative distribution, in space and time, of elements exposed (people, buildings, infrastructures, etc.). These elements can be grouped into categories based on their behaviour under hazard conditions (called "vulnerability classes") and based on specific characteristics (i.e. age for people, structural/typological characteristics for buildings, etc.) that influence the damageability of elements exposed to hazards.

Due to lack of available data at European level, CLARITY screening model does not disaggregate the population or the building infrastructure in distinct classes. Development of improved screening models for specific regions where such data is available is possible and part of the CLARITY exploitation plan.

Introduction and data steps (Figure 22, Figure 23) closely resemble the ones in previous stepy and will not be further discussed.

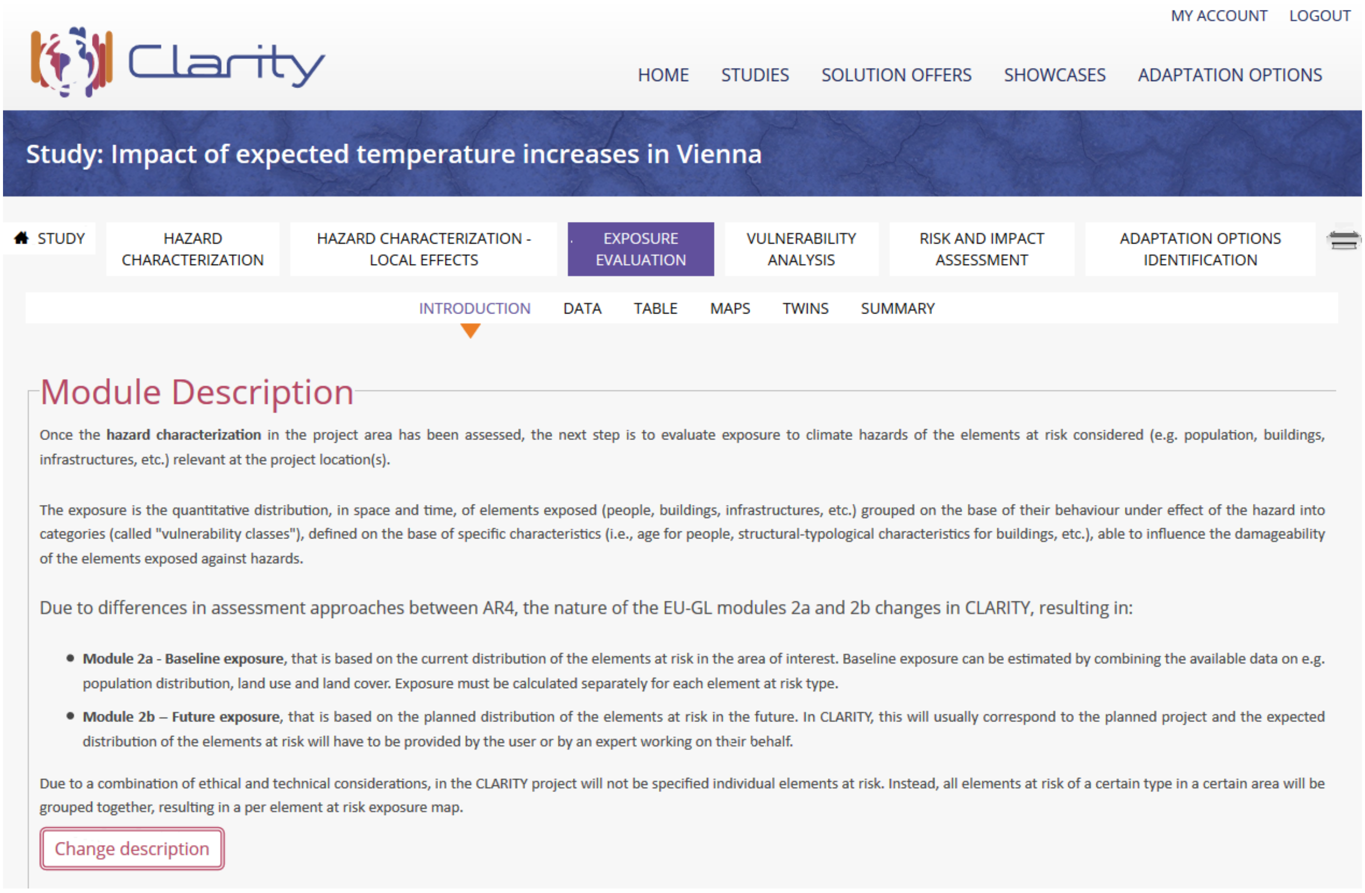


Figure 22: Exposure Evaluation – Introduction

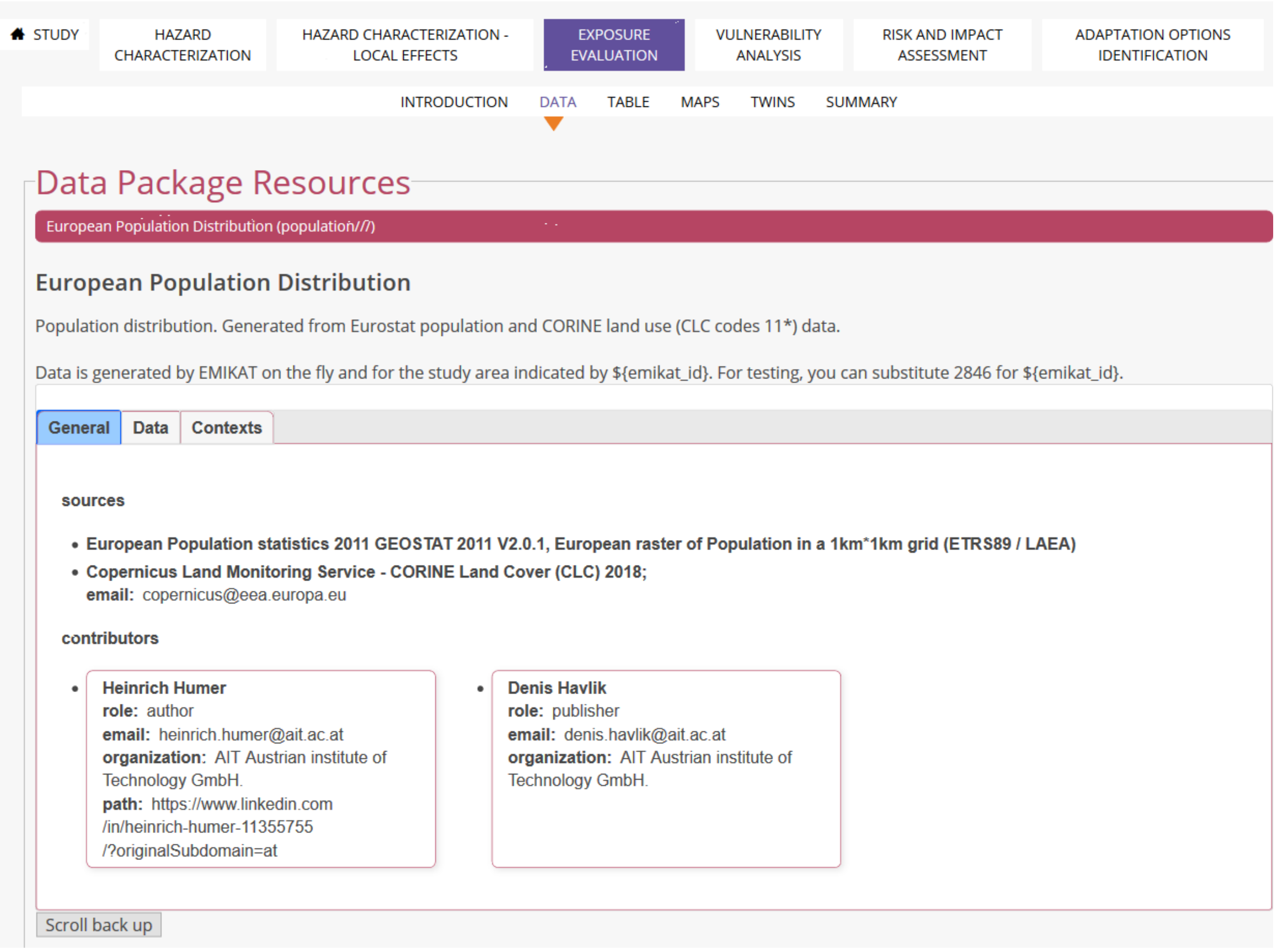


Figure 23: Exposure Evaluation – Data

Table view (Figure 24) is easier to interpret than the one in a previous step because the number of data indices is smaller. At a time of writing this document only the number of people in each 500x500m^2 squares is shown.

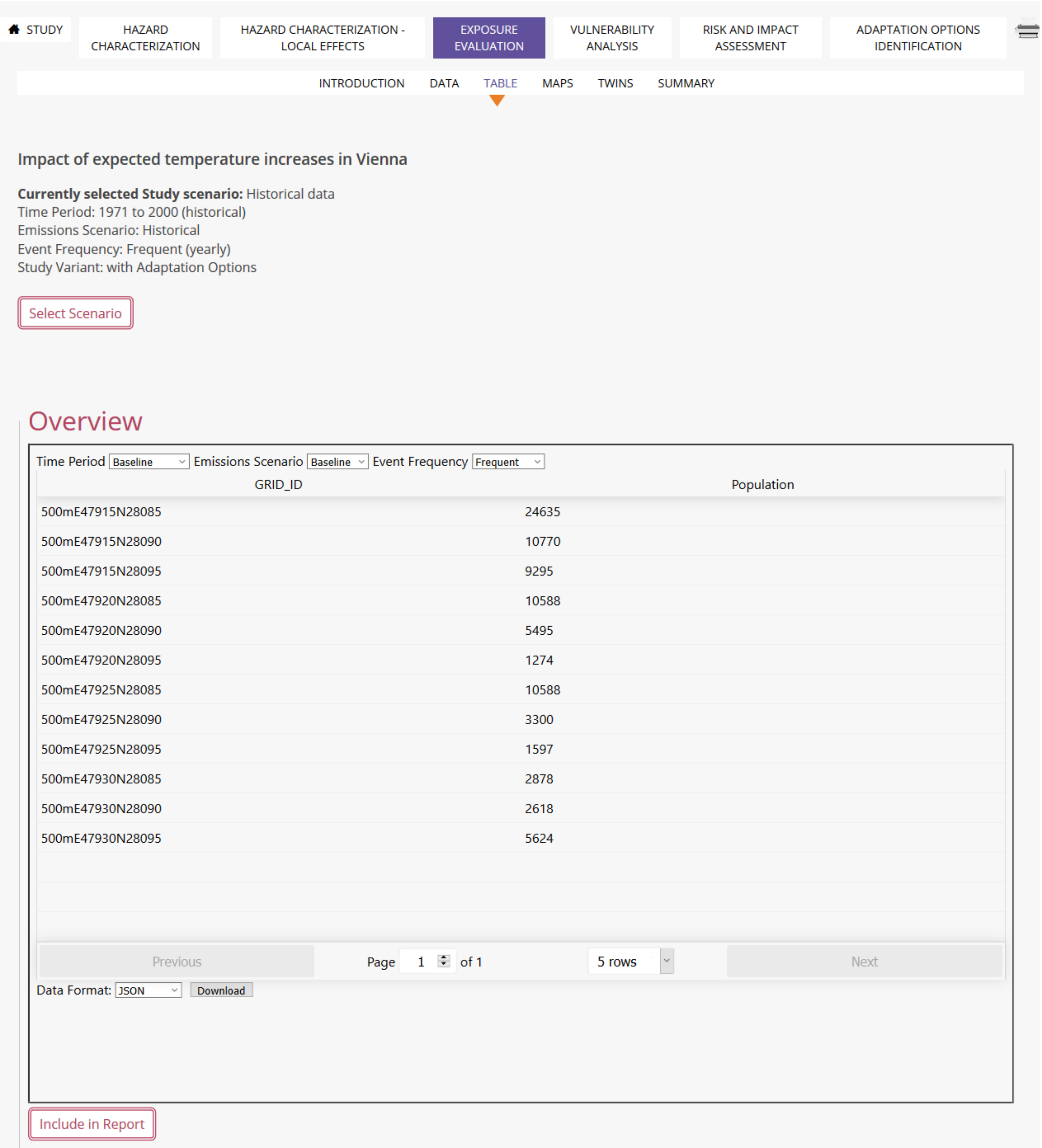


Figure 24: Exposure Evaluation - Table

As illustrated in Figure 25, population density is related to land cover, with more people living in densely built residential areas. Green areas, as well as the traffic and industrial areas are presumed to have no inhabitants. This assumption is not true in 100% of the cases, due to inaccuracies in the underlying data. Again, better results could be achieved for specific areas where better data is available.

The map works similarly to previously shown maps – users can explore the map views and include those they consider important in the report.

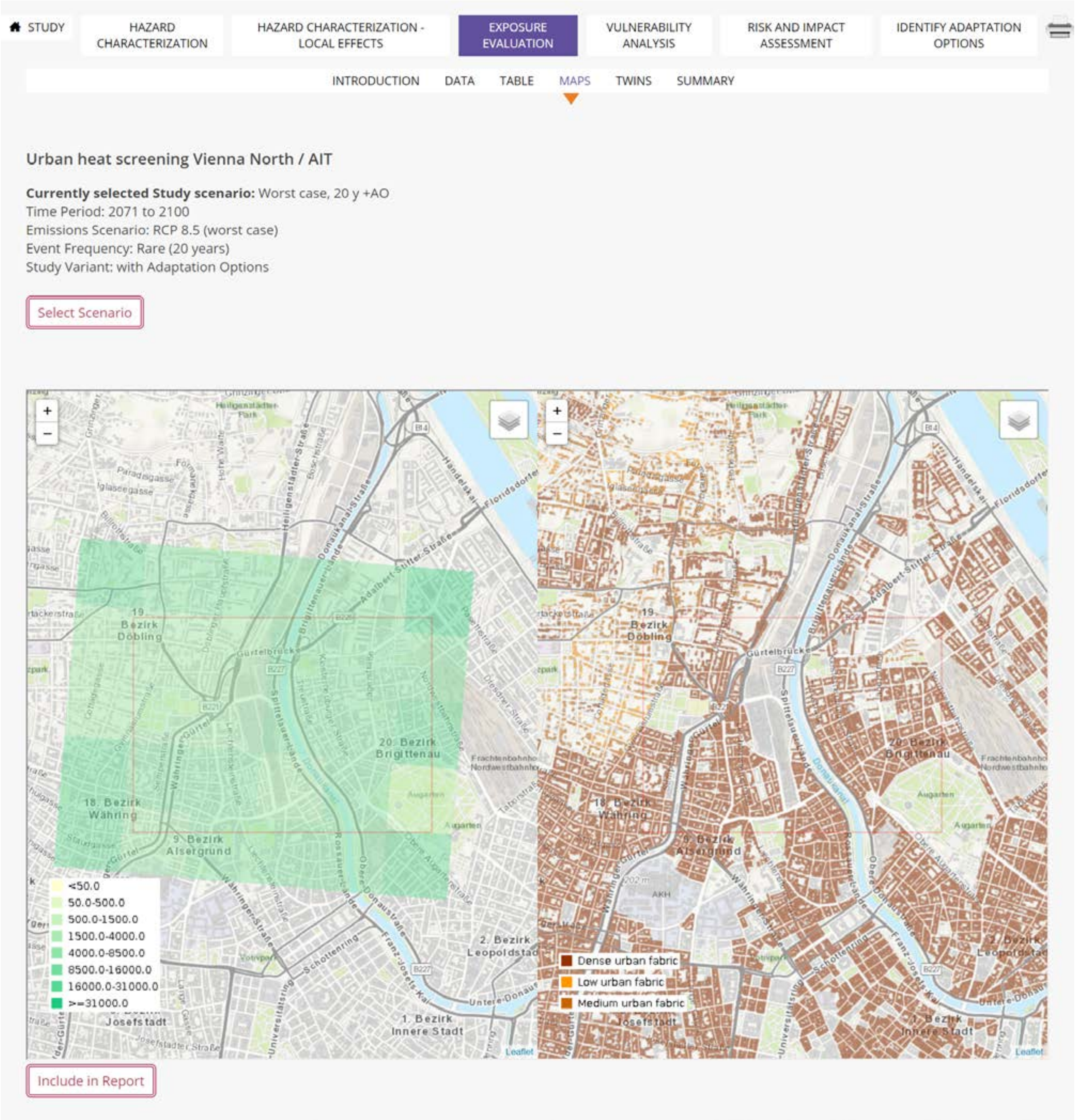


Figure 25: Exposure Evaluation – Maps

Twins tab (Figure 26) is similar to one from the Hazard characterization step (Figure 16), but filtering is on elements at risk rather than on hazards. Finally, the summary / report section tab is a replica of the ones from previous sections.

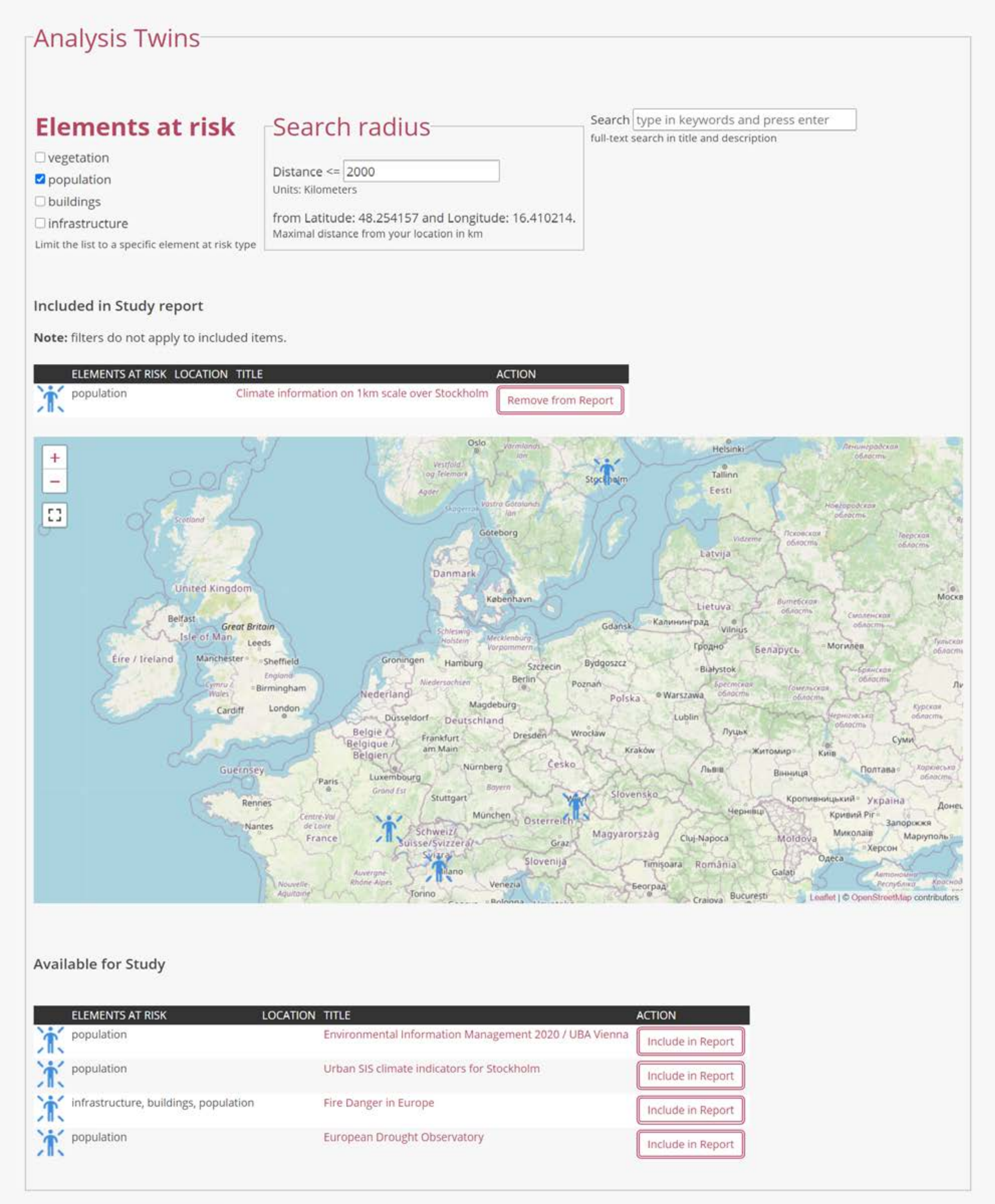


Figure 26: Exposure Evaluation - Twins

2.2.5 Vulnerability Analysis (VA) step

This next section is the **"Vulnerability Analysis"**, which informs the CSIS users about the vulnerabilities of the different "vulnerability classes" of the elements at risk to each of the relevant hazards. This is the simplest of all sections, effectively featuring just the introduction, table and summary/section report tabs.

Vulnerability is a relation between hazard and elements at risk class that indicates what will happen if a certain type of element is exposed to a certain hazard intensity for a certain amount of time. Since our prototype does not foresee the possibility directly influence the vulnerability, this section merely indicates how the vulnerability is calculated. This information is provided in the "table" tab as illustrated in Figure 27.

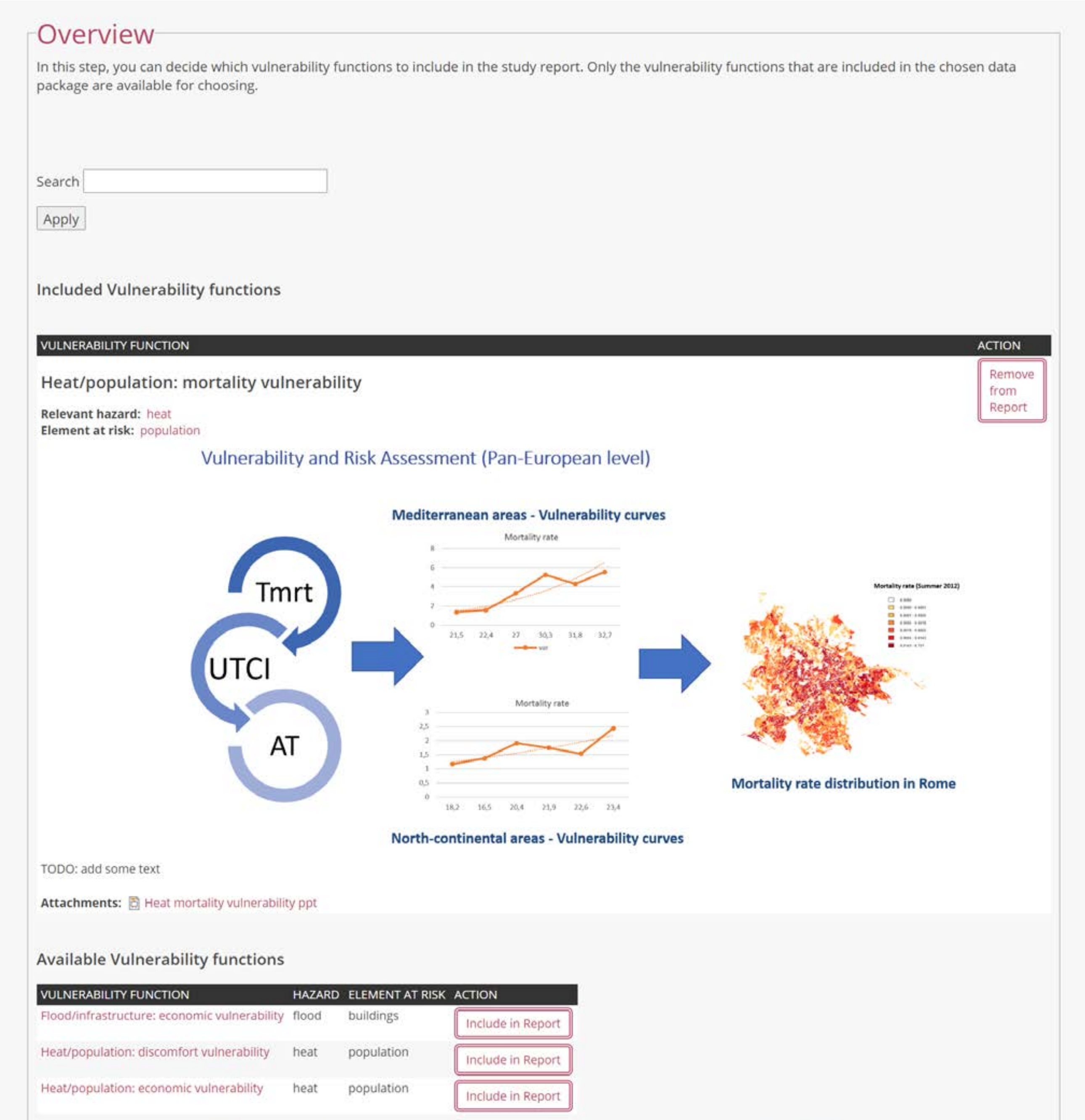


Figure 27: Vulnerability Analysis - Table

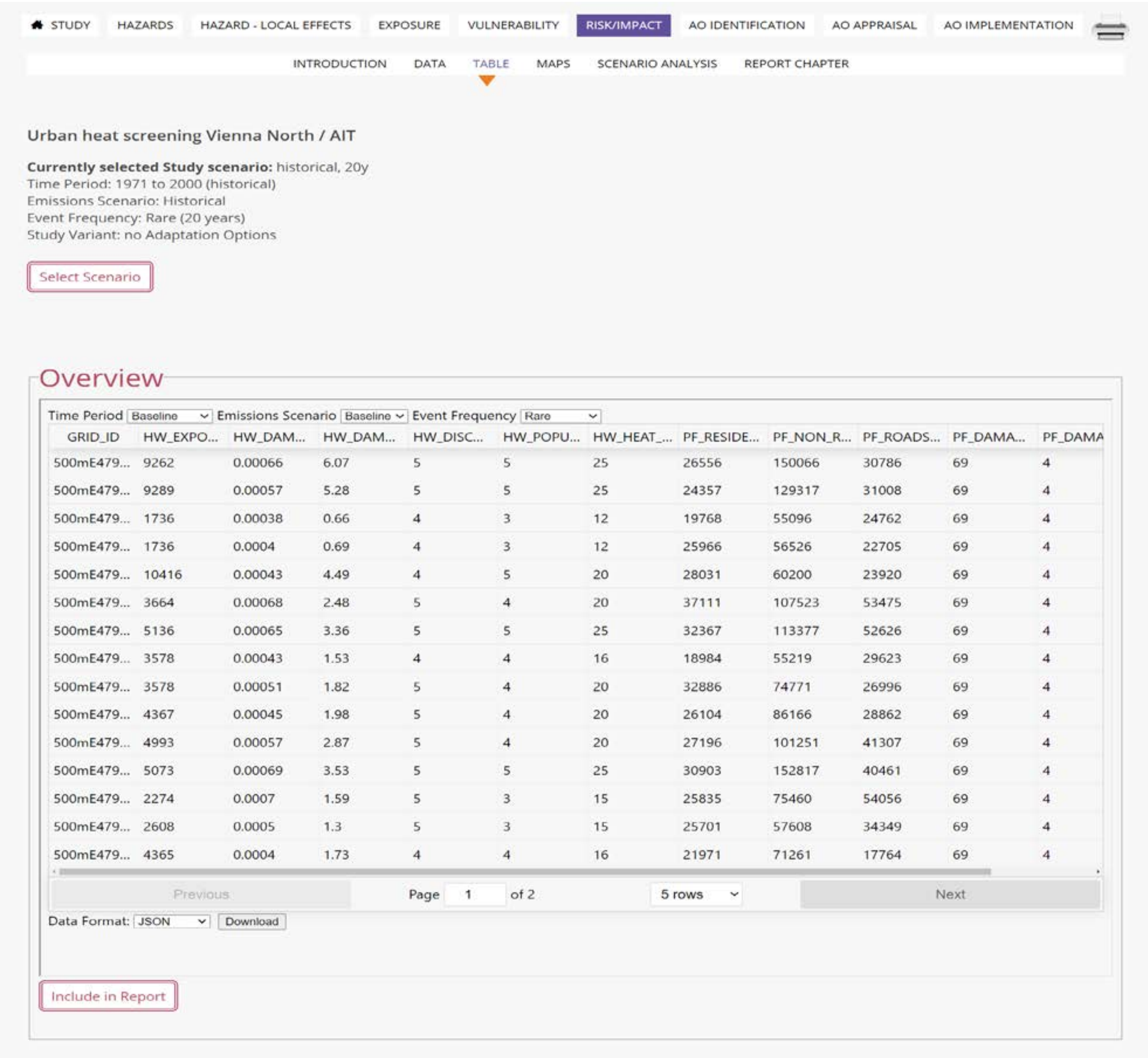
While the consortium did entertain some ideas for allowing the users to change the vulnerability for relevant each element at risk/hazard pair and for each map cell, this idea was deemed too complex for a screening study by the end users.

2.2.6 Risk and Impact Assessment (RA & IA) step

The "**Risks and Impact Assessment"** section provides the users with the information needed to support a decision:

- Which hazard/element at risk combinations are at high, medium or low risk today and in the future?
- What impacts would a specific future extreme weather episode have on different element at risk types?
- What does this mean in terms of expected costs and health effects?
- How does the use of adaptation options change the expected effects?

The introduction, data and summary/section report tabs are very similar to ones in the hazard evaluation and hazard – local effects sections and will not be further elaborated. In addition to these, this section features the usual Table (Figure 28), Map (Figure 29) and a new Scenario Analysis tab (Figure 30).



GRID_ID	HW_EXPO...	HW_DAM...	HW_DAM...	HW_DISC...	HW_POPU...	HW_HEAT_...	PF_RESIDE...	PF_NON_R...	PF_ROADS...	PF_DAMA...	PF_DAMA
500mE479...	9262	0.00066	6.07	5	5	25	26556	150066	30786	69	4
500mE479...	9289	0.00057	5.28	5	5	25	24357	129317	31008	69	4
500mE479...	1736	0.00038	0.66	4	3	12	19768	55096	24762	69	4
500mE479...	1736	0.0004	0.69	4	3	12	25966	56526	22705	69	4
500mE479...	10416	0.00043	4.49	4	5	20	28031	60200	23920	69	4
500mE479...	3664	0.00068	2.48	5	4	20	37111	107523	53475	69	4
500mE479...	5136	0.00065	3.36	5	5	25	32367	113377	52626	69	4
500mE479...	3578	0.00043	1.53	4	4	16	18984	55219	29623	69	4
500mE479...	3578	0.00051	1.82	5	4	20	32886	74771	26996	69	4
500mE479...	4367	0.00045	1.98	5	4	20	26104	86166	28862	69	4
500mE479...	4993	0.00057	2.87	5	4	20	27196	101251	41307	69	4
500mE479...	5073	0.00069	3.53	5	5	25	30903	152817	40461	69	4
500mE479...	2274	0.0007	1.59	5	3	15	25835	75460	54056	69	4
500mE479...	2608	0.0005	1.3	5	3	15	25701	57608	34349	69	4
500mE479...	4365	0.0004	1.73	4	4	16	21971	71261	17764	69	4

Figure 28: Risk and Impact Assessment – Table

Clearly, the table widget provides even more information than the one in the Hazards-local effects step. While a redesign is underway, this tab will mainly be useful for rapid inspection of the data and downloading it for offline analysis by the experts.

Map tab is more interesting for non-experts, as it clearly shows where the hazard will have the highest impact and provides estimates for various impact indices. For example, Figure 29 clearly indicates that heat impact on population is the highest in the densely populated area of the city centre of Linz, despite the industrial area being even warmer than the residential part of the city.

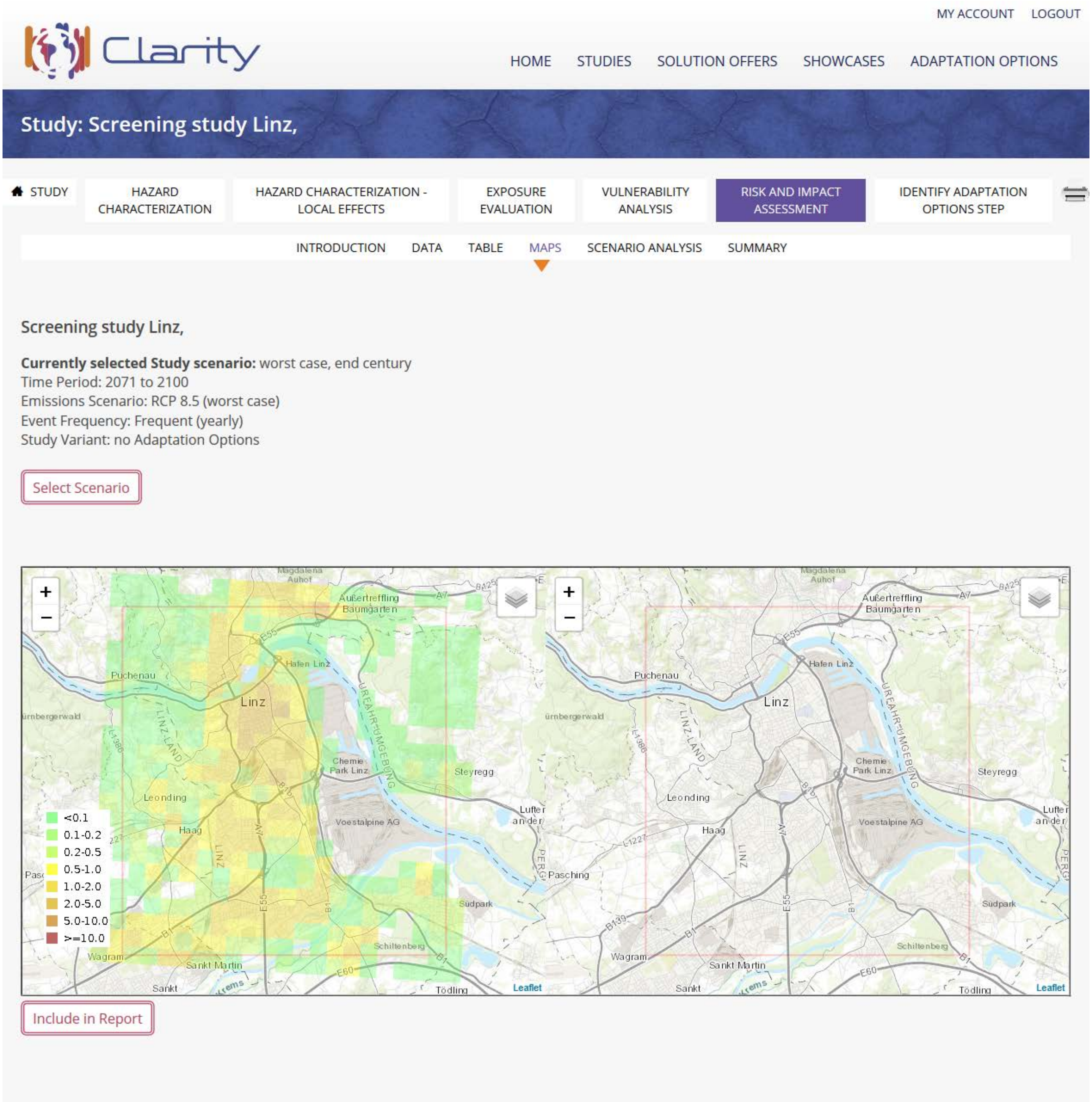


Figure 29: Risk and Impact Assessment – Maps (heat induced excess population mortality in Linz)

Compared to previous sections, Risk and Impact Assessment has an extra feature: the “Scenario Analysis” tab (Figure 30). This tab allows the users to to focus on and displays the analysis of the impact data for the whole study area in table and in chart form for better visualization. Both types of data representation can be included in the report.

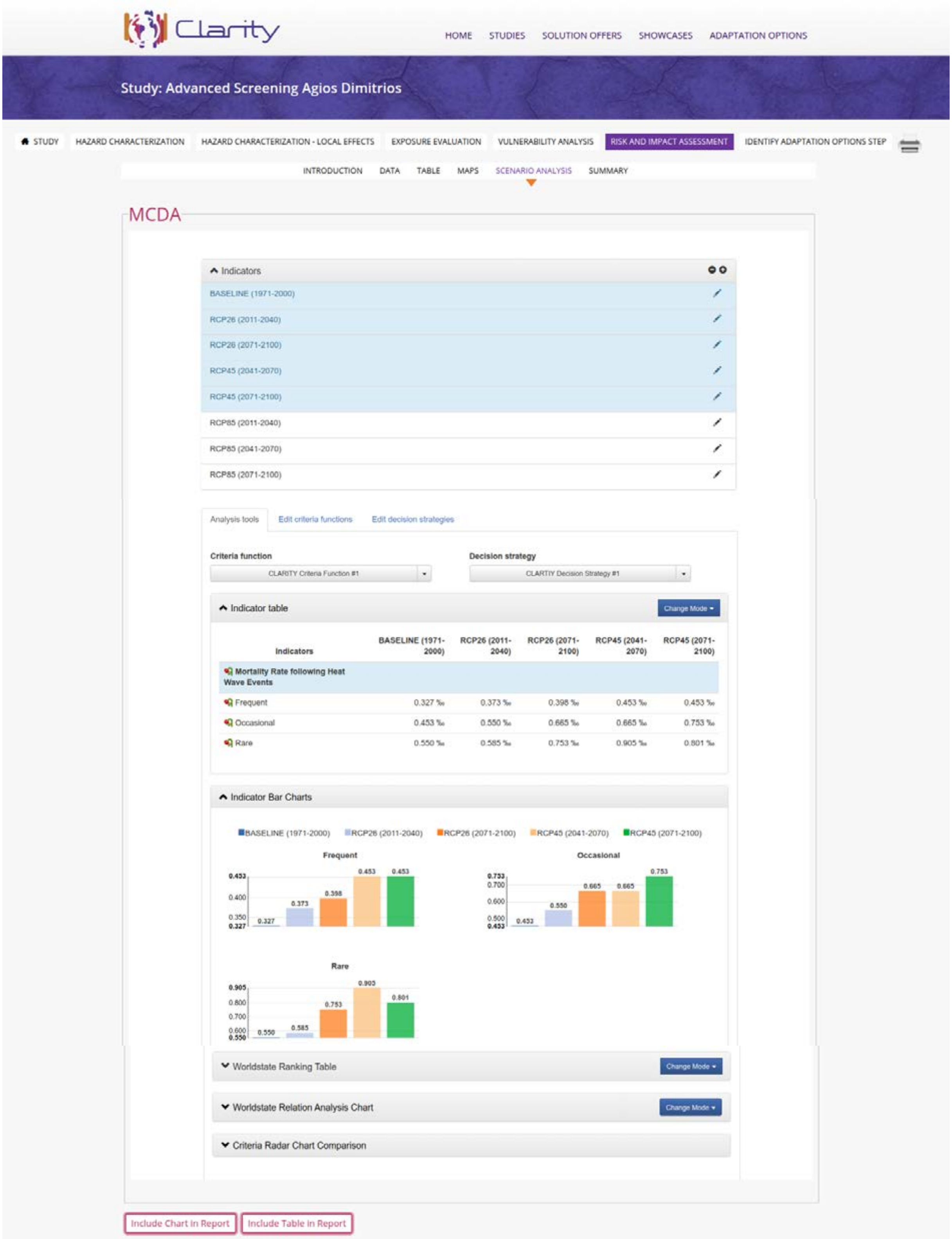


Figure 30: Risk and Impact Assessment – Scenario Analysis (Risk and Impact Indicators)

2.2.7 Adaptation Options Identification (AOI) step

Finally, the users can explore the adaptation options that are relevant to their project. In the initial demonstrator, the adaptation options will be presented just as a way to inform the users of the options they have, their co-benefits and adverse effects (see Figure 31).

In addition to the usual introduction and summary tabs, this step features three new elements: a table of adaptation options (Figure 31); a proof of concept of integrating third party "external" applications in the workflow (Figure 32); and the "adaptation twins" tab (Figure 33) showcasing how the adaptation options that are chosen in the "table" tab are used in the real world. These three features are presented hereafter.

"Table" tab is illustrated in Figure 31. It features a table with a list of available adaptation options that have been defined in the project. Once an adaptation option is selected by the user, following things happen:

1. Full description of selected adaptation option(s) appears at the top of the table (intensive green roofs in Figure 31
2. Real world projects using this adaptation option become available in the twin step (Figure 33).
3. Full description of selected adaptation option(s) is included in the report.

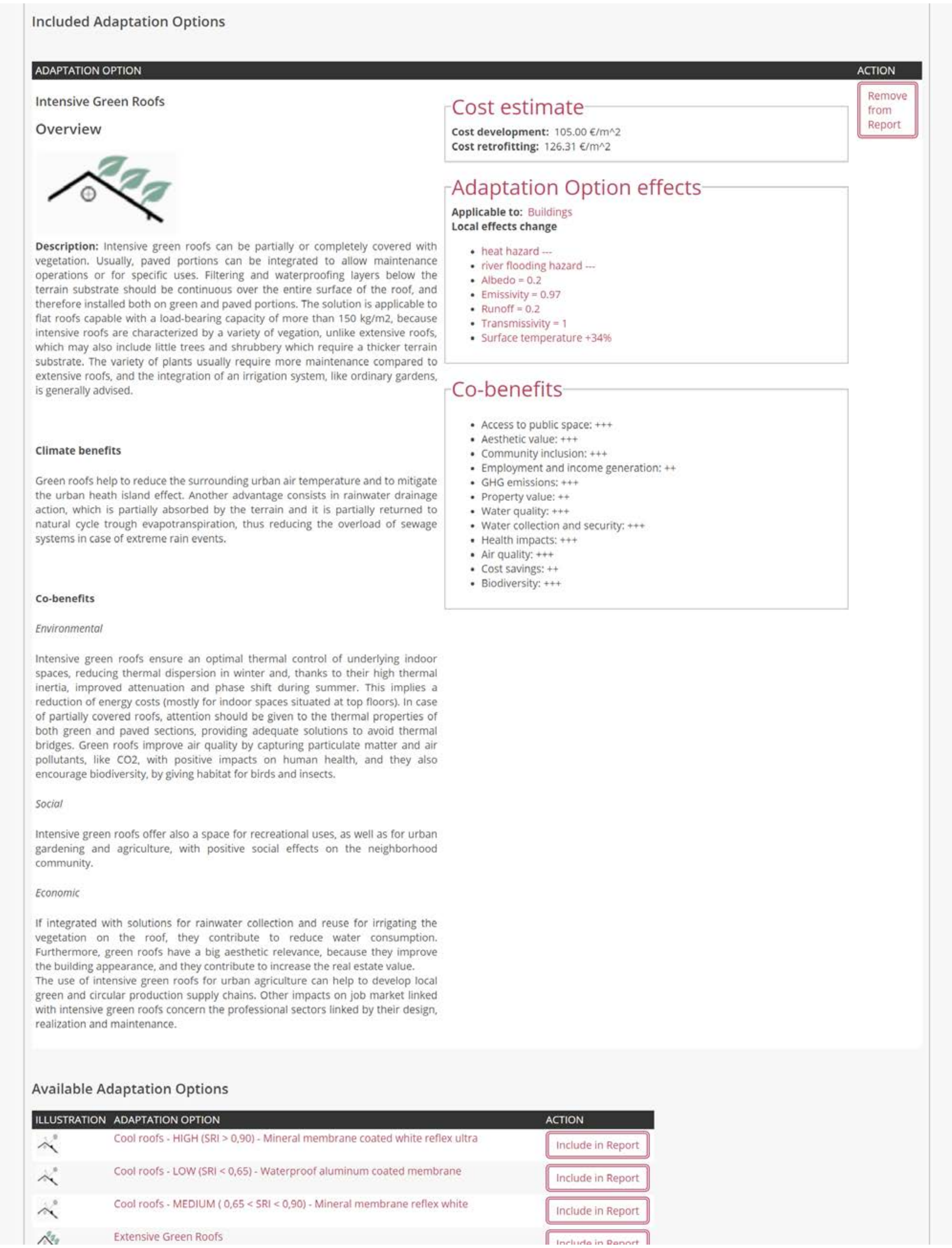


Figure 31: Adaptation Options Identification - Table

“External” tab is illustrated in Figure 32. It allows the users to study the city climate profile dashboard that is published by European Environmental Agency. This tab is mainly meant as a proof of concept illustrating how external applications can be

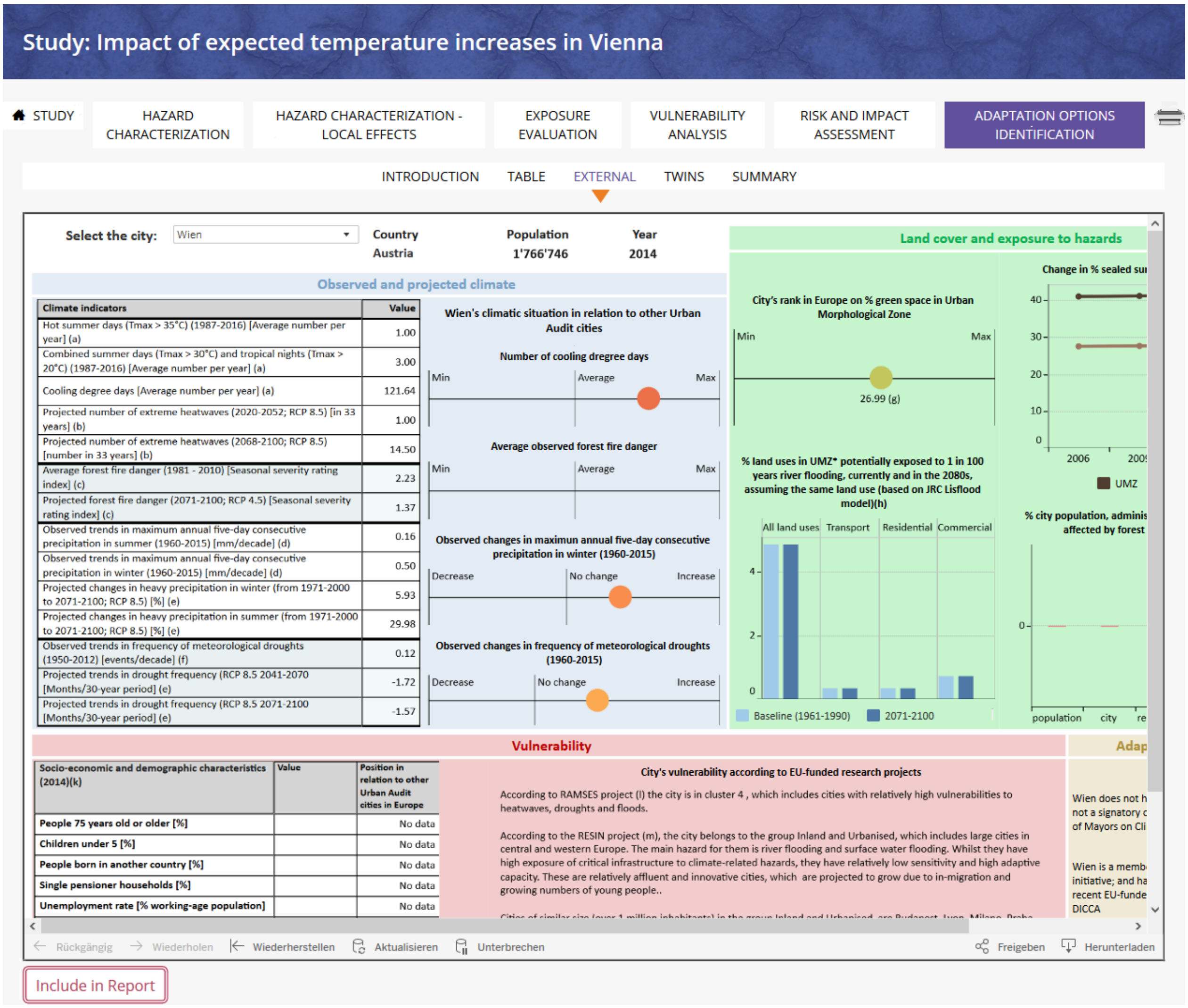


Figure 32 Adaptation Options Identification - External

Finally, the “twins” tab (Figure 33) is similar to previously presented twins tabs in other study steps, with two changes. First, this twin presents the examples of using specific adaptation options in the real world. Second, only the entries corresponding to adaptation options chosen in the “table” step are shown. This is also meant as a proof of concept illustrating the capabilities of the system. So far, the feedback collected is split, with some users liking the feature and others complaining that no examples are shown, which is normal If no adaptation options were selected previously, in the “table” tab.

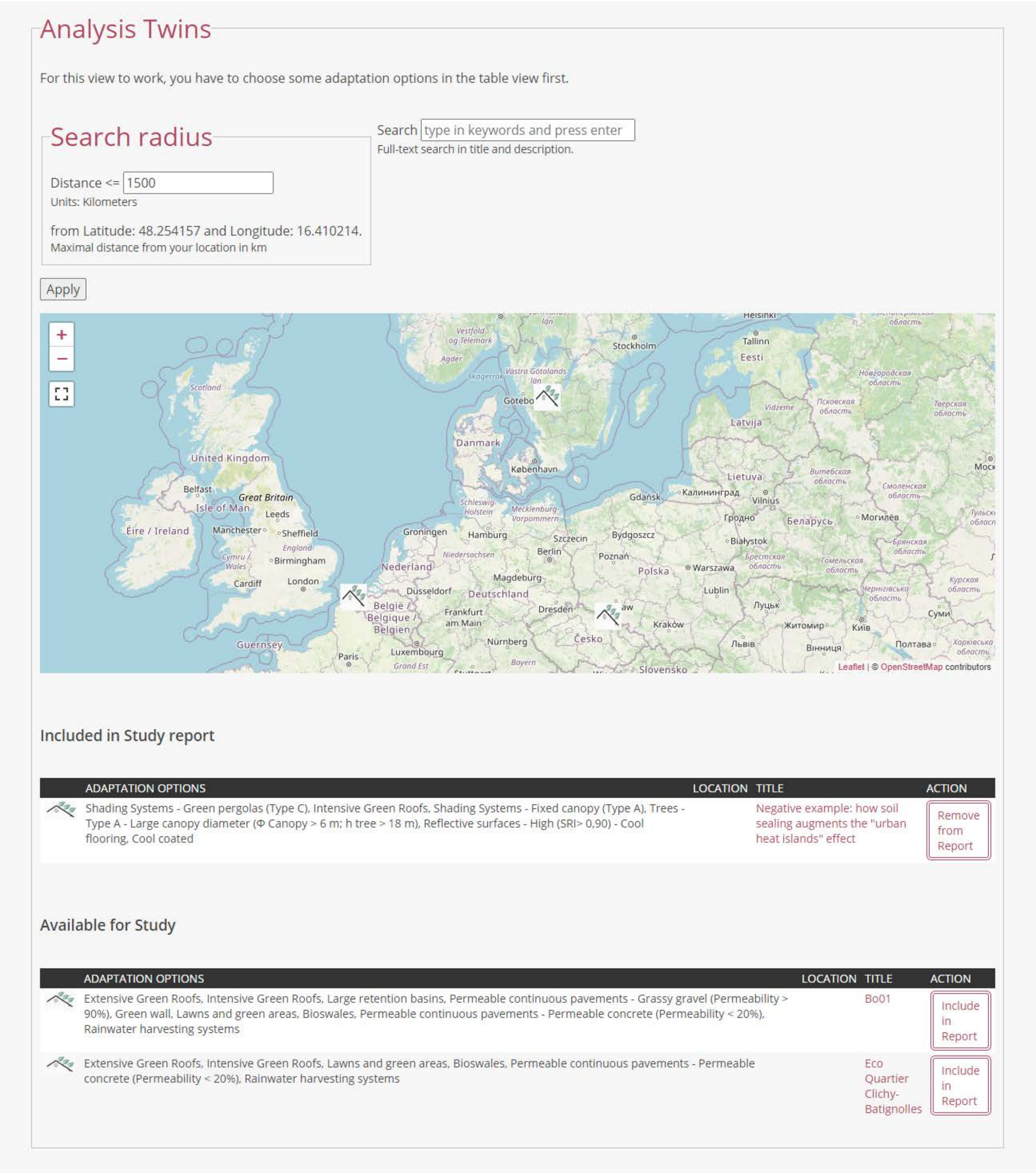


Figure 33: Adaptation Options Identification – Twins

2.2.8 Further developments

At the development server, two more steps have been defined and are currently being tested: the adaptation option appraisal and adaptation option implementation.

The AO appraisal section features a table of pre-defined adaptation strategies that can be applied to four distinct groups of infrastructures: built open spaces, buildings, transport infrastructure and vegetated areas. Each adaptation strategy consists of application of several adaptation options in a sensible way (Figure 34). This simplifies the task of selecting appropriate adaptation options for the users, as compared to our initial idea of users applying the individual adaptation options to the project or to the parts thereof.

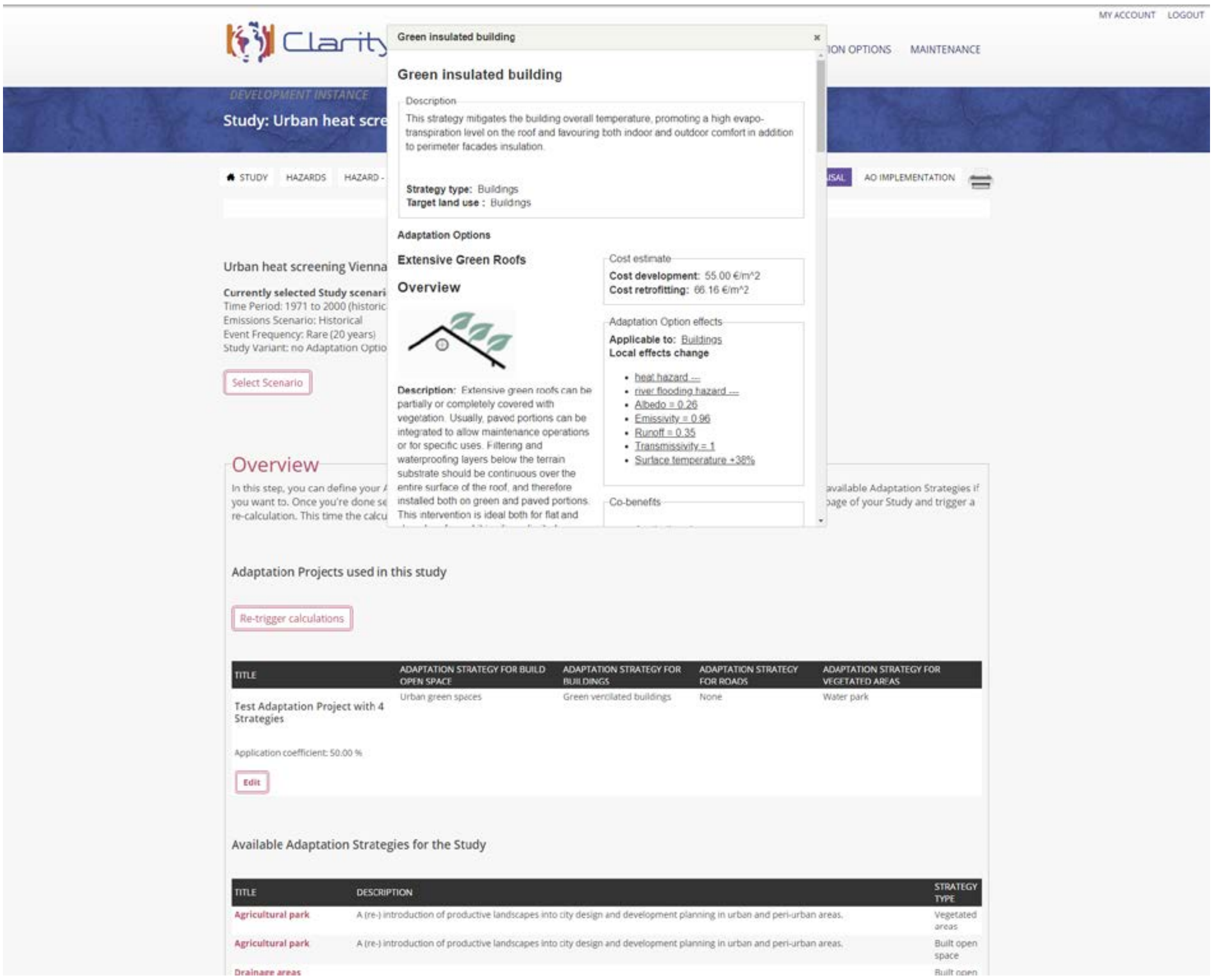


Figure 34: Adaptation Options Assessment – table step

Finally, the Adaptation Options – Implementation step basically duplicates the risk/impact assessment step but allows the side-by-side comparison of the impact with and without the adaptation options. Main motivations for this was to assure that users don't need to return back to the risk/impact assessment step after defining the adaptation strategies and triggering the re-calculation.

2.3 Advanced Screening: Traffic Infrastructure

This case study is oriented to different users of climate services and decision makers for the planning and management of transport infrastructures, as well as for agents involved in infrastructure design and maintenance activities in medium to long term time horizons, or for the forecast of human and material resources in seasonal periods.

Due to its specific particularities, the road and rail demonstration case (Spanish case) has been addressed developing a special adaptation on the CSIS platform. The CSIS needs to connect to an external platform, the Transport Module, to complete most of the process. The workflow is equivalent to the one described previously but the information has to be provided through this external platform that has been embedded in the CSIS.

Login, account creation, study creation, and other tasks related to management are performed on the CSIS as has already been described on the previous section, so this section will focus on the specifics of the Transport Module.

The Transport Module is accessible for the first time when the user has to select the area of study during the first steps of the study creation. Afterwards it will be available, embedded on the CSIS, every time new information needs to be provided or shown to the user.

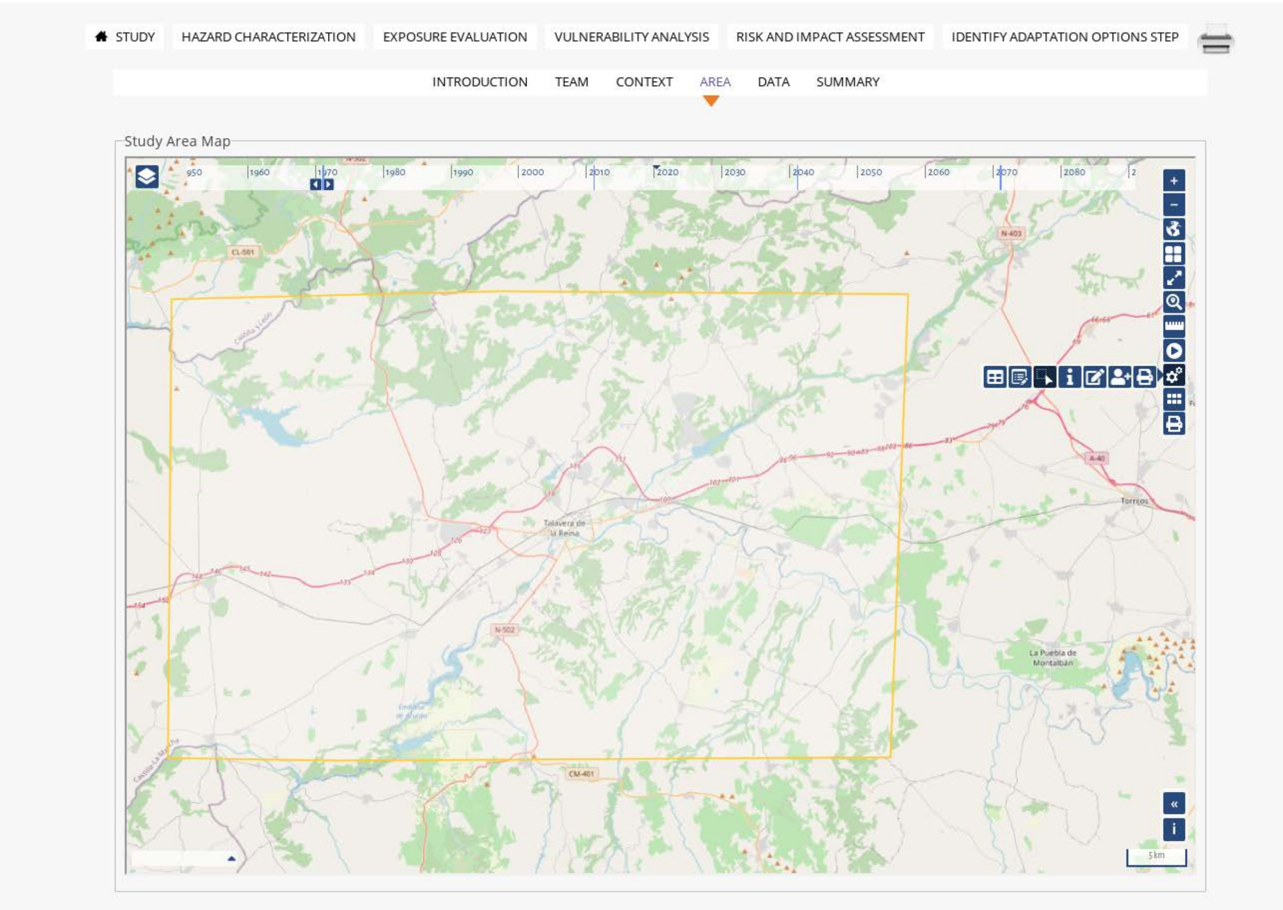


Figure 35: Study Area definition (Spanish DC4)

2.3.1 Hazard Analysis

After the selection of the study area, the user can start the Climate Hazard analysis. For this purpose, the Transport Module offers direct access to a set of climate hazard indicators associated to transport infrastructures. These indicators are provided by AEMet (State Agency of Meteorology in Spain) through the Adaptecca[3] platform and are available for the RCP4.5 and RCP8.5 emission scenarios and for the near (2011-2040), medium (2041-2070) and distant (2071-2100) future.

Firstly, the user can analyse the evolution of the indexes associated with climate hazards for each element created on the Table tab. By selecting the desired variable, the user can view the climate values for each time horizon.

Overview

Select variable: Percentile 95 of daily maximum temperature - rcp85 (ºC)

Element type	Element	2011-2040	2041-2070	2071-2100
Clearance	Terraplén inundable	36.39	38.30	40.71
Engineering structure	Viaducto sobre río Alberche	36.39	38.30	40.71
	Paso arroyo cerca rio Alberche	36.55	38.46	40.86
	Paso supeior Camino del rey	36.55	38.46	40.86
	Puente sobre CM 5001	36.55	38.46	40.86

Figure 36: Hazard assessment for the Spanish demo case

[3] To consult the metadata of the climate indicators click here: http://escenarios.adaptecca.es/info

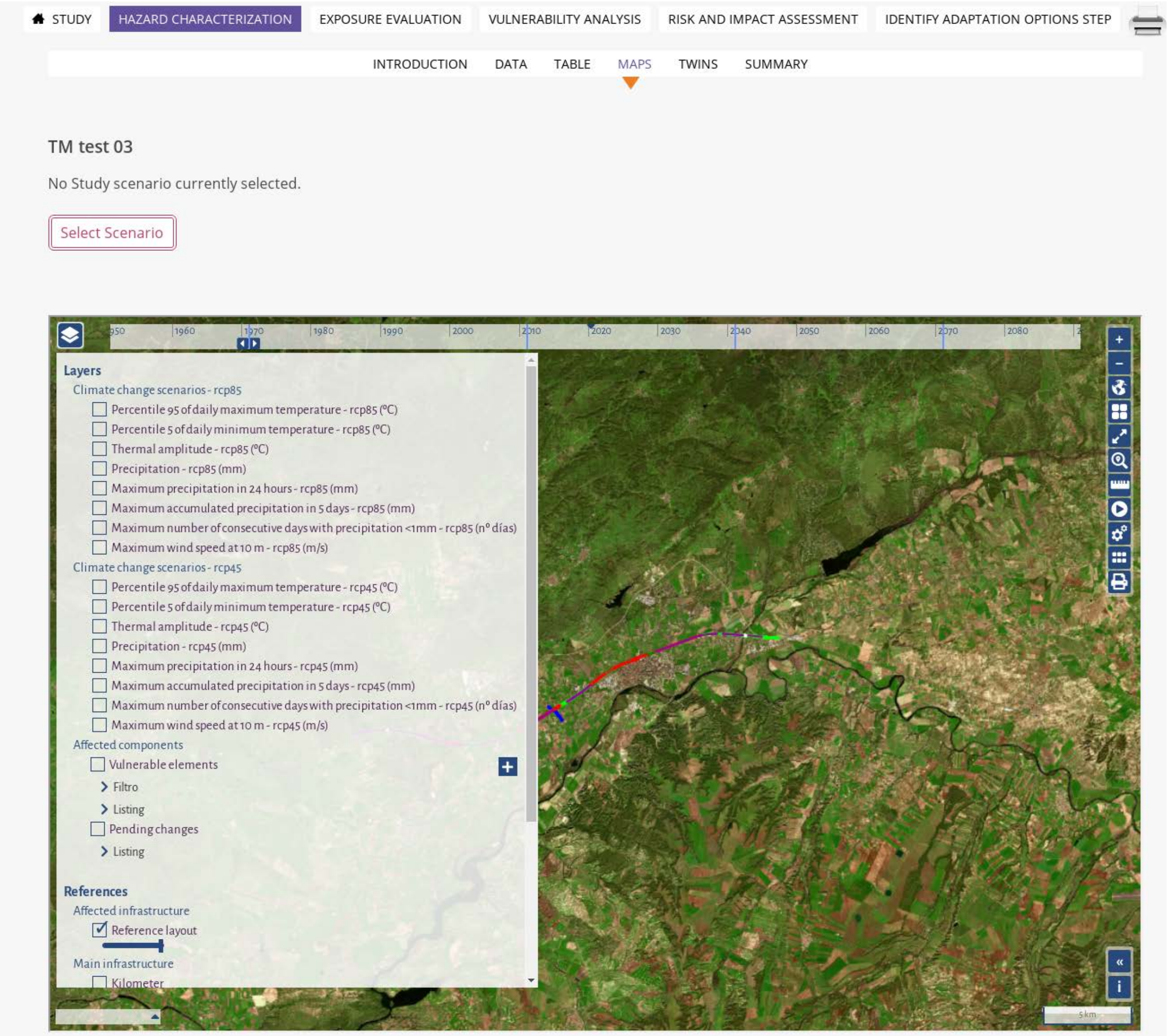


Figure 37: Hazard assessment for the Spanish demo case

In the Transport Module environment, the following functionalities are available:

- Select the indicator(s) the user wants to display for the area of study and the emission scenario associated with each indicator through the options available in the menu on the left side bar.
- Select the time period (near, medium or far future) through the time bar at the top of the Saver content window. This selection is dynamic, i.e., the user can view the changes of the indicator as they move through the time bar.

By default, the layer shown by the system corresponds to the historical or starting period. The system offers the possibility of displaying the indicator for the short, medium and long term through the time bar located at the top of the window. To do so, the user must click on the date they want to show in the time bar and the system will show the future indicator for the previously selected climate and CPR variable.

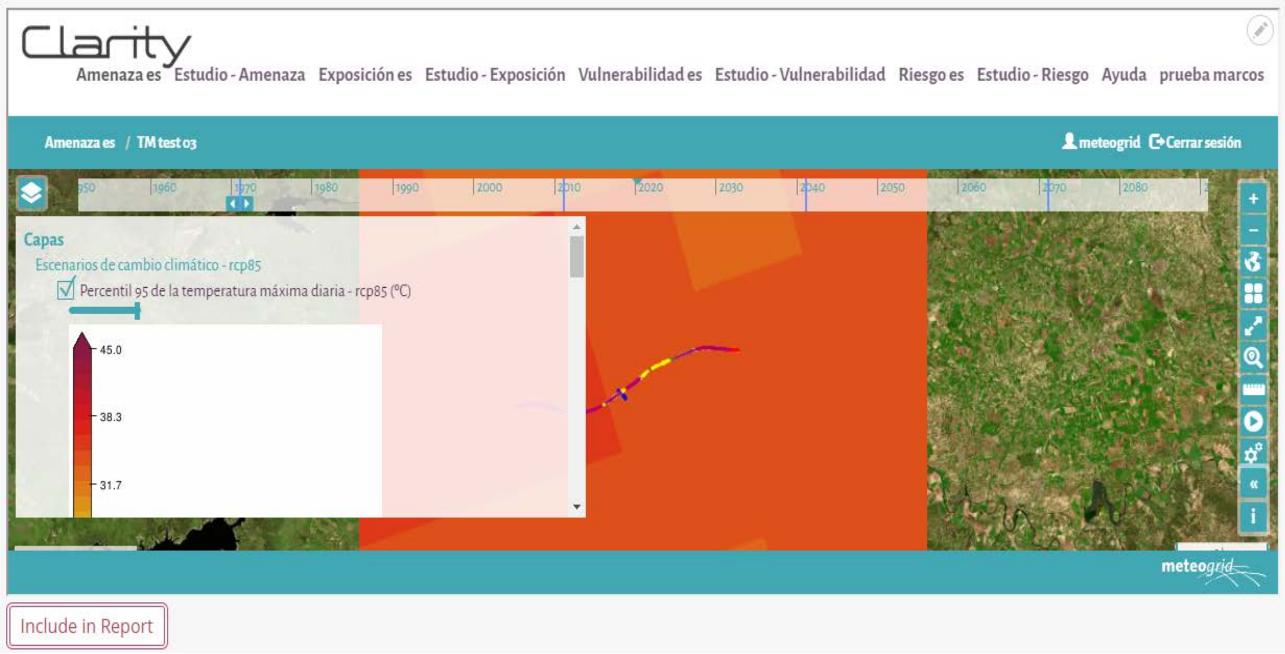


Figure 38: Visualization of climate hazard indicators

The system also incorporates options for displaying and selecting hazards for the current time, for example, by flooding for different return periods. In this case, it is not an indicator of threat, but rather the representation of the threat of flooding from extreme rainfall for the current conditions. The map shown in the system is the official map of return periods maintained by the Spanish Ministry of Ecological Transition. For the European case, it will be possible to visualize the threat of rainwater flooding obtained by the Austrian Central Institute for Meteorology and Geodynamics -ZAMG- (Zentralanstalt für Meteorologie und Geodynamik) within the framework of the CLARITY project. In this case, it shows the evolution of the threat along the different horizons for the 21st century.

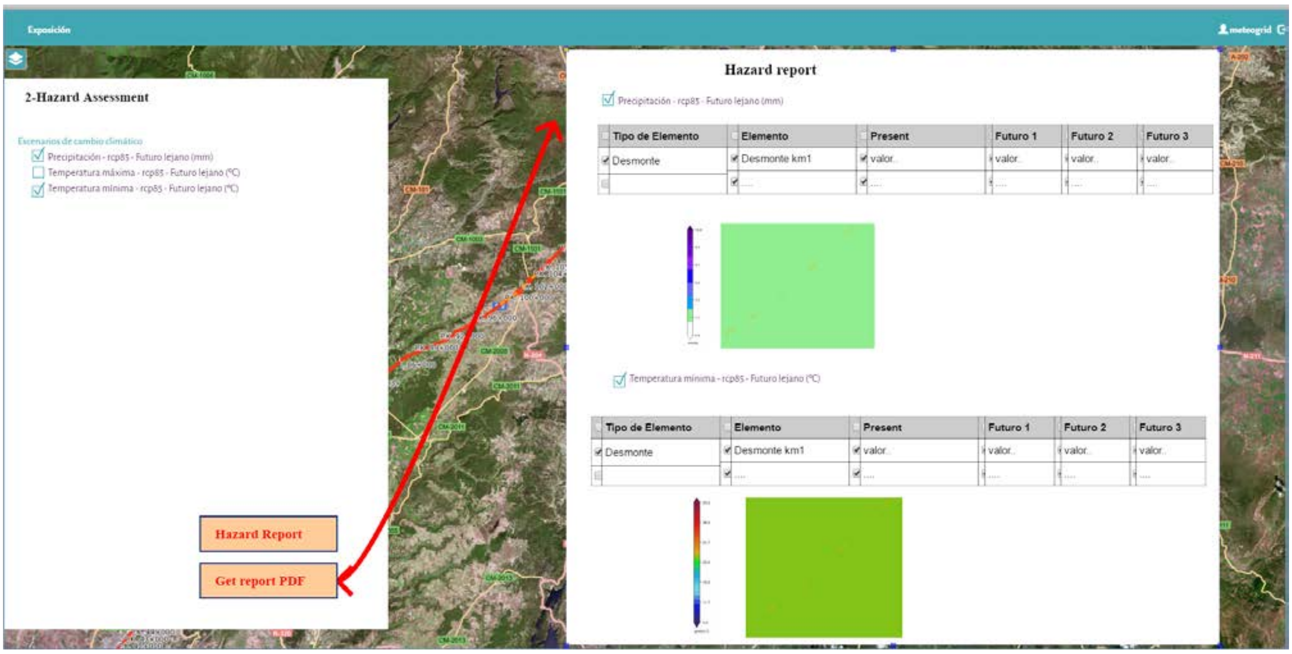


Figure 39: Hazard report generation

2.3.2 Exposure Analysis

The next step for the user will be the exposure analysis.

This module attempts to identify the elements exposed to potential hazards that may affect each case, also considering the incidence of the phenomenon on traffic flow or circulation conditions. The analysis tool offers the possibility of selecting which road components are likely to be affected by climate hazards in order to obtain impact and vulnerability results. The exposed elements (in relation to potential hazards) considered in the system are listed below:

- Land slide and erosion and slope fall;
- Structural movements in the structure due to the presence of water
- Insufficient capacity of drainage works due to heavy rainfall;
- Insufficient capacity of the drainage works due to heavy rains;
- Insufficient carrying capacity due to the presence of water in the pavement;
- Pavement in heat as a result of high temperature;
- Insufficient drainage capacity of the road surface as a result of heavy rains;
- Effect of snow on a section of road traffic;
- Effect of ice on a section of road traffic;
- Effect of snow on a section on road traffic
- Effect of forest fires on a road traffic section
- Effect of fog on a section of road traffic.

By default, in the Transport Module, all types of infrastructure elements are active when a study is started. By starting the exposure analysis, the user can:

- Deactivate those element types that are not needed to be displayed.
- Select and create the elements to analyse through the (+) option available in the upper right margin of the content window.

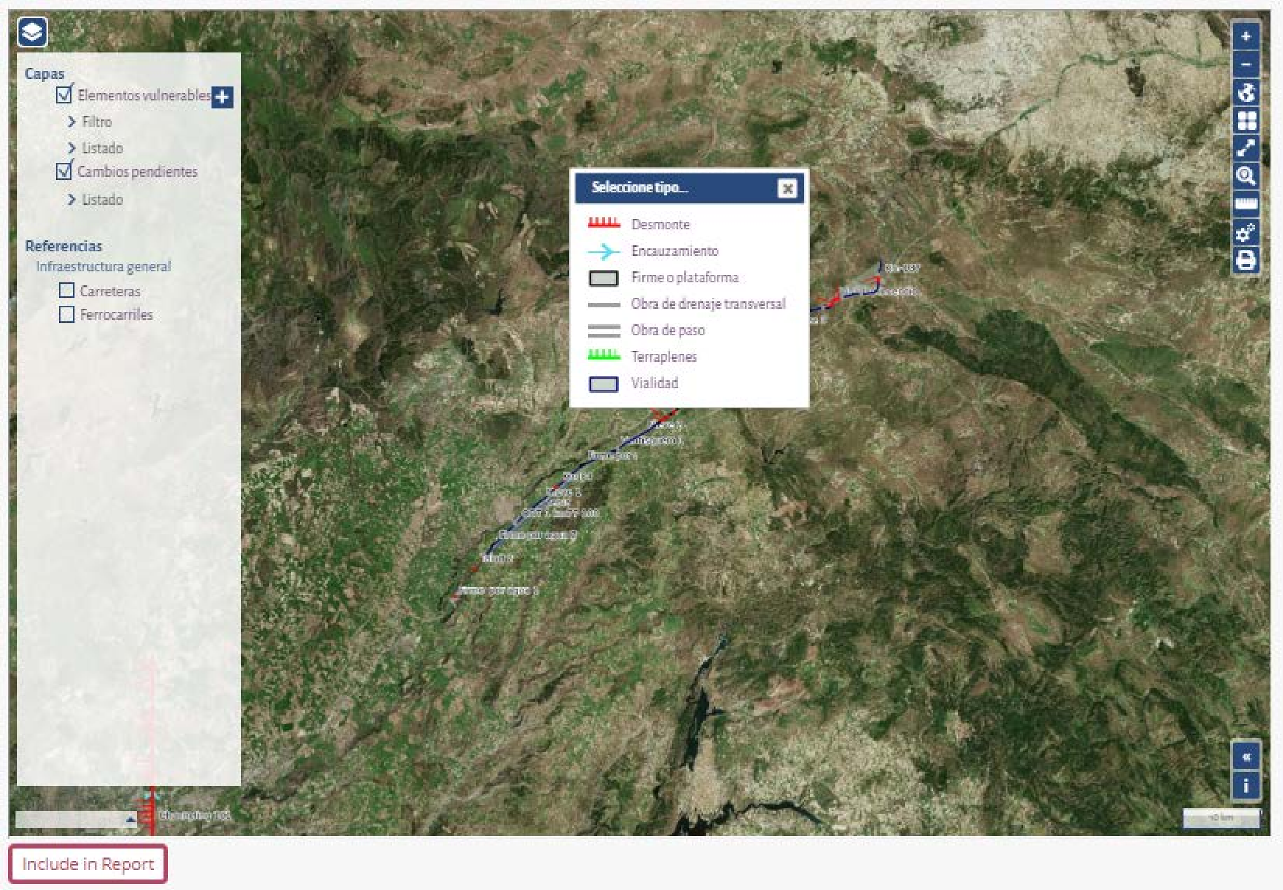


Figure 40: Creation of elements to assess the exposure on the Spanish demo case.

The Transport Module then displays a new content window with descriptive attributes that the user must edit through a series of default fields:

- General descriptive fields: name, address, comments
- Threat selection fields. The Transport Module shows by default the threat that, in general, is associated to the selected element type. However, it allows other threat options to be selected at the discretion of the user performing the analysis. To do this, the user must use the drop-down menu and select one of the available options.
- Analysis fields for the severity and probability of damage to components: (1) element integrity and (2) circulation conditions for each analysis period. To complete these attributes, the Transport Module offers the quantification options through a new drop-down menu.

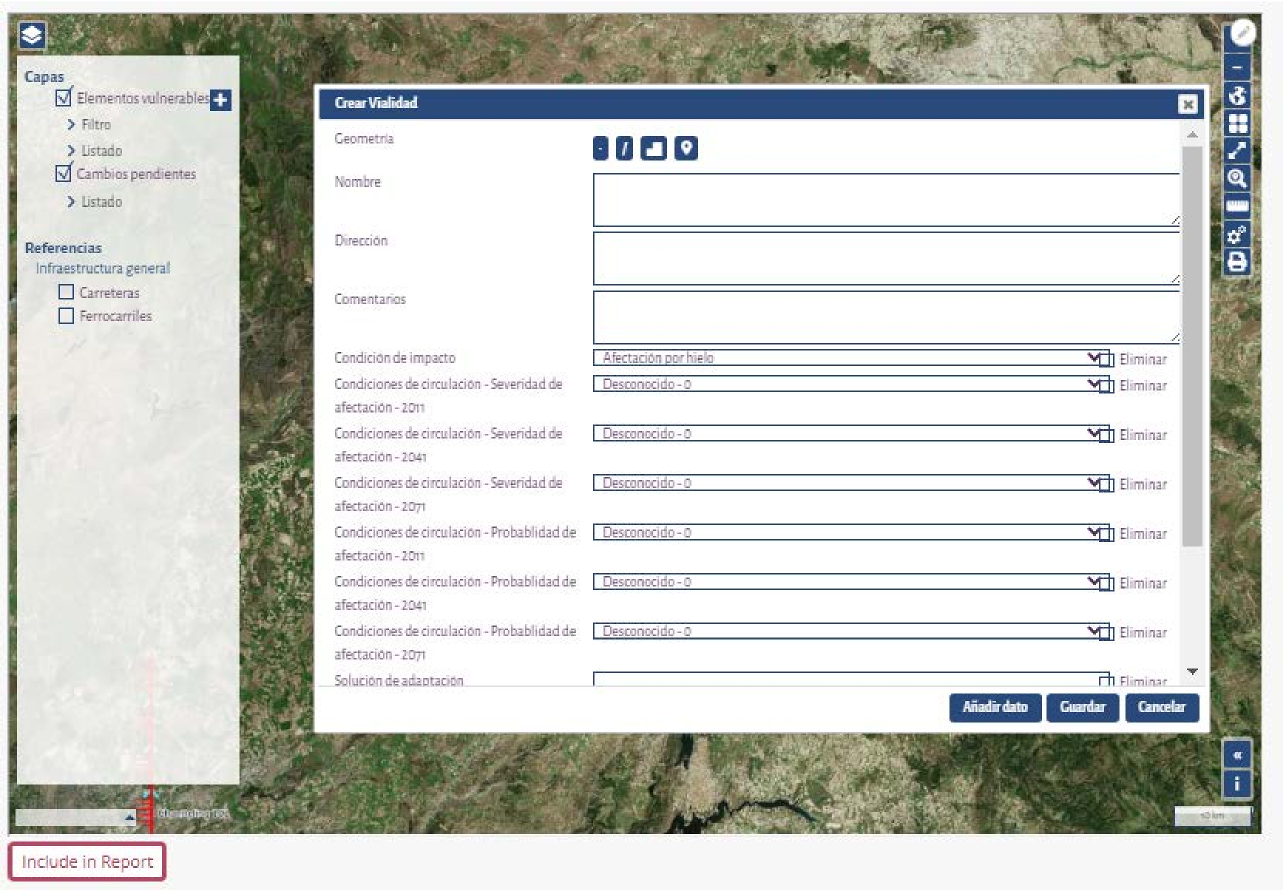


Figure 41: Exposure assessment - Options of Spanish demo case

The user can then perform the following actions: (1) deactivate and activate the elements of interest, (2) modify elements, (3) create new elements, (4) display a report with the elements of interest in table form.

As in the case of the Hazard Analysis, the user can access the data on the Table tab. This table shows a summary of the elements exposed classified by typology together with information associated with the most representative attributes for their characterization. There is an option to select scenarios but this is not available for transport studies at the moment.

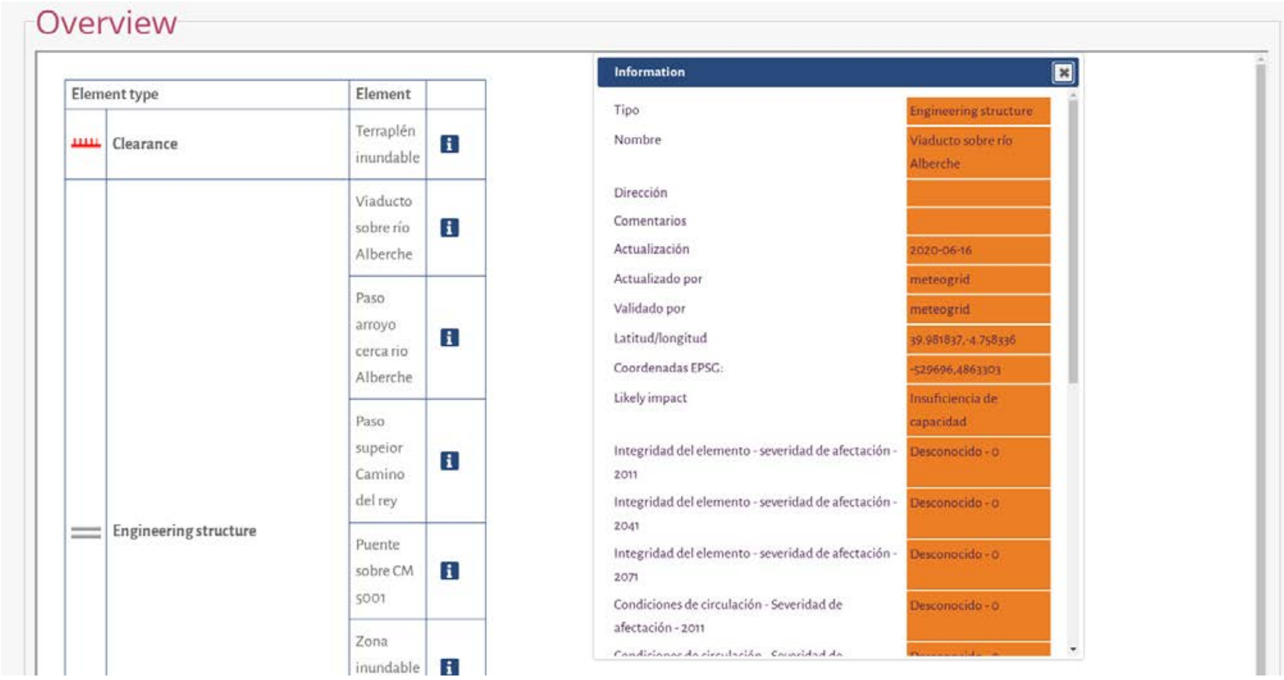


Figure 42: Exposure assessment – Summary of exposed elements

2.3.3 Vulnerability study

Once the current and future climatic conditions in the Study area are known, and the main potential hazards for each element of the study are identified, the vulnerability assessment can be initiated. The vulnerability assessment for each element (or grouping of elements) will be carried out from a double perspective: first, the danger to its integrity or severity of damage will be assessed, and then the danger that such loss of integrity may pose to traffic conditions. Based on this data in both cases, the level of risk will be characterized by combining the severity of the possible consequences of the impact in the event that it occurs, with the probability that this impact will occur.

• Severity of affectation: The assessor shall estimate for each element at risk (or grouping of elements at risk) the maximum foreseeable level of affectation of each selected threat (except for hazards that refer to the Roads component). For each threat and element (or group of elements), the assessor will estimate the current and the foreseeable potential level of impact over 30 and 80 years. The assignment of one level of impact or another to the elements in question will be made on the basis of the expert judgement of the assessor, taking into account the characteristics of the element and the current variability and expected evolution of the climatic events in the area. The scale for characterising the severity of the impact on the integrity of the road elements is shown below.

Non-existent	Reduced	Moderate low	Moderate high	Remarkable	Important
The effect on the integrity of the element is null or irrelevant, and does not require action.	The effect on the integrity of the element is reduced and its resolution is compatible with routine maintenance actions.	The effect on the integrity of the element is moderate, and requires a modest and timely repair and/or replacement.	The effect on the integrity of the element is moderate, and requires a modest but widespread repair and/or replacement.	The effect on the integrity of the element is remarkable and significant. Its repair requires specific rehabilitation/reconstruction of the element.	The effect on the integrity of the element is important, and can even be total. Its repair requires a generalized rehabilitation/reconstruction of the element.

In order to assess the current level of affectation of an element of the infrastructure, it will be necessary to take into account the stage of development in which it is found. In the case of elements that have been recently designed in accordance with the technical regulations in force and have not yet been built, it may be assumed that the current level of involvement is non-existent or reduced. Once built, the level of effect on the element will depend not only on the design criteria used, but also on the time that has elapsed since it was built, the actual conditions in which the work is carried out and the conditions in which it has been maintained since then. In these cases, the evaluator should estimate the current level of affectation by incorporating the experience that - about the behaviour in front of the climatic events - the road manager has been able to accumulate since its commissioning. In the case of elements for which such experience is not available (e.g. recently constructed elements), it should at least be verified whether there has been any substantial change in the technical design rules since the element was designed and, if so, what consequences such a change may have on the current foreseeable level of impairment. This check should also be carried out for those elements pending construction where the time elapsed since they were designed is appreciable.

When assessing the level of future impact, the assessor must consider not only the possible climatic alterations that may occur, but also the effect that the passage of time may have on the ageing of the infrastructure element, and the maintenance, improvement or replacement actions that may be carried out on it throughout its useful lifetime. If the assessor does not specify otherwise during the assessment, it will be assumed that no improvement or replacement actions are undertaken during the time horizon covered by the assessment. As a rule, the maintenance conditions of the infrastructure shall be assumed to be constant over time and at a level comparable to the usual practices at the time of the assessment.

• Probability of affectation: The assessor will then characterise the probability with which it is considered that the impact associated with the level of severity assumed can occur. To do so, the assessor will use the scale shown in the table below. The assignment of one probability or another of impairment to the item in question will again be based on the assessor's expert judgment, taking into account criteria similar to those described for rating the severity of impairment. The scale for characterising the probability of affecting the integrity of the road elements is shown below:

Very unlikely	Unlikely	Possible	Probable	Very probable
The affectation of the element is null or very improbable (<5%)	Affectation of the element is unlikely (≈2%)	Affectation of the element is possible (≈50%)	Probable The element is likely to be affected (≈80%)	Very likely The affectation of the element is very probable (95%)

The probability of occurrence should be estimated by the expert carrying out the study based on their experience and on the climate indices provided by the system in the "Analyze Hazards" section.

In summary, this module attempts to analyse the probability of an element experiencing a level of damage in response to a hazard event of given intensity by applying expert judgement or value judgement. Vulnerability is determined through two basic parameters:

- Severity. Affected level according to a pre-established scale of values: non-existent (0), reduced (1), moderate low (2), moderate high (3), notable (4) or important (5)
- Probability of affectation. The probability by which it is considered that an affectation may occur according to a predetermined scale of values: very unlikely (1), unlikely (2), possible (3), probable (4) or very probable (5).

These parameters can be evaluated, in turn, for two main properties or additional parameters:

-Element integrity refers to the functional and structural state of the road component that allows an adequate use for the purpose for which it is installed or built.

-Traffic conditions refer to the set of phenomena of different nature (meteorological, service or functional) that influence and determine the mobility or flow of vehicles.

The Transport Module allows to:

- Visualize the vulnerability values (affectation probability and severity) for each analysed element and for the two study parameters: (1) circulation conditions and (2) element integrity. These values have been characterized by the user under expert criteria in the previous step.
- Modify the values of severity and probability of affectation and display the final values for each element and time analysed and for the 2 analysis parameters.

The analysis is carried out for the element's integrity and for the circulation conditions according to two criteria; severity and probability of affectation. To do this, the user must access the "Overview" Transport Module window and select the default values through the drop-down menu that appears. Finally, the user must "Send" to save the changes and values introduced in each case, located in the lower left margin of the Transport Module window.

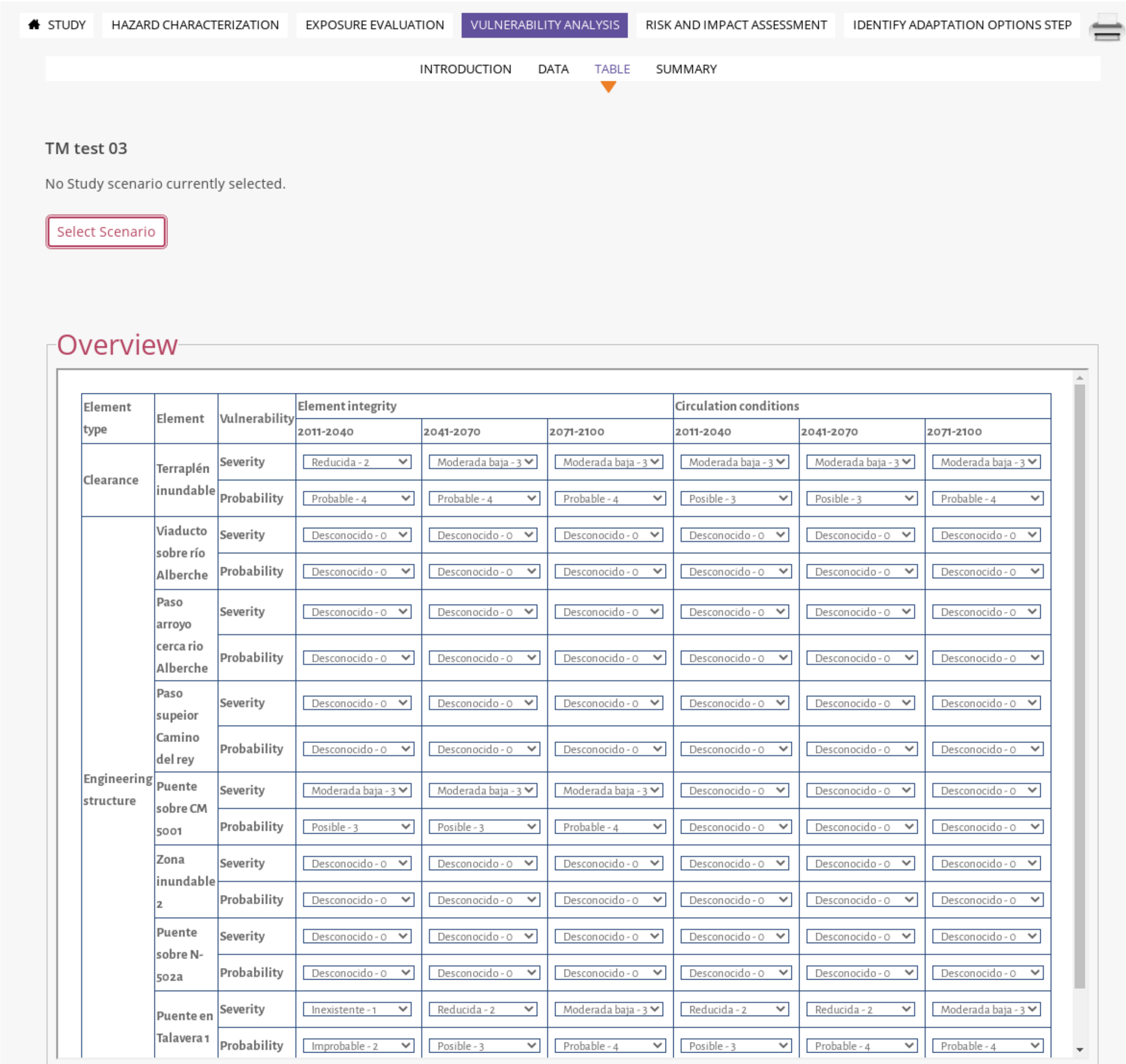


Figure 43: Vulnerability assessment on theSpanish demo case.

2.3.4 Risk and Impact Assessment

Finally, the Transport Module automatically calculates the risk associated with each element, in the periods of study and in the perspective of element integrity and circulation conditions. The level of risk is automatically calculated in the system by combining the possible level of affectation with the probability of occurrence of that type of event based on a double perspective: (1) the integrity of the element and (2) the traffic conditions; except for those hazards that affect only the traffic conditions and not the infrastructure itself.

Under the Table tab, the user is able to quantify the climate risk for each exposed element under expert criteria and in a tabular way. This analysis is carried out for the integrity of the element and for the circulation conditions in each time horizon. To do this, the user must access the "Overview" window of the Transport Module. The Transport Module shows the user the results of the risk resulting from the automatic integration of the values of severity and probability of affectation for each element analyzed (provided by the user in the previous "Vulnerability Assessment").

Overview

Element type	Element	Element integrity			Circulation conditions		
		2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Clearance	Terraplén inundable	Despreciable	Bajo	Bajo	Despreciable	Despreciable	Bajo
Engineering structure	Viaducto sobre río Alberche	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0
	Paso arroyo cerca rio Alberche	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0
	Paso supeior Camino del rey	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0
	Puente sobre CM 5001	Despreciable	Despreciable	Bajo	Desconocido - 0	Desconocido - 0	Desconocido - 0
	Zona inundable 2	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0
	Puente sobre N-502a	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0	Desconocido - 0
	Puente en Talavera 1	Despreciable	Despreciable	Bajo	Despreciable	Despreciable	Bajo

Figure 44: Risk assessment of Spanish demo case, table .

The user can also visualize the elements on the map with the final climate risk values for each moment analysed and for the two analysis parameters. The Transport Module will automatically display the analysed elements on the map with an associated colour legend according to their resulting risk level.

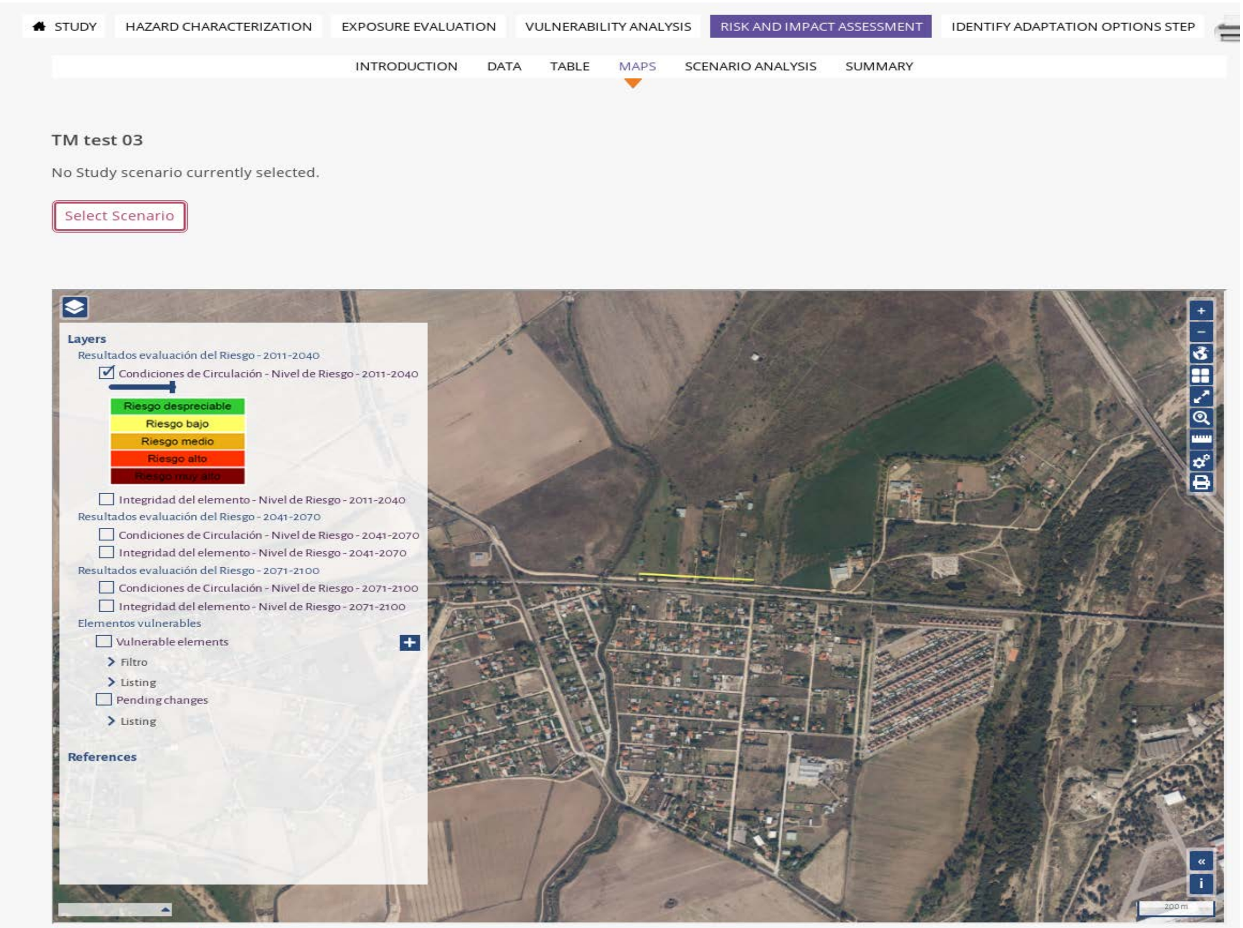


Figure 45: Risk assessment of Spanish demo case.

1.1 2.3.5 Report generation

The CSIS has the possibility of creating a custom Report for each Study. This Report uses the information available for the Study in terms of descriptions and general information, as well as the information available through tables and maps. As the Transport Module is an external tool, the information contained within it cannot be accesses or added to the report using the **Include in Report** button that it is available on most of the tabs on the CSIS.

For transport studies the option to generate a report that includes the data from the Transport Module is made available in the CSIS clicking on the **Printer Icon** available on the right side of the tabs.

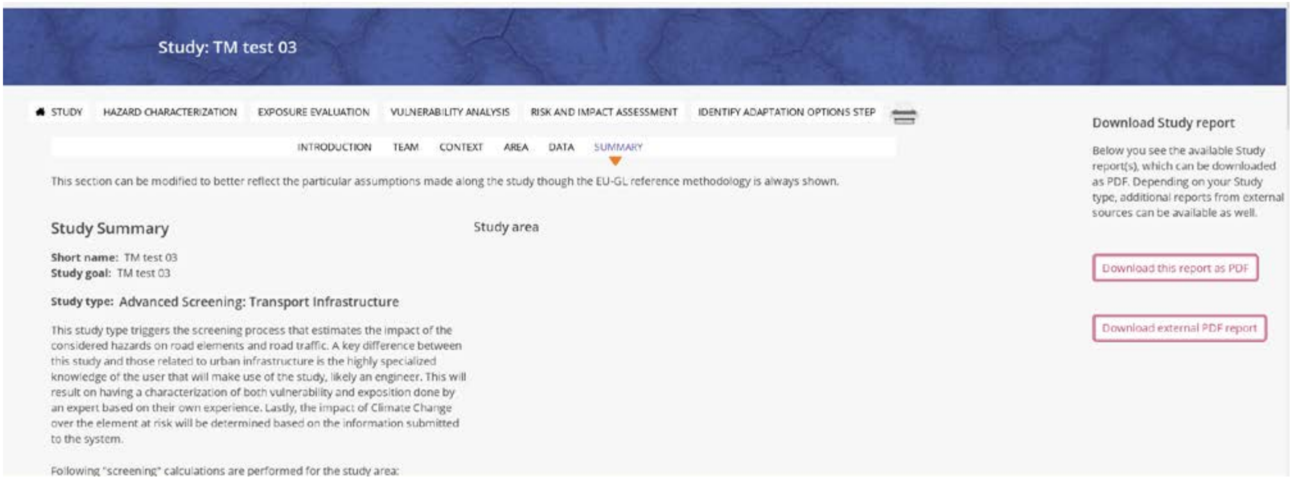


Figure 46: Report generation.

There are two options to get a report:

- Download this report as PDF will produce the report generated by the CSIS.
- Download external PDF report will get the report produced by the Transport Module.

3 Datasets and information models used in the prototype

3.1 Reference Modelling Workflow

The Reference Modelling Workflow describes the technical implementation of the EU-GL/CLARTIY Modelling Methodology (documented in CLARTIY deliverable D3.1 Science Support Plan).

Aligned with the CLARITY adapted EU-GL methodology, in the CSIS prototype workflow tool, at each step, a series of datasets are required in order to present some information to the end-user or to perform certain calculations needed for a further step in the workflow tool.

In that regard, deliverable "D2.2 Data collection report" already made an initial compilation of datasets required at each EU-GL step at European level, and more specifically within each demonstration case (see sections 1. Methodology and 3. Development of the data collection task at screening and DC level).

In addition, deliverable "D3.3 Science support report v2" provides a complete and detailed description on how the various datasets have to be combined in order to produce the information that is required by the CSIS workflow tool (see sections 2. ICT (screening) Services and 3. Expert Services) for each of the DCs.

These detailed descriptions/instructions are used, in parallel to the implementation of the CIS workflow tool, to prepare and produce all required information for the CSIS prototype, covering +500 European cities, and more specifically the four project demonstrator locations, with focus on the heat-wave and pluvial flooding hazards (and their effects over population and buildings and transport infrastructure).

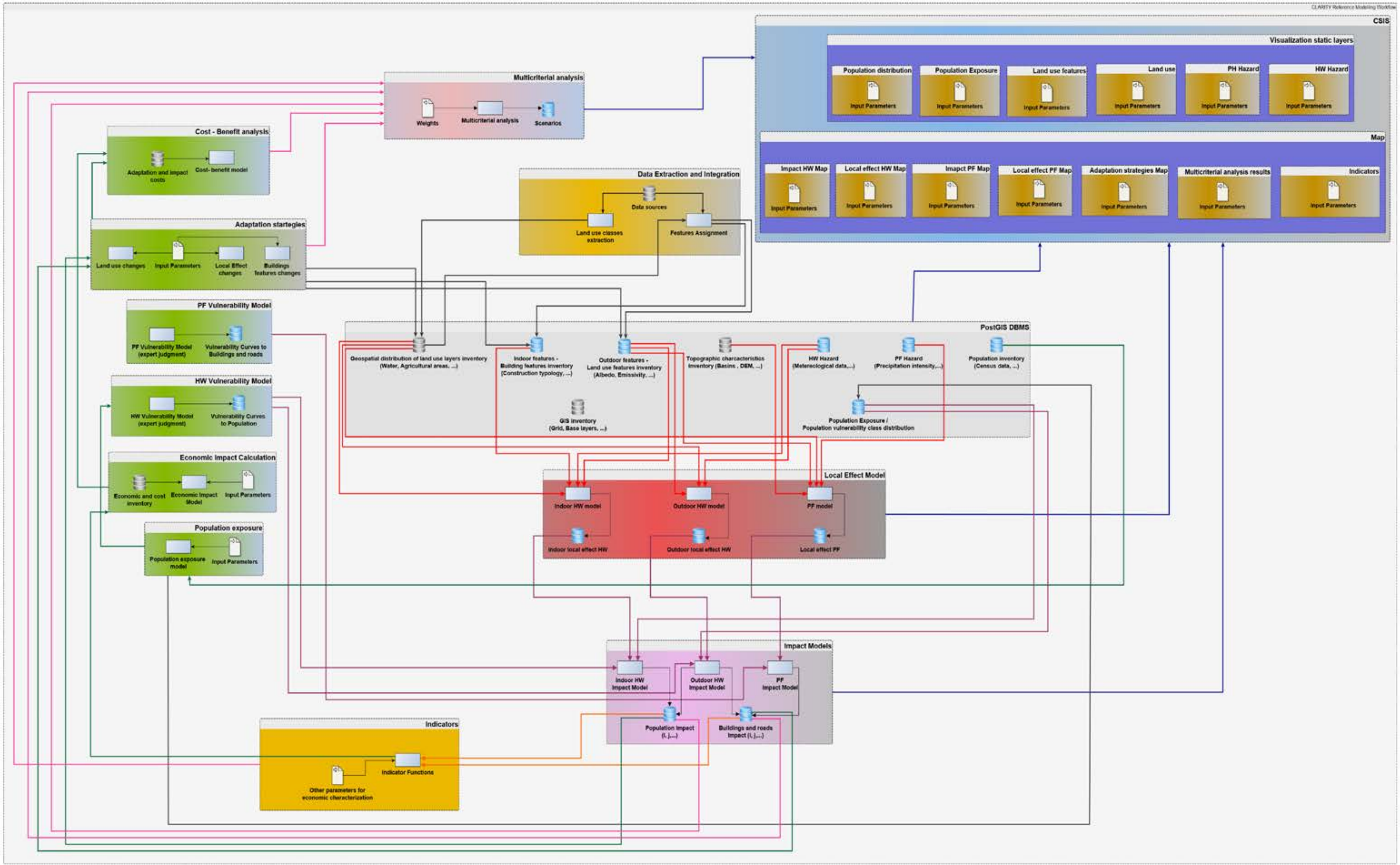
This data preparation process comprehends:

1) Pre-processing of the base source datasets such as Urban Atlas, Street Tree Layers and European Settlement Map (from Copernicus), which included the extraction and adaptation of the origin data to required input formats, coordinate reference system, scale, attributes naming, etc.), produced as result the base layers to be used as input parameters for other datasets calculation processes (e.g., local effects, exposure evaluation, etc.). These new input parameter layers refer to:
    a. geospatial distribution of land use in the territory (e.g., water, agricultural areas, roads, building areas, etc.)
    b. Topographic characteristics of the territory (e.g., DEM, Basins, etc.)
    c. Outdoor and indoor features of the buildings (e.g., construction typology, albedo, emissivity, etc.)
    d. Population data (e.g., Census)
2) Calculation of heat-wave and pluvial flooding related hazard indexes for the three considered emissions scenarios, taking as basis EURO-CORDEX, E-OBS and SWICCA datasets respectively (work carried out by WP3 team).

These new sources of information are used, in combination with the actual hazard information (as the hazard indexes are only used for informative purposes), as part of the inputs for other calculation processes in the EU-GL workflow.

Thus, for instance, the calculation of the local-effects of heat-waves and pluvial flooding hazards over population and buildings in the indoor and outdoor cases is done by using as inputs the data calculated in the above points 1) and 2) (in deliverable D3.3, section 2.2 Local Data versus Local Effect, a series of formulas are provided for this purpose).

The following diagram (:) provides an overview about how datasets are used (as input/outputs) in each of the calculations required to produce the data ingested by the CSIS.


CLARITY Reference Modeling Workflow
CSIS
Visualization static layers
Population distribution
Population Exposure
Land use features
Land use
PH Hazard
HW Hazard
Input Parameters
Map
Impact HW Map
Local effect HW Map
Imapct PF Map
Local effect PF Map
Adaptation strategies Map
Multicriterial analysis results
Indicators
Multicriterial analysis
Weights
Multicriterial analysis
Scenarios
Cost - Benefit analysis
Adaptation and impact costs
Cost- benefit model
Data Extraction and Integration
Data sources
Land use classes extraction
Features Assignment
Adaptation startegies
Land use changes
Input Parameters
Local Effect changes
Buildings features changes
PF Vulnerability Model
PF Vulnerability Model (expert judgment)
Vulnerability Curves to Buildings and roads
HW Vulnerability Model
HW Vulnerability Model (expert judgment)
Vulnerability Curves to Population
PostGIS DBMS
Geospatial distribution of land use layers inventory (Water, Agricultural areas, ...)
Indoor features - Building features inventory (Construction typology, ...)
Outdoor features - Land use features inventory (Albedo, Emissivity, ...)
Topographic charcacteristics inventory (Basins , DEM, ...)
HW Hazard (Meterecological data,...)
PF Hazard (Precipitation intensity,...)
Population inventory (Census data, ...)
GIS inventory (Grid, Base layers, ...)
Population Exposure / Population vulnerability class distribution
Economic Impact Calculation
Economic and cost inventory
Economic Impact Model
Input Parameters
Population exposure
Population exposure model
Input Parameters
Local Effect Model
Indoor HW model
Outdoor HW model
PF model
Indoor local effect HW
Outdoor local effect HW
Local effect PF
Impact Models
Indoor HW Impact Model
Outdoor HW Impact Model
PF Impact Model
Population Impact (I, j,...)
Buildings and roads Impact (I, j,...)
Indicators
Indicator Functions
Other parameters for economic characterization

3.2 Common Datasets used in CSIS prototype supporting the demonstrators and other European cities

The following presents the list of datasets prepared for the second version of the CSIS prototype, supporting the planned project demonstrators plus +500 European cities available in the Urban Atlas dataset.

For further details about each specific dataset, please check deliverables ""D2.2 Data collection report" and "D7.10 Data Management Plan v3". Deliverable "D3.3 Science support report v2" provides detailed information on how the datasets are used as inputs (or as resulting outputs) for (from) various of the involved calculation processes (either offline and within the CSIS workflow).

When ingested as inputs within the CSIS workflow, they are provided as resources in a comprehensive data package – that are suited for each of the EU-GL methodology steps. Section 3.34.3 CLARITY Data Package Specification provides further insights about CLARITY data package specification. Annex I provides an example of data package for Naples to be used as input for the CSIS prototype (latest version of the Naples data package can be downloaded from here: https://github.com/clarity-h2020/data-package/tree/master/examples/dc1-naples).

3.2.1 Pan-European Hazard Datasets

As input for the EU-GL steps "Hazard Characterization" and "Hazard Characterization - Local Effects", both for European-level screening studies and demonstration case specific expert studies, ZAMG is calculating several climate indices for the hazard characterization at European scale. The indices are being calculated for several Global Climate Model – Regional Climate Model combinations from the EURO-CORDEX (https://ckan.myclimateservice.eu/dataset/euro-cordex-ensemble-climate-simulations) simulations at 0.11° resolution (EUR-11) to account for inter-model variability. For each climate index there will be an ensemble mean for each time period (1971-2000, 2011-2040, 2041-2070, 2071-2100) and each representative concentration pathway (RCP2.6, RCP4.5 and RCP8.5).

Hazard indexes currently available in the European Wide Data Package:

98th percentile of daily maximum wind speed: Average annual 98th percentile of daily maximum wind speed

https://ckan.myclimateservice.eu/dataset/98th-percentile-of-daily-maximum-wind-speed

- *Cold nights (TN10p)*: Percentage of days per time period where daily minimum temperature is below the 10th percentile of daily minimum temperatures of a five-day window centred on each calendar day of a given 30-year climate reference period.

  https://ckan.myclimateservice.eu/dataset/percentage-of-days-when-tmin-10th-percentile

- *Consecutive Frost Days (CFD)*: Maximum number of consecutive days per time period with daily minimum temperature below 0°C

  https://ckan.myclimateservice.eu/dataset/consecutive-frost-days-cfd

- *Consecutive Summer Days (CSU)*: Maximum number of consecutive days per time period with daily maximum temperature above 25 °C.

  https://ckan.myclimateservice.eu/dataset/consecutive-summer-days

- *Consecutive Wet Days (CWD)*: Maximum number of consecutive days per time period with daily precipitation amount at least 1 mm.

  https://ckan.myclimateservice.eu/dataset/consecutive-wet-days-cwd

- *Extreme Temperature Range*: Intra-period difference of the maximum of maximum temperature and the minimum of minimum temperature.

  https://ckan.myclimateservice.eu/dataset/extreme-temperature-range
- *Frost days (FD)*: Number of days with daily minimum temperature below 0°C

  https://ckan.myclimateservice.eu/dataset/frost-days-fd
- *Highest five-day precipitation amount (RX5day)*: Maximum of one day precipitation amount in a given time period.

  https://ckan.myclimateservice.eu/dataset/highest-five-day-precipitation-amount-rx5day
- *Highest one-day precipitation amount (RX1day)*: Maximum of one day precipitation amount in a given time period

  https://ckan.myclimateservice.eu/dataset/highest-one-day-precipitation-amount-rx1day
- *Hot days (HD)*: Number of days with daily maximum temperature above 30°C

  https://ckan.myclimateservice.eu/dataset/hot-days-hd
- *Hot days (Tx90p)*: Number of days per time period where daily maximum temperature is above the 90th percentile of daily maximum temperatures of a five-day window centred on each calendar day of a given 30-year climate reference period.

  https://ckan.myclimateservice.eu/dataset/hot-days-tx90p

  Hot days: Maximum number of consecutive days when Tmax > 75th percentile: Maximum number of consecutive days per year where the maximum air temperature at 2 m above ground exceeds the 75th percentile during summer months (Apr-Sep) in the period 1971-2000

  https://ckan.myclimateservice.eu/dataset/hot-days-max-number-of-consecutive-days-when-tmax-75th-percentile

  Hot days: Number of days when Tmax > 75th percentile (Apr-Sept): Number of days where the daily maximum temperature exceeds the 75th percentile of maximum temperature during the baseline period 1971-2000 for the warm months April-September.

  https://ckan.myclimateservice.eu/dataset/number-of-days-when-tmax-75th-percentile-apr-sept
- *Ice days (ID)*: Number of days with daily maximum temperature below 0°C

  https://ckan.myclimateservice.eu/dataset/ice-days-id
- *Maximum wind speed (Fmax)*: Annual maximum of daily maximum wind speed, average over 30-year time-period.

  https://ckan.myclimateservice.eu/dataset/maximum-wind-speed-fmax
- *Snow days*: Number of days with snow precipitation > 1cm (precipitation > 1mm & temperature < 4ºC).

  https://ckan.myclimateservice.eu/dataset/snow-days
- *Summer days (SD)*: Number of days with daily maximum temperature above 25°C

  https://ckan.myclimateservice.eu/dataset/summer-days-sd

  Torro17: Number of days per year with daily maximum wind speed equal or greater than 17 m/s, average over a 30-year time-period.

  https://ckan.myclimateservice.eu/dataset/torro17
- *Tropical Nights (TN)*: Number of days with daily minimum temperature above 20°C

https://ckan.myclimateservice.eu/dataset/tropical-nights-tn

Summer days (SD): https://ckan.myclimateservice.eu/dataset/summer-days-sd

Very heavy precipitation days (R20mm): Number of days per time period with daily precipitation equal or greater than 20 mm.

https://ckan.myclimateservice.eu/dataset/very-heavy-precipitation-days-r20mmhttps://ckan.myclimateservice.eu/dataset/hot-days

- *Wet days (RR1)*: Number of days per time period with daily precipitation of at least 1 mm.

  https://ckan.myclimateservice.eu/dataset/wet-days-rr1
- *Wet days (RR90p)*: Number of days where precipitation is higher than the calendar 90th percentile (centred on a 5 day window) of the reference period.

  https://ckan.myclimateservice.eu/dataset/wet-days-wrt-90th-percentile-of-reference-period

3.2.2 Local Effects Input Datasets

These are the local effects datasets that are applied to the Pan-European Hazard Datasets in order to derive the downscaled datasets. They are mainly based on open Copernicus data and encompass detailed information related to key parameters linked to urban morphology and surface type, such as albedo, emissivity, buildings shadows, etc.

Currently, datasets are available for 455 European cities. The criteria followed to choose those cities is the availability for each of them of the three main data sources (Urban atlas 2012, European Settlement Maps and Street Tree Layers) as well as mortality and population data from Eurostats. The related metadata is made available at CKAN Catalogue at https://ckan.myclimateservice.eu/dataset?tags=Local+Effects.

The Local Effects Datasets have been also published through OGC compliant web services at http://services.clarity-h2020.eu:8080/geoserver following WFS and WMS standards. They have been generated by using different data sources or some combinations of them:

The following layers are calculated (alone or in combination with other datasets) in the context of the **heat waves hazard**:

Urban Atlas

- *Water*: https://ckan.myclimateservice.eu/dataset/naples-water
- *Roads*: https://ckan.myclimateservice.eu/dataset/roads
- *Railways*: https://ckan.myclimateservice.eu/dataset/railways
- *Agricultural areas*: https://ckan.myclimateservice.eu/dataset/agricultural-areas
- *Public, Military and Industrial Unit Areas*: https://ckan.myclimateservice.eu/dataset/public-military-and-industrial-units
- Low, Medium and Dense Urban Fabric Areas:
  - https://ckan.myclimateservice.eu/dataset/low-urban-fabric
  - https://ckan.myclimateservice.eu/dataset/medium-urban-fabric
  - https://ckan.myclimateservice.eu/dataset/dense-urban-fabric
- Urban atlas and Street Tree Layer
  - Trees: https://ckan.myclimateservice.eu/dataset/trees

- Urban atlas and European Settlement Map
    - *Vegetation:* https://ckan.myclimateservice.eu/dataset/vegetation
    - *Roads*: https://ckan.myclimateservice.eu/dataset/roads
    - *Railways*: https://ckan.myclimateservice.eu/dataset/railways
- European Settlement Map
    - *Built Open Spaces*: https://ckan.myclimateservice.eu/dataset/built-open-spaces
    - *Built-up*: https://ckan.myclimateservice.eu/dataset/buildings
- Urban Atlas and European Settlement Map (Trees):https://ckan.myclimateservice.eu/dataset/trees

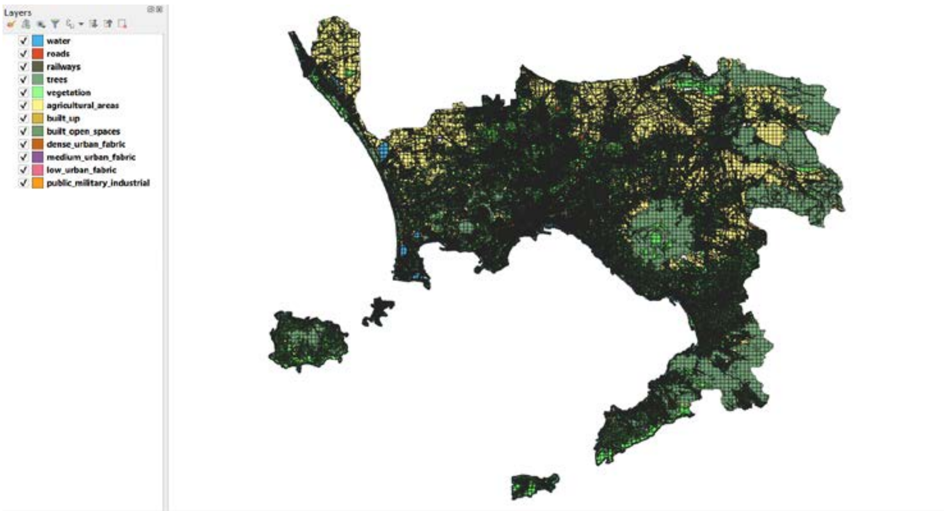


Figure 48: Naples input layers for local effects calculation view

The following layers are calculated (alone or in combination with other datasets) in the context of **the pluvial floods hazard**:

Copernicus

- *Europe streams:* https://ckan.myclimateservice.eu/dataset/streams
- *Europe basins:* https://ckan.myclimateservice.eu/dataset/basins

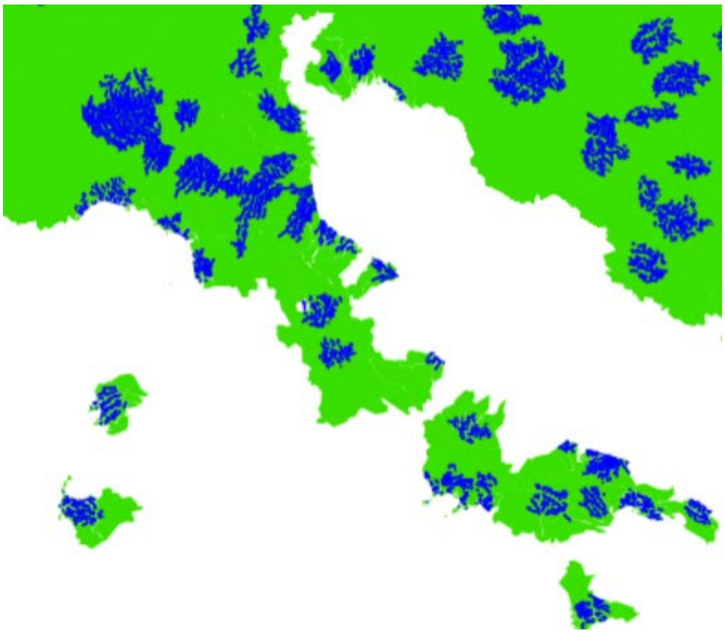


Figure 49: Italy region basins and streams

3.2.3 Datasets used in the Spanish demonstrator for the prototype

The Demonstrator Case for Spain has some special characteristics that set it a bit apart from the others in some aspects. This case is centered around the transport infrastructure and needs meteorological and climate data for short, middle and long term along with road and road-related data. Below it is presented a list of datasets prepared for the Spanish demonstrator.

For further details about each specific dataset, please check deliverables "D2.2 Data collection report" and "D7.10 Data Management Plan v3". Deliverable "D3.3 Science support report v2" provides detailed information on how the datasets are used as inputs (or as resulting outputs) for (from) various of the involved calculation processes (either offline and within the CSIS workflow).

As in the other cases, these datasets are introduced into the system either making use of a data package (Section 3.3 CLARITY Data Package Specification provides further insights about CLARITY data package specification) or directly in the external application designed for this demonstrator case.

3.2.3.1 Climatic and Meteorological data

As stated above, this case will also take into account meteorological data for short and mid-term purposes but when appropriate it will also make use of the same climatic data described in the previous section. These datasets come from a variety of sources, from the Spanish Meteorological agency (AEMET) to Copernicus or NOAA.

- Meteorological observation data. Hourly resolution: https://ckan.myclimateservice.eu/dataset/meteorological-observation-data-hourly
- Mid term meteorological forecasting. Resolution: 6h / 1 degree: https://ckan.myclimateservice.eu/dataset/mid-term-meteorological-forecasting-noaa
- Mid term meteorological forecasting. Resolution: 6h / 0.28 degree: https://ckan.myclimateservice.eu/dataset/mid-term-meteorological-forecasting-ecmwf
- EURO-CORDEX ensemble climate simulations. 0.11 resolution: https://ckan.myclimateservice.eu/dataset/euro-cordex-ensemble-climate-simulations
- Climate Forecast System (CFSv2). Scale: variable: https://ckan.myclimateservice.eu/dataset/noaa-climate-forecast-system-cfsv2

- Current climate data: https://ckan.myclimateservice.eu/dataset/current-climate-atlas
- ECMWF System4. Scale: 1 degree: https://ckan.myclimateservice.eu/dataset/ecmwf-system4
- Decadal models outputs (CMIP5): https://ckan.myclimateservice.eu/dataset/decadal-models-outputs-cmip5
- AEMet-Spanish official projections: https://ckan.myclimateservice.eu/dataset/aemet-spanish-official-projections
- CMIP5 climate projections: https://ckan.myclimateservice.eu/dataset/cmip5-climate-projections

3.2.3.2 Road infrastructure and additional data

Datasets for transport network infrastructure and other data that influence the status of the network have been gathered from different sources. Some datasets come for state agencies but other from private owned companies that work on its design and maintenance.

- Spanish forest fuel model. Scale: 1/100.000: https://ckan.myclimateservice.eu/dataset/spanish-forest-fuel-model
- Digital elevation Model. Resolution: 2 and 5 meters: https://ckan.myclimateservice.eu/dataset/clarityftp-dc4-digital-elevation-models-spain
- Detailed highway design. Scale: 1/500: https://ckan.myclimateservice.eu/dataset/detailed-highway-design
- Spanish Transport Network layers. Scale: 1/25000: https://ckan.myclimateservice.eu/dataset/spain-transport_network-layers
- Traffic volume of Spanish roads. Source: CEDEX
- Detailed drainage systems. Scale: 1/500. Source: ACCIONA
- Detailed Slopes design. Scale: 1/500. Source: ACCIONA
- Exposure elements: https://ckan.myclimateservice.eu/dataset/exposure-elements
- Spanish Pilot Road: Several section of the A2 road: https://ckan.myclimateservice.eu/dataset/spanish-pilot-road
- Vegetation condition on ditches and median strips: https://ckan.myclimateservice.eu/dataset/vegetation-condition-on-ditches-and-median-strips

3.3 CLARITY Data Package Specification

Rationale

Information consumed by CLARITY Climate Services must be provided in a common data package format which contains all or part of the datasets necessary for carrying out the project climate proofing assessment (according to the steps defined in CLARITY EU-GL Methodology).

Technically, a standardized data package can be realized as "distributed data object" so that not all data must reside in the same location (database, server). Here arises also the need for "Smart Links" that can combine, relate and describe different information entities (in this particular case the distinct elements of data package). Furthermore, a serialization feature for data packages is needed that allows to put all contents of package into a concrete (zip) file that can be shared, e.g. with other experts.

Besides, the output of Climate Services must be delivered as such a standardized data package to ensure technical interoperability to the CSIS and thus the Climate Services Ecosystem. Consequently, a data package can either reside on the CSIS as Virtual data package (distributed among several physical data stores) if the provider of the Expert Climate Service uses the CLARITY CSIS to provide its service, or as concrete file (Serialized data package) if the provider works offline.

3.3.1 Design principles

CLARITY data package specification builds on top of the existing data package specification provided by Frictionless Data (https://frictionlessdata.io) in accordance with their **design philosophy** (https://frictionlessdata.io/specs):

- *Simplicity*: seek simplicity in which there is nothing to add and nothing to take away.
- *Extensibility*: design for extensibility and customization. This makes hard things possible and allows for future evolution
- *Human-editable and machine-usable*: specifications should preserve human readability and editability whilst making machine-use easy.
- *Reuse*: reuse and build on existing standards and formats wherever possible.
- *Cross technology*: support a broad range of languages, technologies and infrastructures -- avoid being tied to any one specific system.

This philosophy is itself based on the overall design principles of the Frictionless Data project:

- *Focused*: sharp focus on one part of the data chain, one specific feature – packaging – and a few specific types of data (e.g. tabular).
- *Web Oriented*: build for the web using formats that are web "native" such as JSON, work naturally with HTTP such as plain text CSVs (which stream).
- *Distributed*: design for a distributed ecosystem with no centralized, single point of failure or dependence.
- *Open*: Anyone should be able to freely and openly use and reuse what we build.
- *Existing Software*: Integrate as easily as possible with existing software both by building integrations and designing for direct use – for example we like CSV because everyone has a tool that can access CSV.
- *Simple, Lightweight*: Add the minimum, do the least required, keep it simple. For example, use the most basic formats, require only the most essential metadata, data should have nothing extraneous.

3.3.2 Structure overview

Similarly to a common data package (https://frictionlessdata.io/specs/data-package), CLARITY data package consists of:

- **Metadata** that describes the structure and contents of the package
- **Resources** such as data files that form the contents of the package

The data package metadata is stored in a "descriptor". This descriptor is what makes a collection of data a CLARITY data package. The structure of this descriptor is the main content of the specification.

In addition to this descriptor a data package will include other resources such as data files. The CLARITY data package specification **does impose** some particular requirements on their form or structure -- in contraposition to the lack of any requirements in the original data package specification -- and it also extends the descriptor with additional properties which ensure that data contained in a CLARITY data package is valid and suitable for being ingested and processed by CLARITY Climatic Services.

The data included in the package may be provided as:

- Files bundled locally with the package descriptor
- Remote resources, referenced by URL

A typical CLARITY data package would be according to the following structure:

```
datapackage.json  # (required) metadata and schemas for this CLARITY data package
README.md          # (optional) README file (in markdown format) describing the purpose of this data package


# data files MUST go in "data" subdirectory (this subdirectory may have additional subdirectories for further
# organizing the datasets in the data package\n
data/mydata.csv
data/hazards/heat-waves/summer-days-index.tif


# the directory for code scripts (by convention scripts go in a scripts directory) for processing or
# analyzing the data
scripts/my-preparation-script.py
```

Full CLARITY data package specification can be found at https://github.com/clarity-h2020/data-package

In the Annexes section of this document it can be found the current description of each of the properties that compose CLARITY data package Specification and the example developed for the Naples demonstrator.

4 Conclusions

As presented in the previous sections, this report briefly describes the second prototype version of the CSIS (i.e., deliverable D1.4 CLARITY CSIS v4, marked as OTHER in the DoA) providing new features and advances with respect to the first prototype (deliverable D1.3).

The CSIS prototype implementation work took as basis the initial user requirements in the form of visual mock-ups depicting the features that the tool should provide to its users willing to carry out a preliminary climate proofing study.

The present version of the prototype was also improved bas. ed on the feedback received from end-users and other stakeholders contacted/met in conferences, workshops and webinars that were organized by the project in the past months.

The document also presents the Reference Modelling Workflow, which describes the technical implementation of the EU-GL/CLARTIY Modelling Methodology (documented in CLARTIY deliverable D3.1 Science Support Plan) CLARTIY CSIS. The Reference Modelling Workflow was used to support the data processing team in charge of preparing the datasets to be used by the CSIS prototype in relation to the four project demonstrators and supporting, in addition, the possibility to carry out similar studies in +455 European cities for which there is data available.

CLARITY data package specification was also presented (and further discussed and an example for the Naples region is provided in the annex sections) as the “glue” allowing to relate and describe (by means of metadata properties) the various datasets required by the CSIS at each stage of the EU-GL methodology.

Future work for the final project weeks in the CSIS will focus on opening the prototype beta to the public for further validation of the concept and further testing and improvements of the prototype. As explained in section 2.2.8, the final version of the advanced urban screening prototype is expected to include a second hazard/elements at risk pair (flash floods / infrastructure), additional impact indices and a possibility to assess the effect of chosen adaptation options. This functionality is currently in testing and will be documented in D1.5.

5 References

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6 Annexes

6.1 Annex I - CLARITY data package specification

Data package object

The following is a list of attributes contained in the general part of the descriptor

Table 3: data package object

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
name	Character string without length restriction	0/1	OPTIONAL	MANDATORY	A short url-usable (and preferably human-readable) name of the package. This MUST be lower-case and contain only alphanumeric characters along with ".", "_" or "-" characters. It will function as a unique identifier and therefore SHOULD be unique in relation to any registry in which this package will be deposited (and preferably globally unique). The name SHOULD be invariant, meaning that it SHOULD NOT change when a data package is updated, unless the new package version should be considered a distinct package, e.g. due to significant changes in structure or interpretation. Version distinction SHOULD be left to the version property. As a corollary, the name also SHOULD NOT include an indication of time range covered.
id	Character string without length restriction	0/1	OPTIONAL	MANDATORY	A property reserved for globally unique identifiers. A common usage pattern for data packages is as a packaging format within the bounds of a system or platform. In these cases, a unique identifier for a package is desired for common data handling workflows, such as updating an existing package. While at the level of the specification, global uniqueness cannot be validated, consumers using the id property MUST ensure identifiers are globally unique. For the CLARITY, we propose to use URLs as a means for ensuring gloabal uniqueness of the data package id. Taking as basis the Identifier String in data package Identifier

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
					specification (https://frictionlessdata.io/specs/data-package-identifier/#identifier-string), the following examples would be valid data package identifiers : - A URL that points directly to the datapackage.json file: http://data.myclimateservice.eu/datapackages/clarity-dc4.json - A URL that points directly to the data package: http://github.com/clarity-h2020/datapackages/clarity-dc4 - A GitHub URL: http://github.com/clarity-h2020/datapackages/clarity-dc4 Note 1: The 4th example provided in https://frictionlessdata.io/specs/data-package-identifier/#identifier-string (i.e., using the name of the dataset in the Core Datasets registry) would not be supported as it is not a URL, although it would be valid to use something like this (as it is a URL): https://datahub.io/core/clarity-dc4/datapackage.json Note 2: for the sake of coherence, the "name" attribute value MUST be the same as in the id (according to the examples above, "name" attribute value would "clarity-dc4". Note 3: adding versioning to the url (pending)
version	Character string	0/1	OPTIONAL	MANDATORY	A version string identifying the version of the package. It should conform to the Semantic Versioning requirements (http://semver.org/) and should follow the data package Version pattern (https://frictionlessdata.io/specs/patterns/#data-package-version): MAJOR.MINOR.PATCH (e.g., 1.0.0)
profile	Character string without length restriction	0/1	OPTIONAL	MANDATORY	A string identifying the profile of this descriptor as per the profiles specification (https://frictionlessdata.io/specs/profiles/). Different kinds of data need different data and metadata formats. To support these different data and metadata formats we need to extend and specialise the generic data package. These specialized types of data package (or Data Resource) are termed profiles. Thus, in the context of CLARITY, we define a specialized general data package profile. In the same manner, each of the specific resources contained in the "CLARITY data package" are defined according to the "CLARITY Data Resource" profile.

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
					The value of the profile property is a unique identifier for that profile. This unique identifier MUST be a string in the form of a fully-qualified URL, allowing thus ensuring its uniqueness, that points directly to a JSON Schema that can be used to validate the profile. The profile schema proposed for CLARITY data packages is "profile": http://csis.myclimateservice.eu/data/schemas/clarity-data-package-json-schema.json Note: pending to create clarity-data-package-json-schema.json schema
title	Character string without length restriction	0/1	OPTIONAL	MANDATORY	A string providing a title or one sentence description for this package
description	Character string without length restriction	0/1	OPTIONAL	MANDATORY	A description of the package. The description MUST be markdown formatted -- this also allows for simple plain text as plain text is itself valid markdown. The first paragraph (up to the first double line break) should be usable as summary information for the package.
keywords	List of character strings without length restriction	0/1	OPTIONAL	MANDATORY	An array of string keywords characterizing the package, assisting users searching for it in catalogs.
created	DateTime	0/1	OPTIONAL	MANDATORY	The datetime on which this was created. Note: semantics may vary between publishers -- for some this is the datetime the data was created, for others the datetime the package was created. In CLARITY data packages, it refers to the datatime when the data package was created. The datetime must conform to the string formats for datetime as described in RFC3339 (https://tools.ietf.org/html/rfc3339#section-5.6). Example: { "created": "2018-09-20T23:20:50.52Z" }"

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
homepage	Character string without length restriction	0/1	OPTIONAL	OPTIONAL	A URL for the home on the web that is related to this data package.
sources	List of Source objects	0*	OPTIONAL	OPTIONAL	The raw sources for this data package. It MUST be an array of Source objects. Each Source object MUST have a title and MAY have path and/or email properties. Example: "sources": [{ "title": "World Bank and OECD", "path": "http://data.worldbank.org/indicator/NY.GDP.MKTP.CD" }]"
contributors	List of Contributor objects	0*	OPTIONAL	MANDATORY	The people or organizations who contributed to this data package. It MUST be an array. Each entry is a Contributor and MUST be an object. A Contributor MUST have a title property and MAY contain path, email, role and organization properties. Example: "contributors": [{ "title": "Joe Bloggs", "email": "joe@bloggs.com", "path": "http://www.bloggs.com", "role": "author" }]"
licenses	List of License objects	0*	OPTIONAL	MANDATORY	The license(s) under which the package is provided. This property is not legally binding and does not guarantee the package is licensed under the terms defined in this property. "licenses" MUST be an array. Each item in the array is a License object. The object MUST contain a name property and/or a path property. It MAY contain a title property.
image	Character string without length restriction	0/1	OPTIONAL	OPTIONAL	An image to use for this data package. For example, when showing the package in a listing. The value of the image property MUST be a string pointing to the location of the image. The string must be a url-or-path, that is a fully qualified HTTP address, or a relative POSIX path (see the url-or-path definition in Data Resource for details).

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
resources	List of Resource objects	1+	MANDATORY	MANDATORY	The resources property is required, with at least one resource. Packaged data resources are described in the resources property of the package descriptor. This property MUST be an array of objects. Each object MUST follow the Data Resource specification (https://frictionlessdata.io/specs/data-resource/) OR the CLARITY extension of the Data Resource specification for concrete resources needed as input for the CSIS (e.g., Hazard, Exposure, Vulnerability, etc. Maps Resources). See CLARITY Resources table for a detailed list of attributes of the object. Note1: According to the Data Resource specification: "A resource MUST contain a property describing the location of the data associated to the resource. The location of resource data MUST be specified by the presence of one (and only one) of these two properties: • path: for data in files located online or locally on disk. • data: for data inline in the descriptor itself." Note2: CLARITY data packages ONLY support resources that describe their location with the "path" property. This is to avoid having data package descriptors (.json) files bloated with thousands of text lines encoding the data which would make unmanageable and unreadable the descriptor. Instead of that, CLARITY data packages forces to store that data in a file and reference it within the data package itself or to a remote location.
language	String enumeration	0/1	N/A	OPTIONAL	ISO/TS 19139 alpha-3 (three characters) code denoting the language in which the textual information of the metadata is presented. IF empty, it is assumed English ("eng")
price	Price object	0/1	N/A	OPTIONAL	Price of the data package. If empty, then assume that it is free.

6.1.1 Source object

Table 4: Source object

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
title	Character string without length restriction	0/1	OPTIONAL	MANDATORY	title of the source (e.g. document or organization name)
path	Character string without length restriction	0/1	OPTIONAL	MANDATORY	A url-or-path string, that is a fully qualified HTTP address, or a relative POSIX path (see the url-or-path definition in Data Resource for details).
email	Character string without length restriction	0/1	OPTIONAL	OPTIONAL	An email address

6.1.2 Contributor object

Table 5: Contributor object

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
title	Character string without length restriction	0/1	OPTIONAL	MANDATORY	name/title of the contributor (name for person, name/title of organization)

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
path	Character string without length restriction	0/1	OPTIONAL	OPTIONAL	A fully qualified http URL pointing to a relevant location online for the contributor.
email	Character string without length restriction	0/1	OPTIONAL	OPTIONAL	An email address
role	String enumeration	0/1	OPTIONAL	OPTIONAL	A string describing the role of the contributor. It MUST be one of: author, publisher, maintainer, wrangler, and contributor. Defaults to contributor. Note on semantics: use of the "author" property does not imply that that person was the original creator of the data in the data package - merely that they created and/or maintain the data package. It is common for data packages to "package" up data from elsewhere. The original origin of the data can be indicated with the sources property - see above.
organization	Character string without length restriction	0/1	OPTIONAL	OPTIONAL	A string describing the organization this contributor is affiliated to.

6.1.3 License object

Table 6: License object

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
name	String enumeration	0/1	OPTIONAL	MANDATORY	The name MUST be an Open Definition license ID (see https://licenses.opendefinition.org/)
path	Character string without length restriction	0/1	OPTIONAL	MANDATORY	A url-or-path string, that is a fully qualified HTTP address, or a relative POSIX path (see the url-or-path definition in Data Resource for details).
title	Character string without length restriction	0/1	OPTIONAL	MANDATORY	A human-readable title

6.1.4 Price object

Table 7: Price object

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
amount	Float	1	N/A	MANDATORY	The price of the data package. If the data package is free, then the value of this parameter MUST be 0.0
currency	String enumeration	1	N/A	MANDATORY	The currency property of a price is given. It must be one of of the codes listed here: https://www.currency-iso.org/en/home/tables/table-a1.html. By default, the currency code is "EUR"

6.1.5 Resource

The following is a list of attributes contained in the Data Resource section of the data package descriptor.

Table 8: Resource object

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
id	Character String without length restriction	1	N/A	MANDATORY	Unique identifier of the resource within the data package. The id value is built by appending to the data package id the following string "#r" plus [auto-generated-sequential-number (starting from 1)] E.g., "id": "http://github.com/clarity-h2020/data-package/examples/dc1-naples#r1"
name	Character String without length restriction	1	MANDATORY	MANDATORY	A resource MUST contain a name property. The name is a simple name or identifier to be used for this resource. If present, the name MUST be unique amongst all resources in this data package. It MUST consist only of lowercase alphanumeric characters plus ".", "-" and "_". It would be usual for the name to correspond to the file name (minus the extension) of the data file the resource describes. The name SHOULD be invariant, meaning that it SHOULD NOT change when a resource is updated.
profile	Character string without length restriction	0/1	OPTIONAL	MANDATORY	A string identifying the profile of this resource descriptor as per the profiles specification (see the profile property in "General" tab). For CLARITY: http://csis.myclimateservice.eu/data/schemas/clarity-data-resource-json-schema.json
title	Character string without length restriction	0/1	OPTIONAL	MANDATORY	A string providing a title or one sentence description for this resource

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
description	Character string without length restriction	0/1	OPTIONAL	MANDATORY	A description of the resource package (see the description property in "General" tab).
sources	List of Source objects	0+	N/A	OPTIONAL	The raw sources that were used for producing this resource. For further information, please check the sources property description at data package level.
contributors	List of Contributor objects	0+	OPTIONAL	OPTIONAL	The people or organizations who contributed to produce this resource. For further information, please check the contributors property description at data package level.
licenses	List of License objects	0+	OPTIONAL	OPTIONAL	The license(s) under which the resource is provided. If not specified the resource inherits from the data package. For further information, please check the license property description at data package level.
format	String enumeration	0/1	OPTIONAL	MANDATORY	The value of this property would be expected to be the standard file extension for this type of resource. Currently, CLARITY data package supports the following resource formats: • Tabular data: o "csv": Comma Separated Values • Vector based: o "geojson": GeoJson o "shape": ESRI Shapefiles o "shape-zip": Compressed ESRI Shapefiles o "gpkg": OGC GeoPackage o "gml2": GML 2 o "gml3": GML 3 o "gml32": GML 3.2

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
					o "kml": OGC Keyhole Markup Language o "kmz": OGC Compressed Keyhole Markup Language ▯ Raster based: o tif | tiff: (.tif, .tiff) o jpeg o png o gif o geotiff: Geo-tagged tif (.tif, .tiff) Note: the use of GeoPackages allows to overcome the limitations of ESRI Shapefiles (Check the list of limitations at http://switchfromshapefile.org/ and https://www.gis-blog.com/geopackage-vs-shapefile) and therefore, its use in data packages should be preferrable. Nevertheless, when using GeoPackages as resources within the data packages, in order to comply with the data package specification, take into account that a resource of this type can only have ONE dataset within the GeoPackage (although its specification allows having one or more different datasets).
mediatype	String enumeration	0/1	OPTIONAL	OPTIONAL	The mediatype/mimetype of the resource e.g. ""text/csv"". Mediatypes are maintained by the Internet Assigned Numbers Authority (IANA) in a media type registry (https://www.iana.org/assignments/media-types/media-types.xhtml). Note: it is possible that some particular GIS formats are not listed in the media type registry. Some typically used media types used in OGC services are: ▯ application/gml+xml ▯ application/x-gzip ▯ image/jpeg ▯ image/png ▯ image/tiff ▯ text/plain ▯ text/xml

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
					application/json
encoding	String enumeration	0/1	OPTIONAL	OPTIONAL	Specify the character encoding of the resource's data file. The values should be one of the ""Preferred MIME Names"" for a character encoding registered with IANA (https://www.iana.org/assignments/character-sets/character-sets.xhtml). If no value for this key is specified then the default is UTF-8. Note: what happens if the resource is a raster?
bytes	Long	0/1	OPTIONAL	OPTIONAL	Size of the file in bytes. Note: This parameter is hepful for determining how to process the data package, thus for instance, if we know in advance that several of the resources are large, we can determine that it is better to process the contents in a batch process and later on inform the user when the results are ready. In this sense, the parameter is considered MANDATORY if the resource is included within the data package (the path parameter points to a local file within the data package), whereas it is considered OPTIONAL if the path parameter points to a remote location (e.g., HTTP request to a WFS service or ftp location). This is so because the size of the resource is unknown until it is requested to the server hosting it."
hash	Character string without length restriction	0/1	OPTIONAL	OPTIONAL	the MD5 hash for this resource. Other algorithms can be indicated by prefixing the hash's value with the algorithm name in lower-case. For example: "hash": "sha1:8843d7f92416211de9ebb963ff4ce28125932878"
data	Character string without length restriction	0/1	OPTIONAL	N/A	Resource data rather than being stored in external files can be shipped 'inline' on a Resource using the data property. Note: this property is not supported in CLARITY data package Resources.
path	url-path character	1+	OPTIONAL	MANDATORY	Location property for data in files located online or locally on disk (within the data package itself).

<table>
<tr><th colspan="3">Attribute</th><th colspan="2">Obligation / Condition</th><th rowspan="2">Description</th></tr>
<tr><th>Name</th><th>Type</th><th>Multiplicity</th><th>FrictionlessData</th><th>CLARITY</th></tr>
<tr><td></td><td>string without length restriction</td><td></td><td></td><td></td><td>
The path property MUST be a string -- or an array of strings (see "Data in Multiple Files"). Each string MUST be a "url-or-path" string, defined as the following:

URLs MUST be fully qualified. MUST be using either http or https scheme. (Absence of a scheme indicates MUST be a POSIX path)
POSIX paths (unix-style with / as separator) are supported for referencing local files, with the security restraint that they MUST be relative siblings or children of the descriptor. Absolute paths (/) and relative parent paths (../) MUST NOT be used, and implementations SHOULD NOT support these path types.

Examples:

fully qualified url

"path": "http://ex.datapackages.org/big-csv/my-big.csv"
"path": "http://demo.geo-solutions.it/geoserver/tiger/ows?service=WFS&version=1.1.0&request=GetFeature&typeName=tiger:tiger_roads&srsName=EPSG:3857&bbox=40.7,-74,40.8,-73,urn:ogc:def:crs:EPSG:4326&maxFeatures=1"
"path": "jdbc:postgresql://localhost:5432/database"
"path": "sftp://clarityftp@w.x.y.z/clarityftp/europe/population/population_naples_age_groups_500_LAEA.zip"

relative path (note: this will work both as a relative path on disk and on online)

"path": "data/my-csv.csv"

SECURITY: / (absolute path) and ../ (relative parent path) are forbidden to avoid security vulnerabilities when implementing data package software. These limitations on resource path ensure that resource paths only point to files within the data package directory and its subdirectories. This prevents data package software being exploited by a malicious user to gain unintended access to sensitive information.
Data in Multiple Files: Usually, a resource will have only a single file associated to it. However, sometimes it may be convenient to have a single resource whose data is split across multiple files -- perhaps the data is large and having it in one file would be inconvenient. To support this use case the path property MAY be an array of strings
</td></tr>
</table>

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
					rather than a single string: "path": ["myfile1.csv", "myfile2.csv"] It is NOT permitted to mix fully qualified URLs and relative paths in a path array: strings MUST either all be relative paths or all URLs. Best Practice (proposal): dataset resources MUST be located in a "data" folder in the root of the in a data package (where the json descriptor is also located) in order to have a better organization of the contents. Within the data folder, datasets MAY be further organized creating additional subfolders if necessary.
schema	url-path character string without length restriction	0/1	OPTIONAL	MANDATORY	In CLARITY data packages, a Data Resource MUST always have a schema property to describe the schema of the resource data. Note: even for raster-based resources, having the schema is necessary, as it can describe useful information like what is/are the paremeter(s) measured as well as its/their measurement unit(s), which may be necessary for the application in charge of process the resource afterwards. The value for the schema property on a resource MUST be an object representing the schema OR a string that identifies the location of the schema. If a string it must be a url-or-path as defined above, that is a fully qualified http URL or a relative POSIX path. The file at the location specified by this url-or-path string MUST be a JSON document containing the schema. The next section provide a complete schema description with the parameters for each of the typical resources included in a CLARITY data package.
service_type	Character String enumeration	0/1	N/A	OPTIONAL	This property is primarily to be used to support the client software (that has to process the data package) to identify if the resource is being offered via some commonly used (download) geoservice service (mainly OGC WFS or OGC WCS). Listed below there is a (non-exhaustive) list of possible protocol values: - ogc:wms - ogc:wms-t - ogc:wfs - ogc:wcs - osm

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
					• tms
mapview	Mapview Object	0/1	N/A	OPTIONAL	This property provides another "view" of the data in the form of a visual map by indicating a path (url) to the mapping service. This property is to be typically used when the resource is available via wfs or wcs (or even an static geo-resource) and we want to be able to easily visualize the data (e.g., using for instance the wms o osm protocols) which is more convenient and efficient than loading the heavy raster or vector-based data into the in a map client.
quality	Quality object	0/1	OPTIONAL	OPTIONAL	Check with LUIS possible parameters: * uncertainty * fiability
spatial_context	SpatialContext object	0/1	OPTIONAL	OPTIONAL(*)	MANDATORY if the resource is a spatial dataset. Otherwise, this property is empty.
temporal_context	Temporal Context object	0/1	OPTIONAL	OPTIONAL(*)	MANDATORY if the resource is has a temporal component. Otherwise, this property is empty.
analysis_context	AnalysisContext object	1	N/A	MANDATORY	This property describes contextual information needed by the CSIS in order to understand how to process this specific resource (e.g., in which step of the CLARITY workflow it must be used, to which hazard the resource is related to, etc.

6.1.6 SpatialContext object

Table 9: SpatialContext object

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
crs	CharacterString enumeration	1	N/A	OPTIONAL	Property indicating the Coordinate Reference System. Its value must be a valid EPSG code (https://sis.apache.org/tables/CoordinateReferenceSystems.html). By default, CLARITY data packages use EPSG:3035 Example: "crs": "EPSG:3035"
extent	SpatialExtent object	1	N/A	MANDATORY	The extent property defines the minimum bounding rectangle (xmin, ymin and xmax, ymax) defined by coordinate pairs of the spatial data resource. All coordinates for the data source fall within this boundary. E.g., "extent": { "xmin":-180.0, "ymin":-90.0, "xmax":180, "ymax":90.0 }
resolution	SpatialResolutionByDistance OR SpatialResolutionByScale object	1	N/A	MADATORY	The spatial resolution property refers to the level of detail of the data set. It shall be expressed as a resolution distance value (typically for gridded data and imagery-derived products) or an equivalent scale value (typically for maps or map-derived products). Note 1: An equivalent scale is generally expressed as an integer value expressing the scale denominator. A resolution distance shall be expressed as a numerical value associated with a unit of length. Note 2: For grids it is assumed that the resolution of the cells is the same in the x and y axis Examples: • "resolution": { "scale": 50000 }

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
					"resolution": { "distance": 12.5, "uom": "km"}
grid_info	GridInfo object	0/1	N/A	OPTIONAL(*)	This property is MANDATORY if the resource is a raster. Please, see GridInfo object description for further details.

SpatialResolutionByDistance object

Table 10: SpatialResolutionByDistance object

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
distance	Float	1	N/A	MANDATORY	The resolution expressed in distance
uom	CharacterString enumeration	1	N/A	OPTIONAL	The units of measurement used to define the distance. By default, in meters. Possible values are: "m" // urn:ogc:def:uom:OGC::m "km" // urn:ogc:def:uom:OGC::km ...

6.1.7 SpatialResolutionByScale object

Table 11: SpatialResolutionByScale object

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
scale	Long	1	N/A	MANDATORY	The resolution expressed in scale

6.1.8 SpatialExtent object

Table 12: SpatialExtent object

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
xmin	Float	1	N/A	MANDATORY	Minimum coordinate value in the "x" axis that defines the spatial extent.
ymin	Float	1	N/A	MANDATORY	Minimum coordinate value in the "y" axis that defines the spatial extent.
xmax	Float	1	N/A	MANDATORY	Maximum coordinate value in the "x" axis that defines the spatial extent.
ymax	Float	1	N/A	MANDATORY	maximum coordinate value in the "y" axis that defines the spatial extent.

6.1.9 GridInfo object

Table 13: GridInfo object

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
band_count	Integer	0/1	N/A	OPTIONAL	Number of bands contained in the gridded dataset. If absent, the raster is assumed with only one band.
bit_depth	CharacterString enumeration	1	N/A	MANDATORY	The bit depth (also known as pixel depth) of a cell determines the range of values that a particular raster file can store, which is based on the formula 2n (where n is the bit depth). For example, an 8-bit raster can have 256 unique values, which range from 0 to 255. Possible "bit_depth" values for this property: Bit depth (Range of values that each cell can contain): • 1-bit (0 to 1) • 2-bit (0 to 3) • 4-bit (0 to 15) • unsigned-8-bit (0 to 255) • signed-8-bit (-128 to 127) • unsigned-16-bit (0 to 65535) • signed-16-bit (-32768 to 32767) • unsigned-32-bit (0 to 4294967295) • signed-32-bit (-2147483648 to 2147483647) • floating-point-32-bit (-3.402823466e+38 to 3.402823466e+3)
columns	Long	1	N/A	MANDATORY	This property indicates the number of columns in the grid
rows	Long	1	N/A	MANDATORY	This property indicates the number of rows in the grid

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
no_data_value	Character string without length restriction	1	N/A	MANDATORY	Value used to represent the absence of data in a cell. The value must be in relation to the ranges used with the bit_depth property
start_cell	CharacterString enumeration	1	N/A	MANDATORY	This property indicates the starting cell of the raster. Possible values are: - "top-left" - "bottom-right"
compression_type	CharacterString enumeration	0/1	N/A	OPTIONAL	This property indicates compression method used to compress the information contained in the raster. Possible values are: - uncompressed - packbits - lzw - deflate - jpeg - ....

6.1.10 TemporalContext object

Table 14: TemporalContext object

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
trs	CharacterString enumeration	0/1	N/A	OPTIONAL	This property indicates the temporal reference system used to represent the time information. If the property is absent, default time reference system is "ISO 8601:2004" will be assumed.
reference_period	List of dates	1	N/A	OPTIONAL	The temporal reference property indicates an ordered list with all the years (or dates) comprehended in the information present in the dataset. Example: "reference_period": [2005, 2006, 2007, 2008]
extent	TemporalExtent Object	1	N/A	MANDATORY	The temporal extent property defines the global temporal extent of all the indicator values present in the dataset. This is the start and the end marks of the union of all the time periods covered by the indicator values. For example, if the indicator values existing in the dataset cover the years 2005, 2006, 2007 and 2008, the extent property must have the value "extent": { "start": 2005, "end": 2008}.

6.1.11 TemporalExtent object

Table 15: TemporalExtent object

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
start	Date	1	N/A	MANDATORY	The starting date

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
end	Date	1	N/A	MANDATORY	The ending date

6.1.12 Mapview object

Table 16: Mapview object

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
service_type	CharacterString enumeration	1	N/A	MANDATORY	The protocol (service type) of the mapping service. Similar to "protocol" property defined at resource level, but possible values are limited to: • ogc:wms • ogc:wms-t • osm • (maybe others?)
url	url CharacterString without length restriction	1	N/A	MANDATORY	The url with the complete WMS GetMap request (or similar request) used to obtain the rendered map image of the geospatial resource. Map clients using it should be able to use and modify the url in order to specifiy a different image format, width and height of the image or even provide a different SLD styling (if supported by both the client and the mapping service).

6.1.13 EU-GL object

Table 17: EU-GL object

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
workflow_step	List of CharacterString enumeration	1+	N/A	MANDATORY	The list of workflow steps where the resource can be used. Allowed values are: • eu-gl:hazard-characterization --> https://csis.myclimateservice.eu/taxonomy/eu-gl/hazard-characterization • eu-gl:hazard-characterization:local-effects --> https://csis.myclimateservice.eu/taxonomy/eu-gl/hazard-characterization/local-effects • eu-gl:exposure-evaluation --> https://csis.myclimateservice.eu/taxonomy/eu-gl/exposure-evaluation • eu-gl:vulnerability-analysis --> https://csis.myclimateservice.eu/taxonomy/eu-gl/vulnerability-analysis • eu-gl:risk-and-impact-assessment --> https://csis.myclimateservice.eu/taxonomy/eu-gl/risk-and-impact-assessment • eu-gl:adaptation-options:identification --> https://csis.myclimateservice.eu/taxonomy/eu-gl/adaptation-options/identification • eu-gl:adaptation-options:appraisal --> https://csis.myclimateservice.eu/taxonomy/eu-gl/adaptation-options/appraisal • eu-gl:adaptation-action-plans:implementation --> https://csis.myclimateservice.eu/taxonomy/eu-gl/adaptation-options/implementation • any
hazard	List of CharacterString enumeration	1+	N/A	MANDATORY	The hazard property describes to which hazard type is the resource related to. Its value can be one of the following list:

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
					• hazard:heat:heat-wave --> https://csis.myclimateservice.eu/taxonomy/hazard/heat/heat-weave • hazard:heat:extreme-heat --> https://csis.myclimateservice.eu/taxonomy/hazard/heat/extreme-heat • hazard:flood:extreme-precipitation --> https://csis.myclimateservice.eu/taxonomy/hazard/flood/extreme-precipitation • hazard:flood:wet-periods --> https://csis.myclimateservice.eu/taxonomy/hazard/flood/wet-periods • hazard:flood:river-flooding --> https://csis.myclimateservice.eu/taxonomy/hazard/flood/river-flooding • hazard:flood:pluvial-flooding --> https://csis.myclimateservice.eu/taxonomy/hazard/flood/pluvial-flooding • hazard:drought --> https://csis.myclimateservice.eu/taxonomy/hazard/drought • hazard:storm --> https://csis.myclimateservice.eu/taxonomy/hazard/storm • hazard:extreme-wind-speed --> https://csis.myclimateservice.eu/taxonomy/hazard/extreme-wind-speed • hazard:forest-fire --> https://csis.myclimateservice.eu/taxonomy/hazard/forest-fire • hazard:landslide --> https://csis.myclimateservice.eu/taxonomy/hazard/landslide • hazard:earthquake --> https://csis.myclimateservice.eu/taxonomy/hazard/earthquake • hazard:volcanic-eruption --> https://csis.myclimateservice.eu/taxonomy/hazard/volcanic-eruption • any --> the resource can be used in relation to any hazard.
resource_type	CharacterString enumeration	1	N/A	MANDATORY	The resource_type property indicates which kind of resource is provided for the analysis within the CSIS. Possible values are:

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
					• feature-parameters: resource used as input for some internal process within the CSIS/external expert that will typically produce an output shown and analyzed by the user in the CSIS • index: raster resource refererring to a hazard, local effects, vulnerability, exposure or impact index. If this value is used, then the index property (corresponding to any of these index types hazard|local_effect|vulnerability|exposure|impact) MUST be filled in as well. • vulnerabilty-function: tbd • adaptation-measures: tbd • others to be defined
index	CharacterString enumeration	0/1	N/A	OPTIONAL(*)	This property is MANDATORY if the resource is an index. Possible values are: For hazard and local-effects indexes: • hazard:heat:heat-wave:index:consecutive-summer-days --> https://csis.myclimateservice.eu/taxonomy/hazard/heat/heat-weave/index/consecutive-summer-days • hazard:heat:heat-wave:index:hot-period-duration --> https://csis.myclimateservice.eu/taxonomy/hazard/heat/heat-weave/index/hot-period-duration • hazard:heat:extreme-heat:index:hot-days-75p --> https://csis.myclimateservice.eu/taxonomy/hazard/heat/heat-weaves • hazard:heat:extreme-heat:index:hot-days --> https://csis.myclimateservice.eu/taxonomy/hazard/heat/heat-weaves • hazard:heat:extreme-heat:index:summer-days --> https://csis.myclimateservice.eu/taxonomy/hazard/heat/extreme-heat/index/summer-days • hazard:heat:extreme-heat:index:tropical-nights --> https://csis.myclimateservice.eu/taxonomy/hazard/heat/extreme-heat/index/tropical-nights

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
					▯ hazard:heat:extreme-heat:index:tx90p > https://csis.myclimateservice.eu/taxonomy/hazard/heat/extreme-heat/index/tx90p -- ▯ hazard:flood:extreme-precipitation:index:rx1day > https://csis.myclimateservice.eu/taxonomy/hazard/flood/extreme-precipitation/index/rx1day -- ▯ hazard:flood:extreme-precipitation:index:rx5day > https://csis.myclimateservice.eu/taxonomy/hazard/flood/extreme-precipitation/index/rx5day -- ▯ hazard:flood:extreme-precipitation:index:snow-days > https://csis.myclimateservice.eu/taxonomy/hazard/flood/extreme-precipitation/index/snow-days -- ▯ hazard:flood:wet-periods:index:consecutive-wet-days > https://csis.myclimateservice.eu/taxonomy/hazard/flood/wet-periods/index/consecutive-wet-days -- ▯ hazard:flood:wet-periods:index:wet-days > https://csis.myclimateservice.eu/taxonomy/hazard/flood/wet-periods/index/wet-days -- ▯ hazard:flood:wet-periods:index:very-heavy-precipitation-days > https://csis.myclimateservice.eu/taxonomy/hazard/flood/wet-periods/index/very-heavy-precipitation-days -- ▯ hazard:flood:wet-periods:index:wet-days-90p > https://csis.myclimateservice.eu/taxonomy/hazard/flood/wet-periods/index/wet-days-90p -- ▯ hazard:flood:river-flooding:index:flood-recurrence > https://csis.myclimateservice.eu/taxonomy/hazard/flood/river-flooding/index/ -- ▯ hazard:flood:river-flooding:index:river-flow > https://csis.myclimateservice.eu/taxonomy/hazard/flood/river-flooding/index/ -- ▯ hazard:flood:pluvial-flooding:index:water-runoff > https://csis.myclimateservice.eu/taxonomy/hazard/flood/pluvial-flooding/index/ --

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
					- hazard:drought:index:standardized-precipitation-index --> https://csis.myclimateservice.eu/taxonomy/hazard/drought/index/ - hazard:drought:index:consecutive-dry-days --> https://csis.myclimateservice.eu/taxonomy/hazard/drought/index/ - hazard:storm:index:???? --> https://csis.myclimateservice.eu/taxonomy/hazard/storm/index/???? - hazard:extreme-wind-speed:index:???? --> https://csis.myclimateservice.eu/taxonomy/hazard/extreme-wind-speed/index/????? - hazard:forest-fire:index:fire-weather-index --> https://csis.myclimateservice.eu/taxonomy/hazard/forest-fire/index/ - hazard:forest-fire:index:seasonal-severity-rating --> https://csis.myclimateservice.eu/taxonomy/hazard/forest-fire/index/ - hazard:landslide:index:susceptibility-levels-at-continental-scale --> https://csis.myclimateservice.eu/taxonomy/hazard/landslide/index/ - hazard:earthquake:index:???? --> https://csis.myclimateservice.eu/taxonomy/hazard/earthquake/index/???? - hazard:volcanic-eruption:index:volcanic-explosivity-index --> https://csis.myclimateservice.eu/taxonomy/hazard/volcanic-eruption/index/volcanic-explosivity-index For vulnerability indexes: - tbd - tbd - tbd For exposure indexes: - tbd - tbd

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
					tbd For impact indexes: tbd tbd tbd
threshold	List of Threshold Objects	0+	N/A	OPTIONAL(*)	
emissions_scenario	CharacterString enumeration	0/1	N/A	OPTIONAL(*)	This property indicates to which emissions scenario this resource refers to. Possible emission scenario values are: emissions-scenario:baseline --> https://csis.myclimateservice.eu/taxonomy/emissions-scenario/baseline emissions-scenario:rcp26-early-response --> https://csis.myclimateservice.eu/taxonomy/emissions-scenario/rcp26-early-response emissions-scenario:rcp45-effective-measures --> https://csis.myclimateservice.eu/taxonomy/emissions-scenario/rcp45-effective-measures emissions-scenario:rcp85-business-as-usual --> https://csis.myclimateservice.eu/taxonomy/emissions-scenario/rcp85-business-as-usual
category	List of CharacterString enumeration	0+	N/A	OPTIONAL(*)	Possible element at risk category values are: element_at_risk:population element_at_risk:buildings

Attribute			Obligation / Condition		Description
Name	Type	Multiplicity	FrictionlessData	CLARITY	
					• element_at_risk:infrastructure Possible element at risks class values are: For population: • element_at_risk_class:population:age_group_0to14 • element_at_risk_class:population:age_group_15to65 • element_at_risk_class:population:age_group_greaterthan65 For buildings: • element_at_risk_class:building:continuous-residential • element_at_risk_class:building:discontinuous-residential:low-density • element_at_risk_class:building:discontinuous-residential:medium-high-density For infrastructure (TBC): • element_at_risk_class:infrastructure:roads • element_at_risk_class:infrastructure:railway

6.1.14 Threshold object

Table 18: Threshold object

Attribute			Obligation / Condition		Description
Name	**Type**	**Multiplicity**	**FrictionlessData**	**CLARITY**	
name	CharacterString	1	N/A	MANDATORY	The label of the threshold
lower	float	0/1	N/A	OPTIONAL	The lower boundary of the threshold
upper	float	0/1	N/A	OPTIONAL	The upper boundary of the threshold
relative_to	CharacterString enumeration	0/1	N/A	OPTIONAL	If present, it is used to indicate that upper and lower represent percentages of other values (e.g. "increase in baseline")

6.2 Annex II - CLARITY data package Example: DC1 – Naples

Table 19: CLARITY data package Example: DC1 – Naples


```
{
  "name": "dc1-naples",
  "id": "http://github.com/clarity-h2020/data-package/examples/dc1-naples",
  "version": "0.0.1",
  "profile": "http://github.com/clarity-h2020/data-package/schemas/clarity-data-package.json",
  "title": "Naples Metropolitan Area data package",
  "description": "This is the CLARITY data package for the Naples metropolitan area corresponding to the Demonstrator Case (DC1). \r\n Further description to be completed",
  "keywords": [
    "naples",
    "dc1",
    "TBC"
  ],
  "created": "2019-01-02T16:23:43Z",
  "homepage": "http://www.clarity-h2020.eu",
  "language": "eng",
  "price": {
    "amount": 0.0,
    "currency": "EUR"
  },
  "sources": [],
  "contributors": [{
      "title": "Miguel Ángel Esbrí",
      "role": "author",
      "email": "miguel.esbri@atos.net",
      "organization": "Atos Spain",
      "path": "http://atos.net"
    },
    {
      "title": "Mario Núñez",
      "role": "author",
      "email": "mario.nunez@atos.net",
      "organization": "Atos Spain",
      "path": "http://atos.net"
    }
  ],
  "licenses": [{
    "name": "CC0-1.0",
    "title": "Creative Commons CCZero 1.0",
    "path": "https://creativecommons.org/publicdomain/zero/1.0/"
  }],
  "image": "data/logo/MyCS_48x48.png",
```

```
  "spatial_extent": {
    "xmin": 2145500,
    "ymin": 982500,
    "xmax": 6606000,
    "ymax": 5706500
  },
  "resources": [{
      "id": "http://github.com/clarity-h2020/data-package/examples/dc1-naples#r1",
      "name": "agricultural-areas",
      "title": "Agricultural areas in Naples metropolitan area",
      "description": "Agricultural areas in Naples metropolitan area",
      "profile":         "http://github.com/clarity-h2020/data-package/schemas/clarity-data-package-resource.json",
      "encoding": "binary",
      "format": "shape-zip",
      "mediatype": "application/shape-zip",
      "bytes": "37087552",
      "hash": "tbc",
      "path":                                                  "http://services.clarity-h2020.eu:8080/geoserver/clarity/ows?service=WFS&version=1.0.0&request=GetFeature&typeName=clarity:agricultural_areas&outputFormat=shape-zip",
      "schema":            "https://github.com/clarity-h2020/data-package/blob/master/schemas/input-layers/agricultural-areas.schema.json",
      "sources": [],
      "licenses": [{
        "name": "CC0-1.0",
        "title": "Creative Commons CCZero 1.0",
        "path": "https://creativecommons.org/publicdomain/zero/1.0/"
      }],
      "service_type": "ogc:wfs",
      "mapview": {
        "service_type": "ogc:wms",
        "url":                                                 "http://services.clarity-h2020.eu:8080/geoserver/clarity/ows?service=WMS&version=1.1.0&request=GetMap&layers=clarity:agricultural_areas&bbox=2145500.0%2C982500.0%2C6606000.0%2C5706500.0&width=725&height=768&srs=EPSG%3A3035&format=image%2Fpng"
      },
      "crs": "EPSG:3035",
      "spatial_extent": {
        "xmin": 0.0,
        "ymin": 0.0,
        "xmax": 0.0,
        "ymax": 0.0
      },
      "spatial_resolution": {
        "scale": 50000
      },
      "eu_gl": {
        "workflow_step": "any",
```

```
        "hazard": "any",
        "resource_type": "feature-parameters"
      }
    },
    {
      "id": "http://github.com/clarity-h2020/data-package/examples/dc1-naples#r2",
      "name": "hot-days-historical_19710101-20001231",
      "title": "Hot days > 75th percentile for the baseline emissions scenario in the 1971-2000 period",
      "description": "Number of days per year with a mean air temperature at 2 m above ground above the 75th percentile during summer months (Apr-Sep) for the baseline emissions scenario in the 1971-2000 period",
      "profile": "http://github.com/clarity-h2020/data-package/schemas/clarity-data-package-resource.json",
      "format": "tif",
      "mediatype": "application/x-gzip",
      "bytes": "358616146",
      "hash": "tbc",
      "path": "https://clarity.meteogrid.com/geoserver/wcs?SERVICE=WCS&VERSION=2.0.1&REQUEST=GetCoverage&COVERAGEID=clarity:Tx75p_consecutive_max_EUR-11_ICHEC-EC-EARTH_historical_r12i1p1_SMHI-RCA4_v1_day_19710101-20001231_netcdf3&FORMAT=application/x-gzip",
      "schema": {},
      "sources": [],
      "licenses": [{
        "name": "CC0-1.0",
        "title": "Creative Commons CCZero 1.0",
        "path": "https://creativecommons.org/publicdomain/zero/1.0/"
      }],
      "service_type": "ogc:wcs",
      "mapview": {
        "service_type": "ogc:wms",
        "url": "https://clarity.meteogrid.com/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=clarity:Tx75p_consecutive_max_EUR-11_ICHEC-EC-EARTH_historical_r12i1p1_SMHI-RCA4_v1_day_19710101-20001231_netcdf3&bbox=2145500.0%2C982500.0%2C6606000.0%2C5706500.0&width=725&height=768&srs=EPSG%3A3035&format=image%2Fpng"
      },
      "crs": "EPSG:3035",
      "spatial_extent": {
        "xmin": 2145500,
        "ymin": 982500,
        "xmax": 6606000,
        "ymax": 5706500
      },
      "resolution": {
        "distance": 500,
        "uom": "m"
      },
      "grid_info": {
        "band_count": 1,
```

```
        "bit_depth": "unsigned-32-bit",
        "columns": 9448,
        "rows": 8921,
        "no_data_value": 1e+20,
        "start_cell": "top-left",
        "compression_type": "none"
      },
      "trs": "ISO 8601:2004",
      "temporal_extent": {
        "start": "1971-01-01",
        "end": "2000-12-31"
      },
      "eu_gl": {
        "workflow_step": "hazard-characterization",
        "hazard": "hazard:heat:extreme-heat",
        "resource_type": "index",
        "index": "hazard:heat:extreme-heat:index:hot-days-75p",
        "emissions_scenario": "baseline",
        "threshold": [{
            "name": "low",
            "lower": "to-be-defined"
          },
          {
            "name": "medium",
            "lower": "to-be-defined",
            "upper": "to-be-defined"
          },
          {
            "name": "high",
            "upper": "to-be-defined"
          }
        ]
      }
    },
    {
      "id": "http://github.com/clarity-h2020/data-package/examples/dc1-naples#r3",
      "name": "hot-days-rcp26_20110101-20401231",
      "title": "Hot days > 75th percentile for the rcp26 emissions scenario in the 2011-2040 period",
      "description": "Number of days per year with a mean air temperature at 2 m above ground above the 75th percentile during summer months (Apr-Sep) for the rcp26 emissions scenario in the 2011-2040 period",
      "profile": "http://github.com/clarity-h2020/data-package/schemas/clarity-data-package-resource.json",
      "format": "tif",
      "mediatype": "application/x-gzip",
      "bytes": "358616146",
      "hash": "tbc",
```

```
      "path":
"https://clarity.meteogrid.com/geoserver/wcs?SERVICE=WCS&VERSION=2.0.1&REQUEST=GetCoverage&COVERAGEID=clarity:Tx75p_consecutive_max_EUR-11_ICHEC-EC-EARTH_rcp26_r12i1p1_SMHI-RCA4_v1_day_20110101-20401231_netcdf3&FORMAT=application/x-gzip",
      "schema": {},
      "sources": [],
      "licenses": [{
        "name": "CC0-1.0",
        "title": "Creative Commons CCZero 1.0",
        "path": "https://creativecommons.org/publicdomain/zero/1.0/"
      }],
      "service_type": "ogc:wcs",
      "mapview": {
        "service_type": "ogc:wms",
        "url":
"https://clarity.meteogrid.com/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=clarity:Tx75p_consecutive_max_EUR-11_ICHEC-EC-EARTH_rcp26_r12i1p1_SMHI-RCA4_v1_day_20110101-20401231_netcdf&bbox=2145500.0%2C982500.0%2C6606000.0%2C5706500.0&width=725&height=768&srs=EPSG%3A3035&format=image%2Fpng"
      },
      "crs": "EPSG:3035",
      "spatial_extent": {
        "xmin": 2145500,
        "ymin": 982500,
        "xmax": 6606000,
        "ymax": 5706500
      },
      "spatial_resolution": {
        "distance": 500,
        "uom": "m"
      },
      "grid_info": {
        "band_count": 1,
        "bit_depth": "unsigned-32-bit",
        "columns": 9448,
        "rows": 8921,
        "no_data_value": 1e+20,
        "start_cell": "top-left",
        "compression_type": "none"
      },
      "trs": "ISO 8601:2004",
      "temporal_extent": {
        "start": "2011-01-01",
        "end": "2040-12-31"
      },
      "eu_gl": {
        "workflow_step": "hazard-characterization",
        "hazard": "hazard:heat:extreme-heat",
        "resource_type": "index",
```

```
        "index": "hazard:heat:extreme-heat:index:hot-days-75p",
        "emissions_scenario": "early-response:rcp26",
        "threshold": [{
            "name": "low",
            "lower": "to-be-defined",
            "relative_to": "baseline"
          },
          {
            "name": "medium",
            "lower": "to-be-defined",
            "upper": "to-be-defined",
            "relative_to": "baseline"
          },
          {
            "name": "high",
            "upper": "to-be-defined",
            "relative_to": "baseline"
          }
        ]
      }
    },
    {
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      },
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        "ymin": 982500,
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        "hazard": "hazard:heat:extreme-heat",
        "resource_type": "index",
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        "threshold": [{
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            "lower": "to-be-defined",
            "upper": "to-be-defined",
            "relative_to": "baseline"
          },
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        }
      ]
    }
  },
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    "path": "https://clarity.meteogrid.com/geoserver/wcs?SERVICE=WCS&VERSION=2.0.1&REQUEST=GetCoverage&COVERAGEID=clarity:Tx75p_consecutive_max_EUR-11_ICHEC-EC-EARTH_rcp26_r12i1p1_SMHI-RCA4_v1_day_20710101-21001231_netcdf3&FORMAT=application/x-gzip",
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    "sources": [],
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        "index": "hazard:heat:extreme-heat:index:hot-days-75p",
        "emissions_scenario": "early-response:rcp26",
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            "relative_to": "baseline"
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"sources": [],
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  "title": "Creative Commons CCZero 1.0",
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},
"crs": "EPSG:3035",
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  "ymin": 982500,
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      },
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        "uom": "m"
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        "end": "2070-12-31"
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      "eu_gl": {
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            "relative_to": "baseline"
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          {
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"upper": "to-be-defined",
"relative_to": "baseline"
},
{
"name": "high",
"upper": "to-be-defined",
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"id": "http://github.com/clarity-h2020/data-package/examples/dc1-naples#r8",
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"mapview": {
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      "end": "2100-12-31"
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      "resource_type": "index",
      "index": "hazard:index:heat:extreme-heat:hot-days-75p",
      "emissions_scenario": "effective-measures:rcp45",
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          "relative_to": "baseline"
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        {
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          "lower": "to-be-defined",
          "upper": "to-be-defined",
          "relative_to": "baseline"
        },
        {
          "name": "high",
          "upper": "to-be-defined",
          "relative_to": "baseline"
        }
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      "sources": [],
      "licenses": [{
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        "path": "https://creativecommons.org/publicdomain/zero/1.0/"
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      "mapview": {
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        "distance": 500,
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      },
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        "rows": 8921,
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"workflow_step": "hazard-characterization",
"hazard": "hazard:heat:extreme-heat",
"resource_type": "index",
"index": "hazard:heat:extreme-heat:index:hot-days-75p",
"emissions_scenario": "business-as-usual:rcp85",
"threshold": [{
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"relative_to": "baseline"
},
{
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"upper": "to-be-defined",
"relative_to": "baseline"
},
{
"name": "high",
"upper": "to-be-defined",
"relative_to": "baseline"
}
]
}
}, {
"id": "http://github.com/clarity-h2020/data-package/examples/dc1-naples#r9",
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"title": "Hot days > 75th percentile for the rcp85 emissions scenario in the 2041-2070 period",
"description": "Number of days per year with a mean air temperature at 2 m above ground above the 75th percentile during summer months (Apr-Sep) for the rcp85 emissions scenario in the 2041-2070 period",
"profile": "http://github.com/clarity-h2020/data-package/schemas/clarity-data-package-resource.json",
"format": "tif",
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"sources": [],
"licenses": [{

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        "title": "Creative Commons CCZero 1.0",
        "path": "https://creativecommons.org/publicdomain/zero/1.0/"
      }],
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      "mapview": {
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        "url":
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        "no_data_value": 1e+20,
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        "compression_type": "none"
      },
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      "temporal_extent": {
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        "end": "2070-12-31"
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        "hazard": "hazard:heat:extreme-heat",
        "resource_type": "index",
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        "threshold": [{
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          {
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            "relative_to": "baseline"
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          {
            "name": "high",
            "upper": "to-be-defined",
            "relative_to": "baseline"
          }
        ]
      }
    }, {
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      }],
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        "url":
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      },
      "crs": "EPSG:3035",
      "spatial_extent": {
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    "ymax": 5706500
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  "temporal_extent": {
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    "end": "2100-12-31"
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    "hazard": "hazard:heat:extreme-heat",
    "resource_type": "index",
    "index": "hazard:heat:extreme-heat:index:hot-days-75p",
    "emissions_scenario": "business-as-usual:rcp85",
    "threshold": [{
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      },
      {
        "name": "medium",
        "lower": "to-be-defined",
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        "relative_to": "baseline"
      },
      {
        "name": "high",
        "upper": "to-be-defined",
        "relative_to": "baseline"
      }
    ]
  }
```

```
    }
  ]
}
```

6.3 Annex III - CLARITY local effects layers scripts

A set of bash scripts were implemented in order to facilitate the import, transformation, preparation and storage of the heterogeneous datasets that had to be integrated for producing the resulting layers consumed by the CSIS when carrying out the studies:

- European Settlement Maps (raster data) from Copernicus,
- Urban Atlas 2012 (vector data) from Copernicus,
- Street Tree Layer (raster data) from Copernicus,
- Basins and Streams from Copernicus (vector data),
- Mortality and population (csv data) from Eurostat.

All this information is needed by the scripts in order to produce data for local effects calculation described in section 4.2.2. Depending on its purpose they are classified in 4 different groups.

All scripts are in Github repository:

https://github.com/clarity-h2020/local-effects/tree/master/scripts/mario

Note: All references in this annex to CLARITY database are referring to CLARITY local effects database.

6.3.1 Setup

Essential scripts to prepare database structure where all data will be stored and determine which are going to be the available cities.

<u>European grid</u>

Just a simple script importing from a shapefile the grid for whole Europe in 500m resolution which is needed to determine land usage percentages during local effects calculation.

<u>Database tables</u>

A couple of scripts (one for each hazard) which creates tables in CLARITY database to store each layer data. Those are:

- Heat_wave_setup.sh, it creates CLARITY land use tables for local effects input layers 1 to 12.
- Pluvial_flood_setup.sh, it creates CLARITY streams and basins tables and imports original data from shapefile into database which will be used to generate basins and streams for CLARITY local effects input layers.

<u>Mortality</u>

This script creates a mortality table in CLARITY database and then is fed with all Eurostat data from a CSV file.

<u>Available cities</u>

City.sh script is the one which takes every city in Urban Atlas 2012 and for each one there, it checks the other data sources (Street Tree Layer, European Settlement Maps and mortality) to decide if a city is able to be included as an available city for CLARITY local effects calculation purposes. If so, the city is added to CLARITY database and linked with available mortality data. Also, its boundary is set to allow future spatial queries from CLARITY CSIS.

6.3.2 Management

Scripts which manages the local effects layers creation.

Load all

To ease local effects input layer generation this script will check each city in database seeking for those which have not been generated corresponding input layers. So, for each one of them it will call to load specific city script.

Load city

This script gets a specific city name which has to be loaded so it checks city name to be correct and existing in the CLARITY database as well as having no data for pluvial floods or heat wave hazards. Then it calls for main scripts of each hazard to generate all needed input layers for the city as well as generating land use grid percentages.

Delete city

Useful tool to check if a city is already in the CLARITY database or if it has any intermediate data generated also in the file system, in such a situation it cleans everything to ensure the system is in a consistent state.

Land grid

This process takes European LAEA-ETRS 500m grid file from the file system and imports into CLARITY database and then creates land use grid table for later use.

6.3.3 Heat waves

Specific scripts to generate local effects data for heat waves hazard.

Main

It is the process which checks a specific city to have input layers for heat wave local effects. If not, it gets all cells from European 500m grid matching the city. Then it gathers needed data from different data sources (European Settlement Maps, Urban Atlas 2012 and Street Tree Layer) into a temporal folder in the system which be used later by each layer script. Then it calls for each single layer script to generate them all for the current city and after all it delete temporal files in the file system.

Auxiliary layer (layers 9,10,11,12 combination)

This auxiliary layer is generated by extracting all urban fabric geometries from Urban Atlas data set and putting all of them together, then adding this resulting set of geometries into CLARITY database for further calculations during each land use script (layers 1-12) generation.

Land use (layers 1 to 12)

This describes a set of 12 scripts one for each land use layer. Each one of them focuses on extracting corresponding city data from data sources prepared in the file system by Heat wave main script.

The process consists on extracting urban atlas geometries for a specific land usage by using the corresponding code or doing a reclassification of values and rasterization in case of a raster data source like European Settlement Maps or Street Tree Layer. In some cases, both things are necessary, and results are combined before next step which is to cut all geometries by using the European Grid to obtain different groups of geometries for each European Grid cell, then those groups are put together as separate groups, one for each cell. This way each European Grid cell will contain only one single geometry for each land use. Then a process of difference computation is done, to obtain land use geometries being disjoint from other land usages, this guarantees not to have overlapping land usages anywhere.

Finally, all land use specific variables are set (albedo, emissivity, transmissivity, vegetation shadow, run-off coefficient, FUA tunnel, building shadow, hill shade building, context, etc.) by doing in some cases intersection checking's by using the auxiliary layer combined 9-12 described in previous section.

Land use percentages

Once a city has all needed input layers for heat wave local effects generated, this script can generate the land usage percentages for the city by linking each European 500m grid cell with the city and including those percentages for each of the 12 land usages on each single city grid cell by doing some calculations.

6.3.4 Pluvial floods

Specific scripts to generate local effects data for pluvial floods hazard.

Main

This script is the one in charge of check if a specific city has pluvial floods data already generated and if not, then generate either basins and streams for it. This means get all basins and streams intersecting city boundaries and set heights for streams extremes by using a Digital Elevation Model (DEM).

6.4 Annex IV - CLARITY local effects layers generation

This annex describes all steps taken in order to generate land use layers as input for local effect calculations.

6.4.1 Heat waves

This section describes how heat wave land use layers for local effects calculation are generated.

General approach

Geometries are extracted from Urban atlas dataset by using specific Urban Atlas codes depending on the land use to be extracted from all the content.

Then all extracted geometries are grouped and cut to generate a single geometry for each 500 x 500 meters cell of the European 500m ETRS LAEA grid to ease land u se percentages calculations for each grid cell.

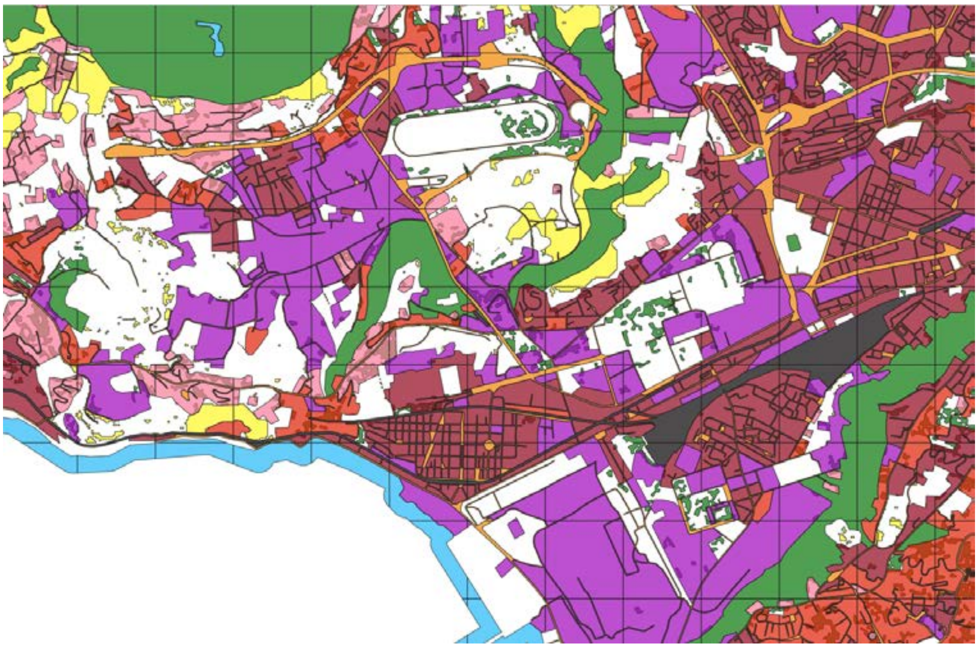


Figure 50: Grouped and gridded geometries data.

After that there is a difference computation with previous layers in order to guarantee geometries are not overlapping different land uses. This is valid only for layers 4 to 8.

Finally, every specific parameter is added/calculated for the specific land use.

Exceptions

In some cases, not only UA specific codes are extracted but also Street Tree Layer geometries are added. To avoid repeating information all geometries are merged together and then gridded by 500m.

In other layers there is also relevant data coming from different nature data sources like European Settlement Maps which is a raster dataset that must be converted into geometries in a polygonization process where values are continuous to obtain discretized values by using a specific threshold. This allows data to be merged with Urban Atlas vector-based information or simply to homogenize results for later usages and gives some pixel look like.

Figure 51: Grouped and gridded geometries from raster data.

6.4.2 Pluvial floods

This section describes how pluvial floods layers for local effects calculation are being generated.

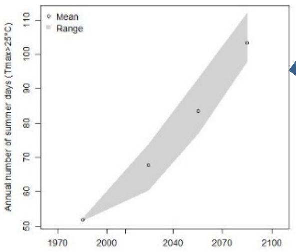
Basins

This layer is easily generated for a specific city by obtaining those European basins which intersect the city boundaries.

Streams

For a specific city, first the streams are obtained by doing intersection of European streams with the city boundary. After that a Digital Elevation Model will determine the altitude of each starting and end point of every stream in the area.

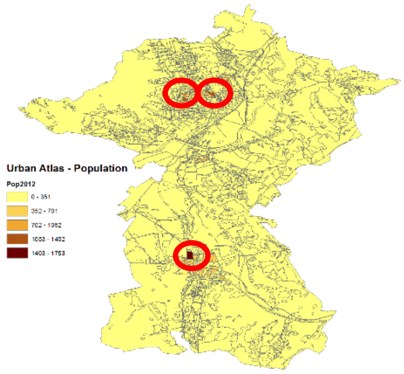
Hazard: Increase in heat stress due to longer periods with high temperature



Local scale: Urban heat island effect (UHI)

Cities are warmer than their rural surroundings, due to e.g. heat storage by built-up structures, etc.

Exposure: Location of elements at risk (people)

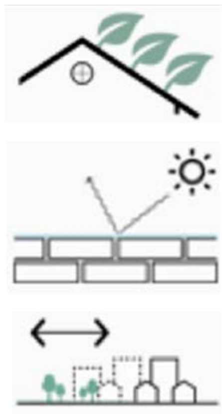


Vulnerability: Who is most vulnerable?

Most vulnerable: Babies and children, old people, sick people

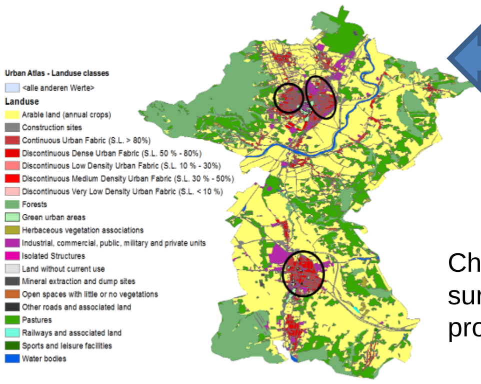
Pay special attention to: Lone pensioner households, retirement homes, daycare for kids, hospitals

Adaptation Options



Change of surface properties

Change of surface properties can reduce the UHI effect



Screening Study Results

1 HAZARD CHARACTERIZATION

The first step to build an adaptation strategy is to identify **hazard conditions** in the project area, in relation to a range of climate variables and natural hazards. This has to be done both for the current climate and for the predicted future climate in the project area. Here, the "business-as-usual" (also referred to as the "worst-case") scenario (RCP8.5) is considered.

For the hazard characterization at European scale EURO-CORDEX data are used to calculate climate indices for the baseline (1971-2000) and future (2011-2040, 2041-2070, 2071-2100) periods. The spatial resolution is approximately 12 km.

HAZARD: HEAT

Figure 1 shows a steady increase in number of summer days (Tmax > 25°C, days with temperatures over 25°C) and number of hot days (Tmax > 30°C, days with temperatures over 30°C) is projected for Alba Iulia.

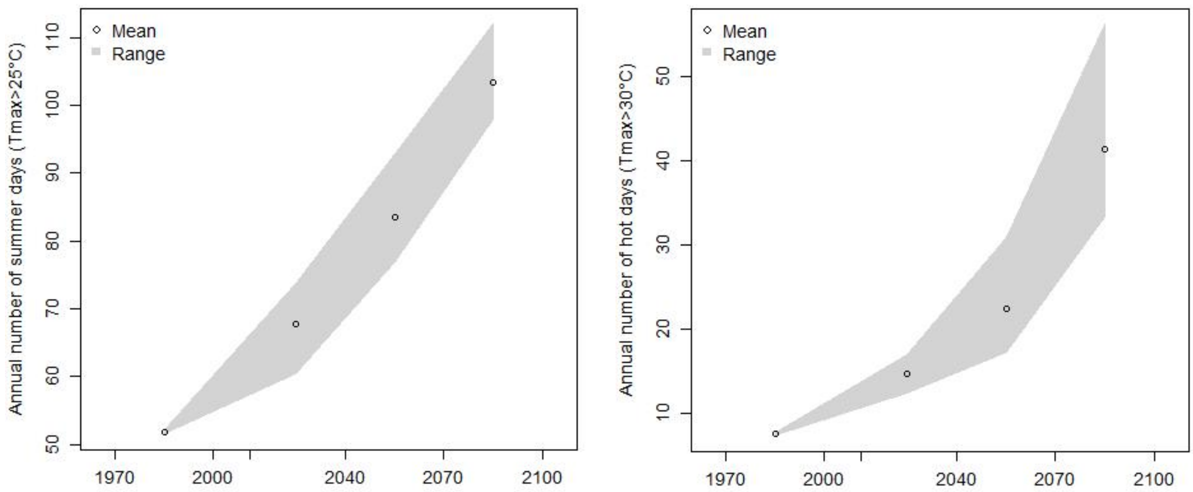


Figure 1: Increase in number of summer days (left) and number of hot days (right) for Alba Iulia for the 30-year periods (preliminary results - data based on four bias corrected EURO-CORDEX simulations with scenario RCP8.5 (worst case))

Climate indices calculated from EURO-CORDEX data alone display the general trend, but do not take into account that urban characteristics (lack of vegetation, paved surfaces, accumulation of built-up structures) also have an effect on the local / micro-climate. Due to e.g. high absorption of solar radiation on paved surfaces, heat storage of built-up structures, a lack of vegetation, less circulation etc. cities are generally warmer than their rural surroundings (**Urban Heat Island (UHI) effect**). Thus, the actual number of summer days, heat days etc. in the city will quite likely be higher than illustrated here.

HAZARD: RAIN

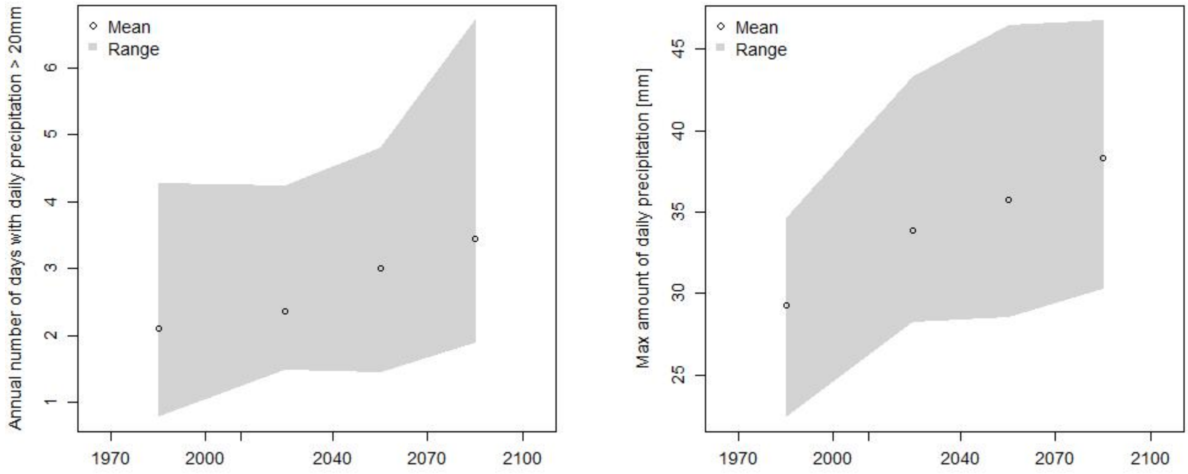


Figure 2: Change in the mean annual number of days with a daily precipitation of at least 20 mm (left) and change of the maximum amount of daily precipitation in mm (right) for Alba Iulia (preliminary results - data based on 17 EURO-CORDEX (not bias corrected) simulations with scenario RCP8.5 (worst case))

The change of the number of days per year with daily precipitation equal or greater than 20mm and the change of the annual maximum daily precipitation amount (in mm), based on EURO-CORDEX simulations, from the baseline period (1971-2000) to the future period 2071-2100, is displayed in Figure 2.

Pluvial flooding risk can increase not only due to a change in climate but also due to growing cities and an increase in sealed surfaces. Urban characteristics (permeability of surfaces, drainage system capacity, etc. – see Figure 3) influence how much rain is being converted to surface runoff (water not infiltrating in the ground). Topography determines where the water will flow and potentially accumulate (not shown).

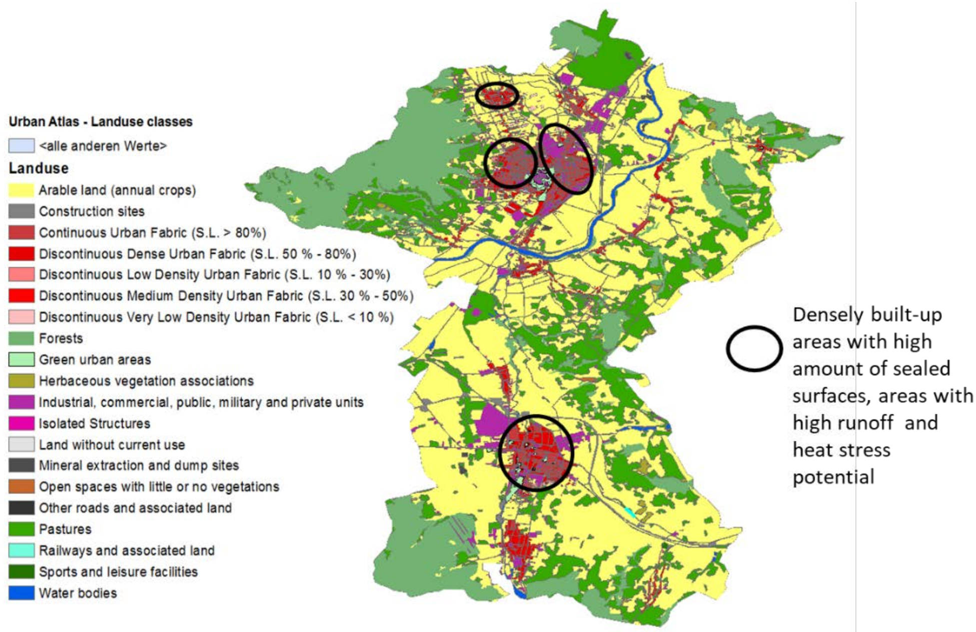


Figure 3: Land use map for Alba Iulia from Urban Atlas (Copernicus). Black circles highlight areas, which are densely build and have a high number of sealed surfaces and should be investigated further with regards to pluvial flooding and heat.

2 Exposure evaluation

Once the **hazard characterization** in the project area has been assessed, the next step is to evaluate **exposure** to climate hazards **of the elements at risk** considered (e.g. population, buildings, infrastructures, etc.) relevant at the project location(s). The exposure is the quantitative distribution, in space and time, of elements exposed.

Depending of the hazard, the following maps are of interest in that respect:

- Population distribution (see Figure 4): for heat hazard, forest fire, flood
- Map with buildings / critical infrastructure (see Figure 5): for floods, forest fire
- Forest map: for forest fire, drought

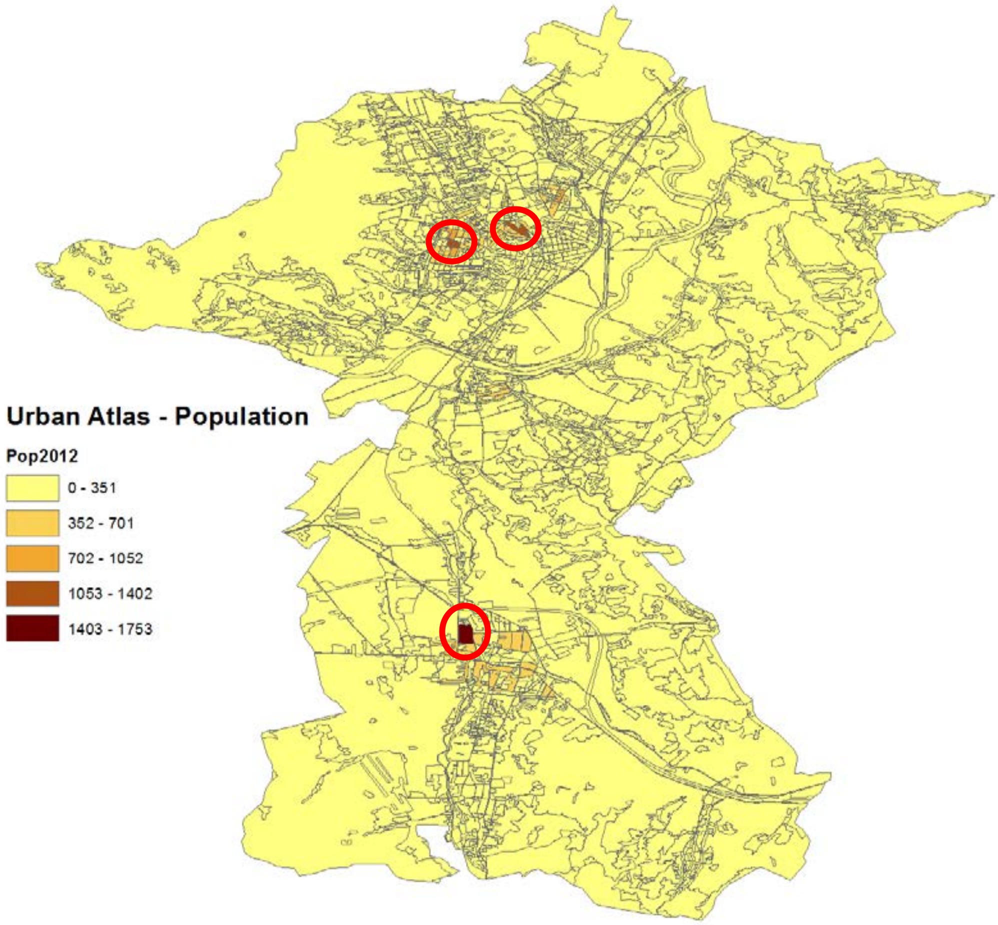


Figure 4: Population distribution for Alba Iulia from Urban Atlas (Copernicus). Red circles highlight areas where most people live.

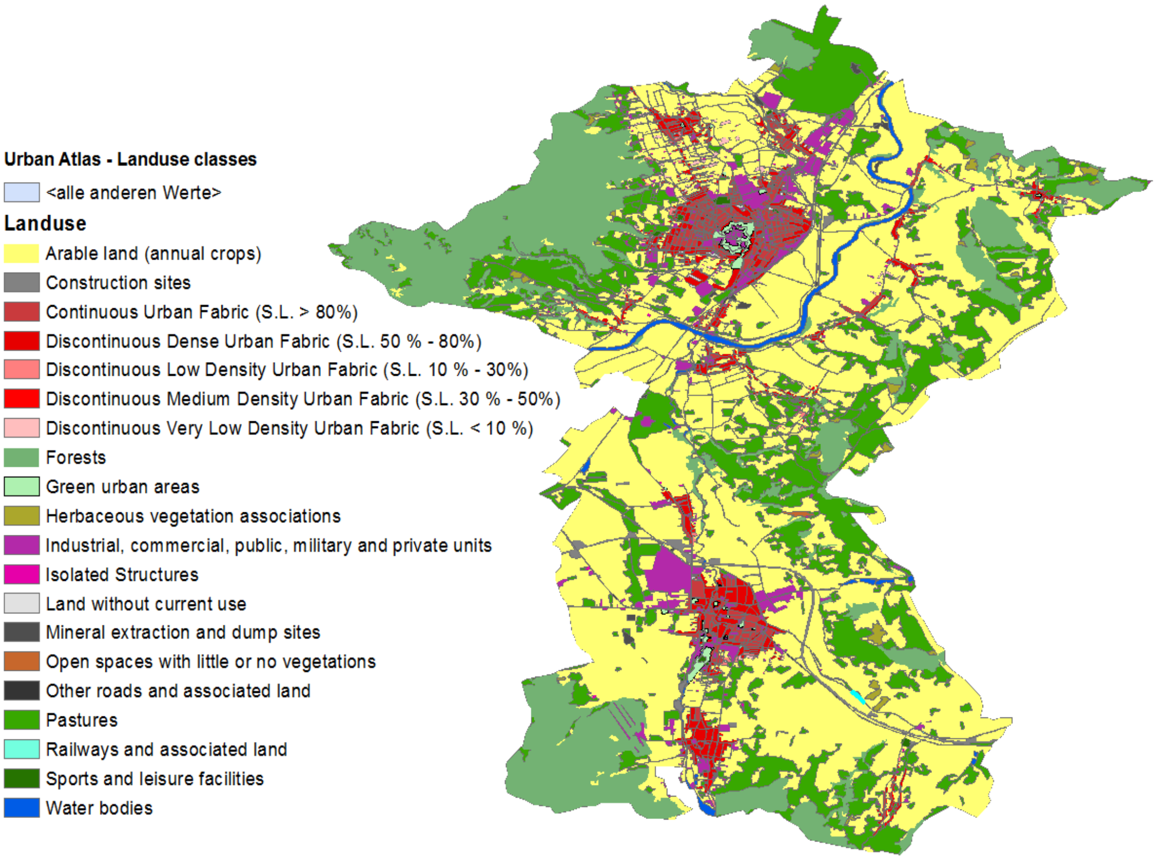


Figure 5: Land use map for Alba Iulia from Urban Atlas (Copernicus), showing the location of urban fabric and industrial, commercial, public, military and private units, which could be adversely affected in case of pluvial flooding or fluvial flooding in that area.

3 Vulnerability analysis

In addition to exposure, the **vulnerability of the elements at risk to the current and to the expected future climate** needs to be assessed. The vulnerability is the probability that a given exposed element is damaged by a given hazard intensity.

You may also want to consult the Climate Adapt website for additional information such as for example a list of potentially vulnerable urban sectors.

Hazard: Heat

Most vulnerable people: young children, elderly people, sick people

Check locations of: Lone-pensioner households, kindergartens, hospitals, retirement homes

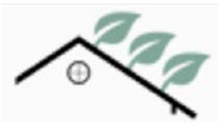
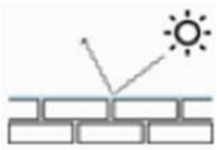
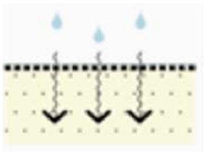
An increase in temperature can lead to a higher discomfort, illness and increased mortality rate.

Hazard: Heavy Rain

A high rain intensity can lead to pluvial flooding and thus can cause damage to buildings, critical infrastructure, but also can have a negative effect on rivers and lakes, where storm water is being discharged (potentially without treatment).

Adaptation Options

List of adaptation options (short version)

Adaptation option	Adaptation goal	Co-benefits	Costs
Green roofs 	Reduce heat Reduce pluvial flood risk	Multifunctional space usage: ++ Air quality: + Energy efficiency: ++ Biodiversity: +++	New development: €€ Retrofitting: €€€ Maintenance: €
Cool pavements and building materials 	Reduce heat risk	Energy efficiency: +	New development: € Retrofitting: € Maintenance: N/A
Reduced paved surfaces 	Reduce heat risk Reduce (pluvial) flood risk	Air quality: + Energy efficiency: + Biodiversity: +++	New development: €€ Retrofitting: N/A Maintenance: N/A
Permeable pavements 	Reduce (pluvial) flood risk Reduce heat risk	Multifunctional space usage: +	New development: € Retrofitting: €€€ Maintenance: after approx. 10 years

Why do these options help adapt?

Hazard: Heat

Urban heat islands are caused by many different factors. On the one hand, urban surfaces, such as buildings, roads and parking lots, absorb more heat than the city's surroundings. Using **"cool materials"**, with lighter colors hence reflecting more solar radiation, can alleviate the heating effect. In rural areas on the other hand, plants and trees provide shade, store less heat and allow for cooling through additional evaporation of water. This effect is much reduced in paved and build-up environments. **Permeable pavements** or a **reduction of the number of paved surfaces**, which allow for the interception of rainwater and subsequent evaporative cooling, are a possibility. Similar cooling effects can be achieved by **vegetation** such as parks and trees or

green roofs. Additionally, these solutions provide water management support, relieving the drainage system during periods of heavy rain.

Hazard: Heavy precipitation / pluvial flood

A **reduction of sealed, impervious surfaces helps the infiltration of storm (rain) water** in the underlying ground. In this way, runoff into the sewage system and urban spaces is reduced, thereby lessening the risk of damage by flooding. Examples of such surfaces include **soil and vegetation systems** such as green roofs or grassed tramway tracks as well as permeable pavements. Also **storm water retention ponds** or basins can be considered to harvest rainwater.

Best-practice examples

Green roofs: not only cooling the city, but also your building

Green roofs (Figure 6) help **counteract the urban heat island** and benefit the local climate by **reducing temperatures** in the urban canyon. At the same time, **building energy efficiency** can be improved using green roof solutions. With such a roof, less heat is transferred to the building below, increasing indoor comfort and saving energy needed for cooling. Also, during winter, the insulating effect ensures less energy is required for heating than under a conventional roof. Additionally, these roofs support **storm water runoff management**.

Figure 6: Green roofs not only counteract the urban heat island, but also increase the energy efficiency of buildings.

The implementation of green roofs can be supported in a variety of ways. **Policy and regulations** (either federal, regional or local) may include the uptake of a green roof strategy in urban landscape planning, as can e.g. be found in the Urban Heat Island Strategy Plan for the City of Vienna (Austria). Also green roof incentive programs, such as in place in the City of Hamburg (Germany), where subsidies are provided for building owners installing a green roof, can be considered. **Scientific support**, through collaborations with research institutes or contracts with consultancy companies, is important **to make sure the most efficient solutions are being considered** (see also 'Determining the local effect of adaptation options for Linz').

Determining the local effect of adaptation options for Linz - CLARITY expert study

When considering adaptation options, it is important to **consider the specific local conditions**. **Urban climate models** enable analysis of atmospheric and surfaces processes in the build environment on a spatial and temporal scales that can meet the specific needs for the urban planning. Using urban climate simulations to map existing urban heat island effect, it is possible to **identify critical zones** in the city with increased environmental risks (Figure 7, left panel) as well as to **evaluate the effectiveness of possible urban planning measures to reduce the heat load** (Figure 7, right panels).

Possible optimization of thermal properties of buildings and open spaces through increased proportion of green and water areas, use of green roofs and façades and application of reflective surfaces can be examined to provide accurate and detailed environmental information. In this way, urban climate modelling can help urban planners to find optimal, cost-effective, scientifically sound and consistent solutions for sustainable, future-oriented cities.

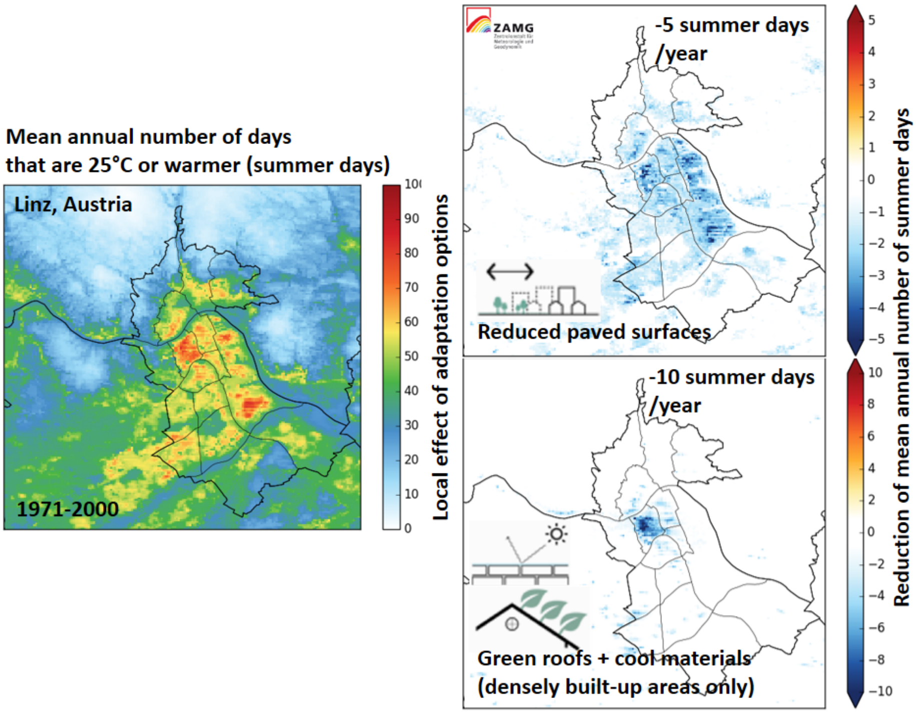


Figure 7: The ‘hot spot’ analysis for Linz (left) identifies critical zones. To aid the identification of efficient adaptation options, the local effect of e.g. a reduction of paved surfaces (top right) and a combination of green roofs and cool materials (bottom right) is analyzed as well.

Text in the Section ‘Adaptation Options’ partially based on the ZAMG Urban Modelling flyer (2017) as well as the article ‘Our hot future is here’, which appeared in Shared Cities Magazine, September 2019 (https://www.sharedcities.eu/wp-content/uploads/2019/09/Cities-Magazine-3.pdf).