D6.6 CLARITY Guideline v1

WP6 – Dissemination and Community Building

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CLARITY Project Overview

Urban areas and transportation infrastructure 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 (7th Framework Programme) climate change, future internet and crisis preparedness projects (SUDPLAN, ENVIROFI, CRISMA) with an average Technical Readiness LEVEL (TRL) of 4-5 and following an agile and user-centred design process, end-users, purveyors and providers of climate intelligence CLARITY co-create an integrated Climate Services Information System (CSIS) to integrate resilience into urban infrastructure and look into the way to adjust the CSIS to transport infrastructure.

As a result, CLARITY provides an operational eco-system of cloud-based climate services to calculate and present the expected effects of Climate Change (CC)-induced and -amplified hazards at the level of risk, vulnerability and impact functions. CLARITY offers 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. Three demonstration cases showcase CLARITY climate services in different climatic, regional, infrastructure and hazard contexts in Italy, Sweden, and Austria; focusing on the planning and implementation of urban infrastructure development projects. A fourth demonstration case in Spain illustrates how the expected effects of CC hazards and risk can be assessed in the case of road transport infrastructure and the flexibility of the CSIS system to adapt to other sectors.

CLARITY provides 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.

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Abbreviations and Glossary

A common glossary of terms for all CLARITY deliverables, as well as a list of abbreviations, can be found in the public document "CLARITY Glossary" available at CLARITY-H2020.eu.

The following table was generated from http://cat.clarity-h2020.eu/glossary?machine_name%5B%5D=abbreviations_and_acronyms on February 11th, 2019 and contains all the acronyms of interest for this deliverable.

Name	Term description
AIT	Austrian Institute of Technology GmbH.
AR5	Fifth Assessment Report of the Intergovernmental Panel on Climate Change
CC	Climate Change
CLARITY	Integrated Climate Adaptation Service Tools for Improving Resilience Measure
CSIS	CLARITY Climate Services Information System
EC	European Commission
EU-GL	Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient (Document). Also, CLARITY methodology based on original EU-GL
IPCC	Intergovernmental Panel on Climate Change
PLINIVS-LUPT	Study Centre for Hydrogeological, Volcanic and Seismic Engineering of LUPT Research Interdepartmental Centre, University of Naples Federico II.
RCP	Representative Concentration Pathway
TRL	Technology Readiness Level
UHI	Urban Heat Islands
ZAMG	Zentralanstalt für Meteorologie und Geodynamik (Austria)

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The following table contains EU-GL Methodology terms used in the CLARITY project. Complete description can be found in the "CLARITY Glossary" available at http://cat.clarity-h2020.eu/glossary?machine_name%5B%5D=eu_gl_methodology_terms.

Name	Term description
Hazard	The potential occurrence of a natural or human-induced physical *event* or trend or physical *impact* that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, *service* provision, ecosystems, and environmental resources (IPCC, 2014). In the IPCC context, the term *hazard* usually refers to climate-related physical events or trends or their physical impacts. (IPCC, 2014).
Exposure	The presence of people, infrastructure, housing, production capacities and other tangible human assets in hazard-prone areas.
Vulnerability	The probability of a given element at risk, classified as part of a specific Vulnerability class, to be affected by a level of damage, according to a prefixed scale of damages, under a given hazard intensity (Glossary of the CLARITY Proposal).
Risk Analysis	Risk is the potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. (IPCC, 2014). Risk Analysis is a systematic use of available information to determine how often specified events may occur and the magnitude of their likely consequences (CRISMA Project glossary).
Impact Scenario Analysis	In probabilistic terms choosing in a deterministic way one or more significant events, among actually occurred past events or as a result of numerical hazard simulation models, shall be obtained as damage evaluation following a specific event.
Adaptation Options	The array of strategies and measures that are available and appropriate for addressing adaptation needs. They include a wide range of actions that can be categorized as structural, institutional, or social (IPCC, 2014).
Decision Support	Functions that help in evaluating the data and deciding what to do.
Action Plan	Functions that help in establishing the report / implementation plan / guideline.
Integration	Integration of adaptation plan into the project.

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Executive Summary

This document is deliverable D6.6 CLARITY Guideline v1” of the CLARITY project (H2020, Contract number 730355).

CLARITY provides data and climate, risk and impact assessments at different levels of detail and accuracy. Each of these levels targets different needs and can be roughly separated into “screening” and “expert studies”. In addition, it also provides an online marketplace where the needs of the planners and decision makers are automatically matched to the know-how, data, service and product offers. **This deliverable presents the guidelines for using the CLARITY online services.**

At the level of screening, users, who aren’t climate science experts, can use the online CLARITY services to rapidly assess the level of impact climate change will have at their projects and perform an initial analysis of the possible adaptation options and their effects. Screening services further subdivide in three distinct classes:

Simple screening allows service users to overlay 21 CLARITY climate hazard indices with land use data. This type of screening works in the whole Europe and allows the users to rapidly compare the past and future climate scenarios and estimate the change in the risk situation. The downside of the simple screening is the low spatial resolution of the hazard indices and lack of numeric values for the risk/impact estimates.

Advanced urban screening provides automated downscaling of two hazard/exposure pairs that are of great societal interest. These are heat/population and the flash floods / urban infrastructure. Service is available in the large number (over 450) of European urban areas where a large majority of all EU population lives and provides estimates (numeric values) of hazard, exposure and various impact parameters at a $500x500m^2$ scale.

Finally, the ***transport infrastructure screening*** service targets the stakeholders involved in 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 and allows forecasting of human and material resources in seasonal periods. This screening is possible in the whole EU but provides improved functionality in Spain where additional input data is available.

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1 Introduction

This document provides an overview of the “tutorial” materials that were produced by CLARITY project.

Reflecting the nature of the project and the zeitgeist, large majority of these materials is in the form of power point presentations and webinar videos rather than in the form of printable MS word or PDF documents. These video materials are available at **CLARITY Climate Adaptation Goto~~s~~Stage channel** **https://www.gotostage.com/channel/climate-adaptation**[1].

This document provides transcripts for some of these materials as well as annotated links to video tutorials. Our expectation is that a great majority of the potential users will prefer watching a video tutorial or browsing through a presentation to reading pages and pages of text.

1.1 Structure of Deliverables

Section 1 presents the structure of this deliverable and summarizes the main project objectives and outcomes. Section 2 presents the CLARITY methodology that is used for both the online services and for the expert studies. Section 3 explains what the CLARITY online services do and how to use them. Finally, the section 4 provides conclusions and outlook for a second release of this document.

[1] Some, but not all, are also available at YouTube and linked through https://myclimateservices.eu/ site.

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1.2 What is CLARITY

CLARITY is a project designed to provide users with a baseline investigation of future climate hazards and their impacts in their chosen region. It provides data and climate, risk and impact assessments at different levels of detail and accuracy. Each of these levels targets different needs and can be roughly separated into **online "screening services"** (section 4) and **offline "expert services"** that are not in the scope of this document. More specifically, CLARITY's key objective is to examine climate-related effects and provide a risk assessment, evaluate climate-change adaption strategies and integrate these adaption measures for sustainable urban development.

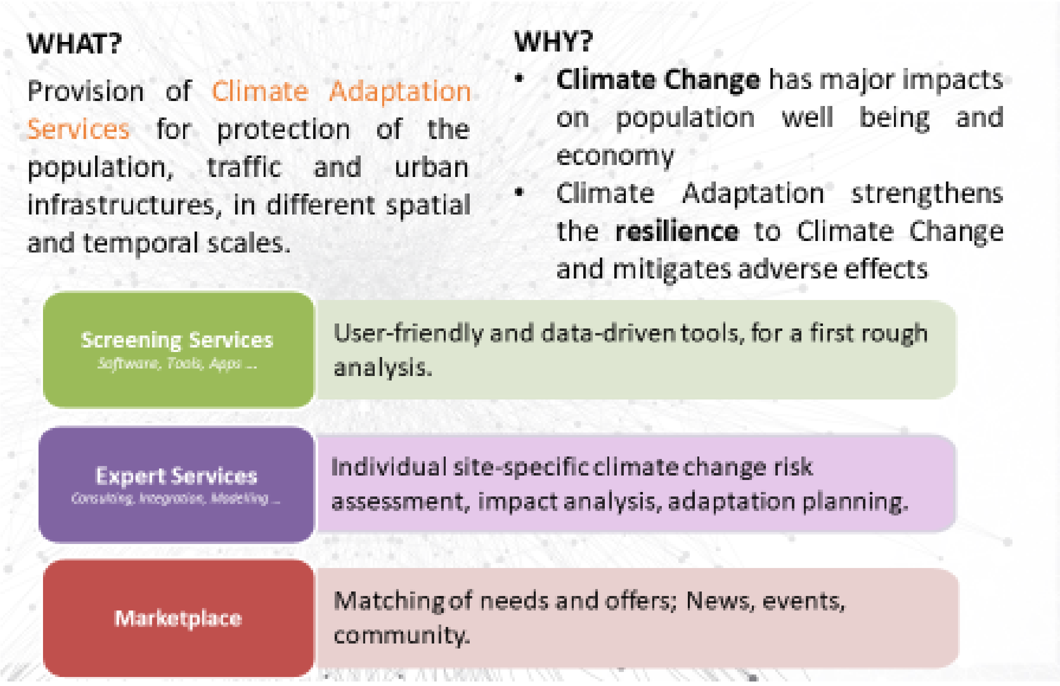

Figure 1: The nature and purpose of CLARITY

A very short video introduction to the CLARITY project is available at CLARITY climate adaptation GotoStage channel:

- https://www.gotostage.com/channel/8a129bbaf5ef40519cd825c902c8e67a/recording/f0d77d8492654cc3bf281460793dbd17/watch

1.3 The importance of CLARITY

Earth's climate is currently undergoing drastic changes. The global average temperature is continually rising due to the enhanced greenhouse gas effect. The anthropogenic-induced increased release of greenhouse gases such as CO_2 and CH_4 into the atmosphere have caused regional and continental fluctuations in earth's climate zones (Figure 1). Extreme weather events, heat and cold waves, heavy local precipitation and far-spreading droughts, all occurring at an increased frequency and magnitude as the burning of fossil fuels (among others) goes unchecked.

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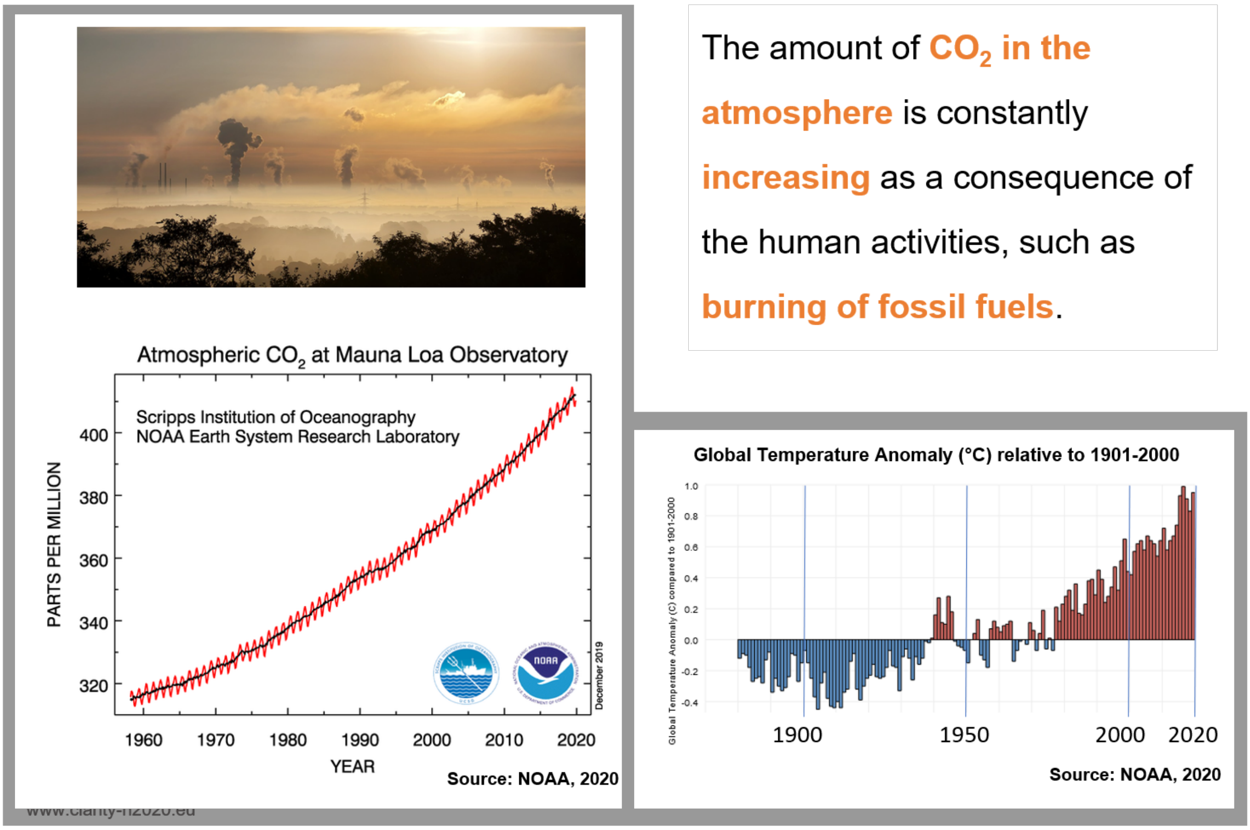

Figure 2: Changes in CO2 concentration and the global temperature anomaly (Source: NOAA).

Climate change is not "just a theory" or a possible future threat. Many people are already suffering from the consequences of climate change. The heat wave in 2003, for instance, has claimed more than 70 000 deaths in Europe alone[2]. Our models show that such heat waves could become very common in the future.

Following video summarizes the high-level estimates for climate change effects in different European regions and highlights the role of CLARITY in their mitigation:

- https://www.gotostage.com/channel/8a129bbaf5ef40519cd825c902c8e67a/recording/337033a47d4d4e418152ae18f00c22c7/watch

It is considered impossible to completely reverse these effects of climatic hazards in foreseeable future. However, it is still possible to mitigate their impacts, especially in the urban areas where most people live. There are many adaptation and mitigation options and strategies available and CLARITY helps its users to find and select the options suitable for their selected regions and hazards. It is a simple, but powerful tool, which allows users to identify potential hazards, investigate their impacts on exposed elements (populations, etc.) select available adaptation options and examine their effect on the identified hazards in less than a day. If the user requires more detailed information tailored to their needs, CLARITY offers so-called expert studies that provides in-depth customized studies for a user's intended region. In short, CLARITY delivers impactful data and vital information validated against more powerful systems that will help any stakeholder to get their important messages concerning climate change across.

[2] https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

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1.4 CLARITY Services

CLARITY offers services at two levels of detail: (1) online "screening" level services, which provide available data and climate evaluations at demand, and (2) offline "expert" level services, which supplements the screening level study with additional, high resolution data and climate analyses customized to the user needs and emphasis. Both service types follow the same methodology (Section 2), with the difference being that the expert level provides higher data resolution, additional datasets, and an analysis better tailored to the urban area or infrastructure project investigated (Figure 3).

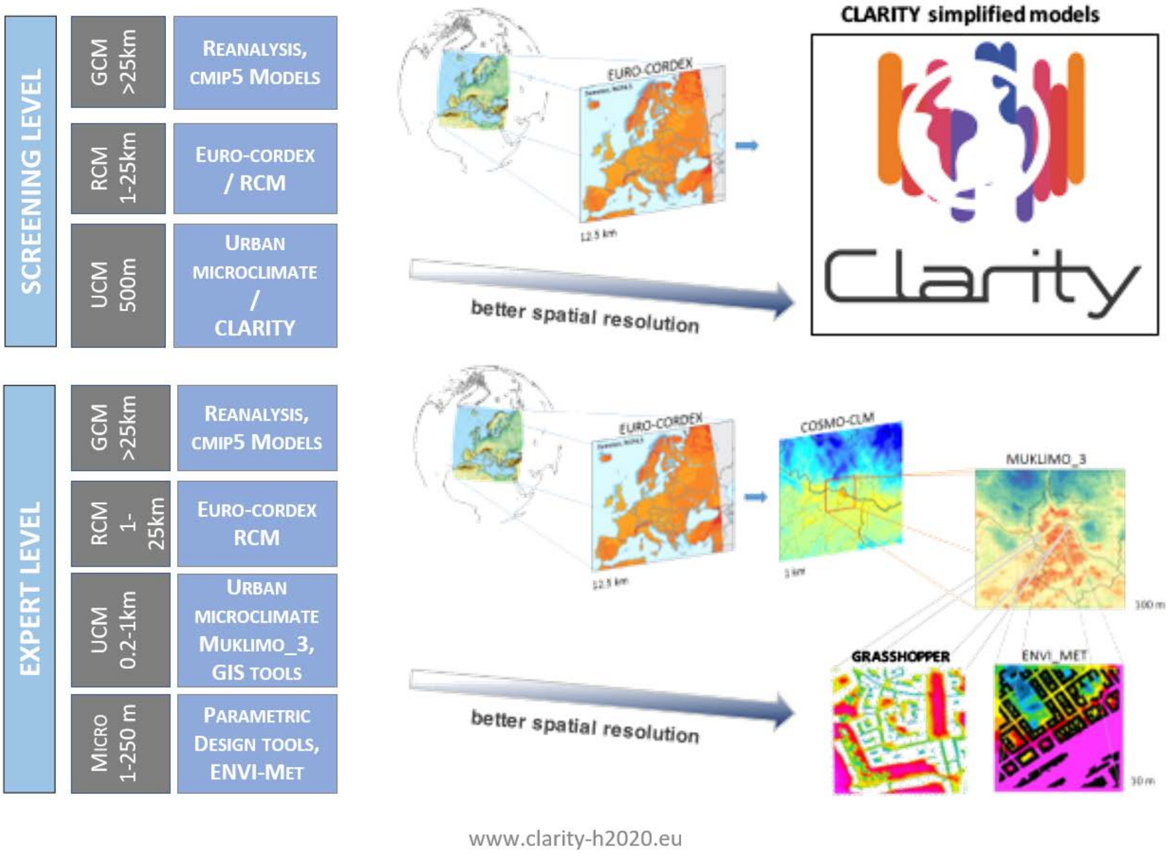

Figure 3: Models used in CLARITY screening and expert studies.

Depending on the user needs, the expert analysis can also focus on certain steps of the CLARITY methodology, such as hazard characterisation and adaptation option assessment only. In this case, the CLARITY framework and CSIS (climate system information service) screening study help to ensure that the remaining steps are considered in a qualitative way. CLARITY allows users to explore various resilience scenarios for their projects considering

1. variable local context
2. climate intelligence provided by experts
3. for the project customized risk analysis
4. varying impact scenarios
5. flexible adaptation and alternative options
6. integration into action plans

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1.5 The Marketplace

The marketplace provides users with the possibility to connect with similarly orientated people, initiatives and organizations from various backgrounds. The marketplace is a service that allows experts to present their ideas, concepts and strategies and advertise their solutions to given problems. Project managers on the other hand can promote their project, look at similar projects or search for options offered that might be suitable for their projects. Alternatively, they can also seek to collaborate on a (new) project through calling for partners. This opportunity is open to experts and project managers also on peer-level in order to drive co-development and knowledge transfer (**Figure 4**).

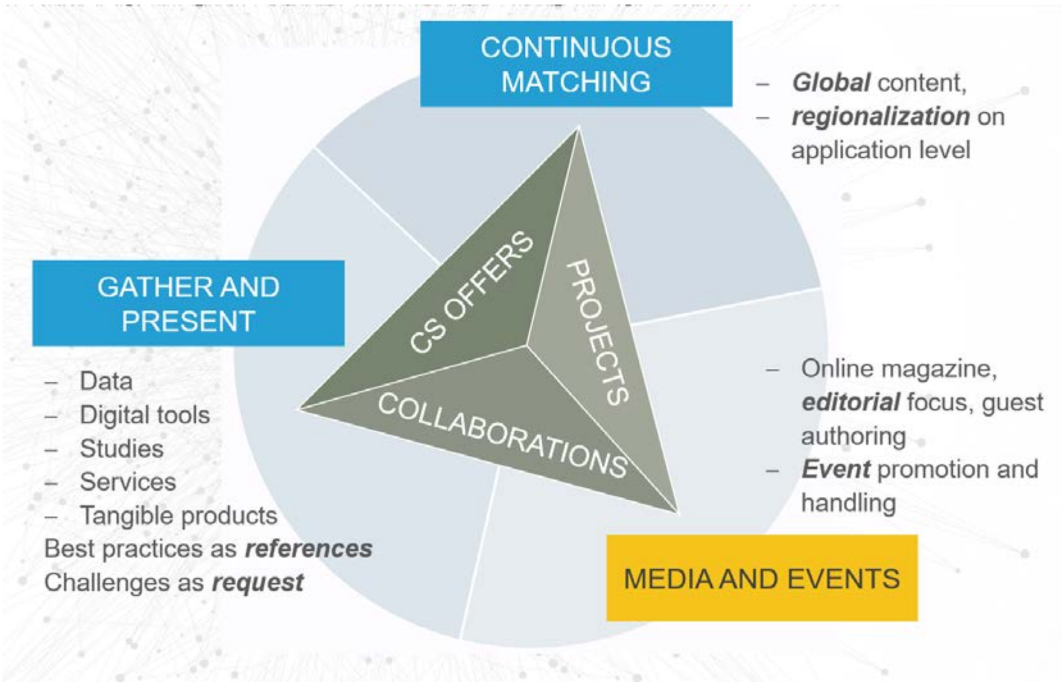

Figure 4: Three main facets of the Clarity Climate Adaptation Marketplace

Short introduction to marketplace is available on CLARITY climate adaptation GotoStage channel:

- https://www.gotostage.com/channel/8a129bbaf5ef40519cd825c902c8e67a/recording/9263a37c76854cff892a6b1e94122832/watch

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2 CLARITY Methodology and Data

All clarity services and studies follow the same methodological approach, which is based on the “Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient” (EU-GL) [1] The EU-GL methodology has been updated by CLARITY to comply with the Fifth Assessment Report (AR5) [2] of the Intergovernmental Panel on Climate Change (IPCC) in order to promote an integrated modelling approach of Disaster Risk Reduction and Climate Change Adaptation

In this document, we will primarily illustrate how EU-GL is supported in CLARTIY online tools, most notably in the advanced urban screening workflow.

At a functional level, there is no difference between the “old” EU-GL and the updated CLARITY methodology. For convenience, we have therefore decided to continue calling the updated methodology EU-GL and recommend its use for all climate adaptation/resilience planning tools and studies in and beyond Europe. “CLARITY methodology” or “CLARITY EU-GL” will be used when differentiation is deemed necessary in this document.

The 7 steps of the updated “CLARITY EU-GL” methodology are illustrated in **Figure 5** and explained in details in CLARITY public deliverable “D3.1 Science Support Plan and Concept”.

Figure 5: The 7 steps of the CLARITY methodology

A very short video introduction to the CLARITY EU-GL methodology is available at our “climate adaptation” GotoStage channel:

- https://www.gotostage.com/channel/8a129bbaf5ef40519cd825c902c8e67a/recording/f518a5be0b3e4687b892678e44e0fbc4/watch

Moreover, detailed descriptions of all models that were used in CLARITY is available in **CLARITY public deliverable “D3.3 Science Support Plan and Concept v2”** [3]. In this document, we will primarily illustrate how EU-GL is supported in CLARTIY online tools, most notably in the advanced urban screening workflow.

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For the start **Table 1** explains the meaning of the terms used in CLARITY EU-GL methodology. Please note that the meaning of some of these terms as well as the way risk and impact were calculated was slightly different in original EU-GL methodology and had to be updated to align it with the methodology and naming conventions that are used in the fifth IPCC assessment report.

Table 1: CLARITY EU-GL methodology naming conventions, aligned with AR5 report of the IPCC

Hazard	The potential occurrence of a natural or human-induced physical *event* or trend or physical *impact* that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, *service* provision, ecosystems, and environmental resources (IPCC, 2014). In the IPCC context, the term *hazard* usually refers to climate-related physical events or trends or their physical impacts. (IPCC, 2014).
Exposure	The presence of people, infrastructure, housing, production capacities and other tangible human assets in hazard-prone areas.
Vulnerability	The probability of a given element at risk, classified as part of a specific Vulnerability class, to be affected by a level of damage, according to a prefixed scale of damages, under a given hazard intensity (Glossary of the CLARITY Proposal).
Risk Analysis	Risk is the potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. (IPCC, 2014). Risk Analysis is a systematic use of available information to determine how often specified events may occur and the magnitude of their likely consequences (CRISMA Project glossary).
Impact Scenario Analysis	In probabilistic terms choosing in a deterministic way one or more significant events, among actually occurred past events or as a result of numerical hazard simulation models, shall be obtained as damage evaluation following a specific event.
Adaptation Options	The array of strategies and measures that are available and appropriate for addressing adaptation needs. They include a wide range of actions that can be categorized as structural, institutional, or social (IPCC, 2014).
Decision Support	Functions that help in evaluating the data and deciding what to do.
Action Plan	Functions that help in establishing the report / implementation plan / guideline.
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2.1 Hazard Characterisation in EU-GL

The Hazard Characterisation comprises the first step of the EU-GL methodology. This section identifies potential hazards in the selected study area and predicts a future climate.

2.1.1 Hazard characterisation- pan European hazard indices

In CLARITY online tools, this is done by establishing historical climate data as a baseline for the predicted future climate in order to assess what changes will occur. The Hazard characterization is performed using

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the CLARITY pan-European data package**.** This data package includes a range of pre-calculated **climate indices related to heat (e.g. summer days, tropical nights), cold (e.g. frost days, ice days), wind (e.g. maximum daily wind speed) and precipitation (e.g. heavy precipitation days)**. These indices have been calculated by CLARITY team for the whole Europe with a resolution of 12km x 12km based on bias corrected (with the exception of wind) EURO-CORDEX data. Full list of CLARITY hazard indices is included in Table 2.

Table 2: CLARITY pan-European climate hazard indices.

Hazard	Index
HEAT: Heat waves	Consecutive summer days
	Consecutive hot days $\geq 75^{th}$ percentile
HEAT: Extreme heat	Hot days
	Summer days
	Tropical nights
	Maximum temperature $\geq 75^{th}$ percentile
COLD: Cold waves	Consecutive frost days
COLD: Extreme cold	Frost days
	Ice days
	Minimum temperature $\leq 10^{th}$ percentile
Thermal stress	Extreme temperature range
FLOODS: Extreme precipitation	Maximum 1-day precipitation
	Maximum 5-day precipitation
	Snow days
FLOODS: Wet periods	Consecutive wet days
	Wet days
	Heavy precipitation days
	Days where daily precipitation $\geq 90^{th}$ percentile
FLOODS: River flooding	Flood recurrence
	River flow

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FLOODS: Pluvial flood	Water runoff
STORMS: Extreme wind speed	98th percentile wind speed
	Maximum wind speed
	Days with wind speed ≥ 17 m/s
DROUGHTS	Consecutive dry days
FOREST FIRES	Fire weather index

All CLARITY climate hazard indices were calculated for a baseline period (1971-2000) and **three future time-periods (2011-2040, 2041-2070, 2071-2100)** using bias corrected EURO-CORDEX data [4]. For the future time periods, **three different greenhouse gas emissions scenarios** (Representative Concentration Pathways - RCP), which were also used in the AR5 of the IPCC, are used: **RCP2.6 (early response), RCP4.5 (effective measures) and RCP8.5 (business as usual / worst case scenario)** [2].

As illustrated in **Figure 6**, the end of century prediction for Europe in RCP8.5 scenario is nothing short of alarming, RCP4.5 predictions are slightly less alarming, but still bad enough to require widespread adaptation activities, whereas the RCP2.8 scenario predicts peaking of the changes in mid-century and gradual return towards normality thereafter.

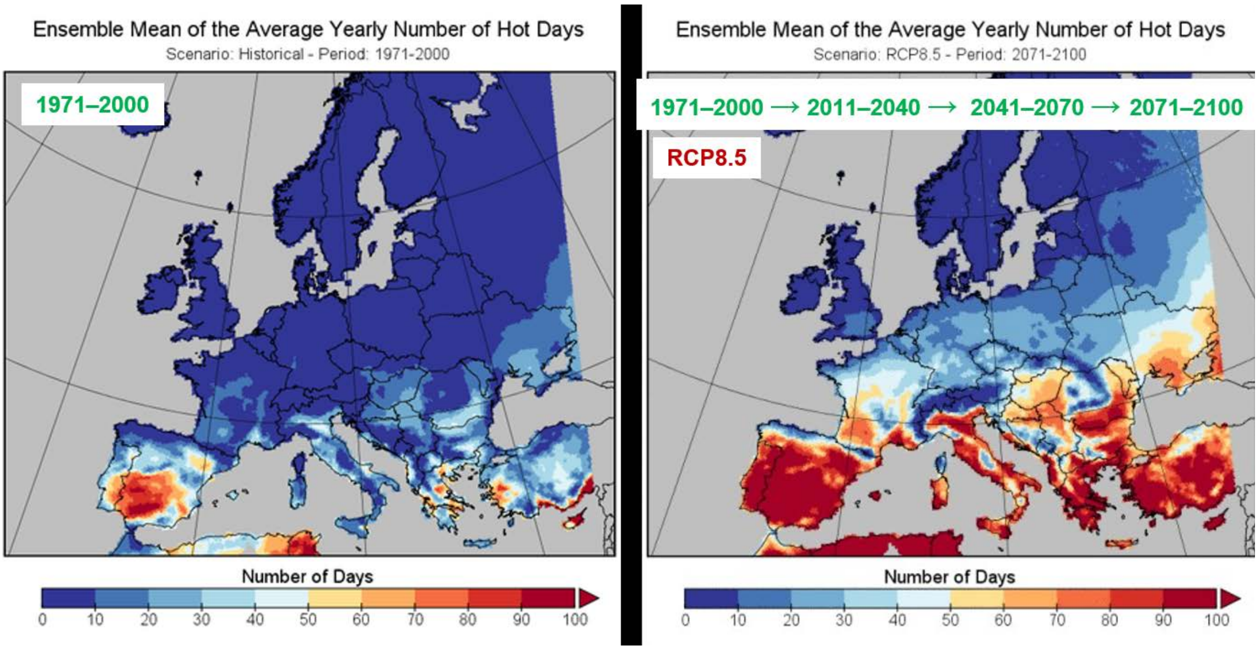

Figure 6: In the "worst case" climate scenario, end of the century yearly heat occurrences in Europe are predicted to be worse than the catastrophic heat wave of 2003 (CLARITY EURO-CORDEX predictions)

Currently, the RCP2.6 is seen as far too optimistic by the experts and the worst-case scenario as very likely. If exponential trends in electro mobility, teleworking and renewable energy persist, the likely outcome by the end of the century is expected to be similar to RCP4.5 predictions.

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To account for the uncertainty in model predictions, all CLARITY climate indices were calculated using several climate models and the resulting ensemble standard deviation is also included in CLARITY online services, as a measure of reliability of the prediction. More information regarding the indices, their definition and results, as well as the data and models used to derive the climate indices is provided in annex of the CLARITY D3.3 deliverable. This information is also available online, in form of the metadata describing the resources at the CLARITY online service[3].

Spatial resolution of these indices is too coarse for urban scale studies. Therefore, these indices are typically used as input for downscaling models in urban studies. In CLARITY, several downscaling models were used in screening and expert studies, with spatial resolutions ranging from ~500m (screening) down to ~1m in detailed expert calculations.

2.1.2 Hazard characterisation- Local effects

Urban heat islands (UHI) effect and pluvial flooding have been identified as two hazards of special interest for the urban areas. The UHI occurs when high energy absorption on paved surfaces as well as heat storage by build-up structures lead to high temperatures in densely build or industrial areas. In the vicinity of water, trees and vegetation, temperatures are usually lower due to shade, evaporative cooling and a better circulation of air. Moreover, temperature also changes with the height and the differences can be significant for cities that are built at hillsides. Similarly, pluvial flooding is caused by intense periods of heavy rainfall and the risk of this type of flooding to occur 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.) influence how much rain is being converted to surface runoff. Topography determines where the water will flow and potentially accumulate.

To simplify the task of assessing the effect of climate change and urban adaptation measures on the potential variation of such climate signals, CLARITY project team has developed automated downscaling models for these two hazards. These models essentially use the detailed information on land cover and topography that is available in many European urban regions to modulate the pre-calculated hazard indices, thus increasing the heat wave and pluvial flood local effect resolution to 500x500 m^2. As illustrated in **Figure 7** and **Figure 8**, urban fabric effects are already recognisable at this resolution and the automated downscaling model predictions are coherent with the predictions of more detailed expert studies.

[3] https://csis.myclimateservice.eu/

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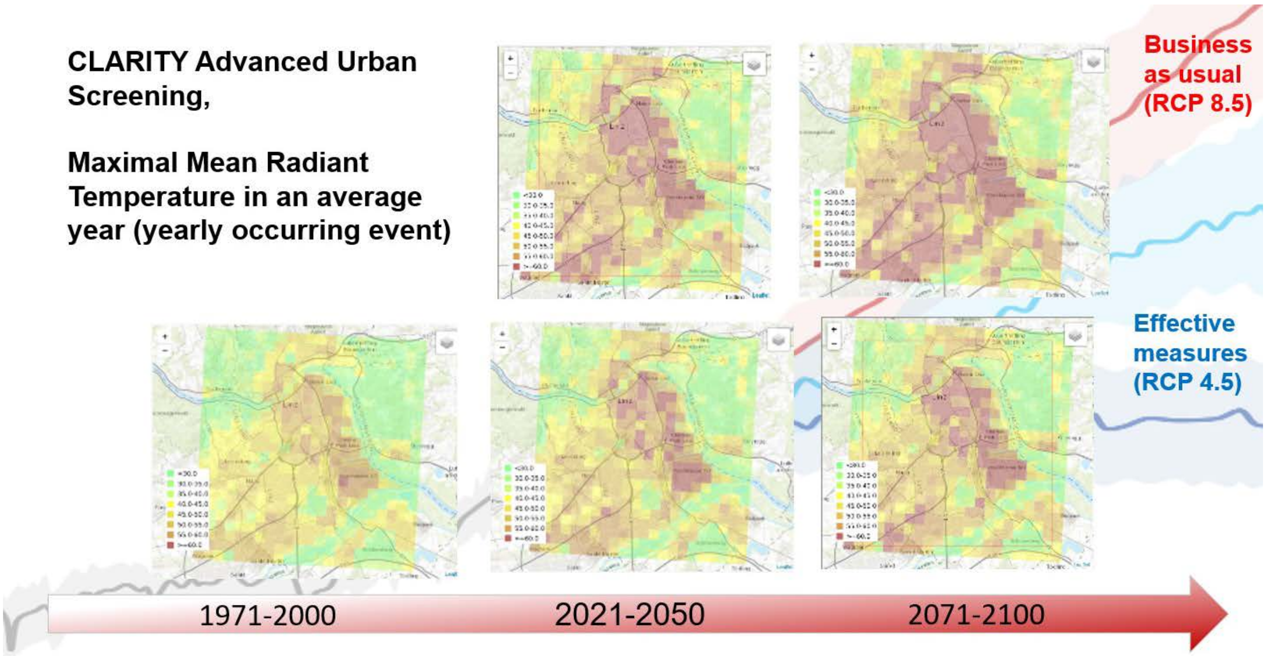

Figure 7: Urban heat island estimates in Linz, Austria – automated CLARITY downscaling

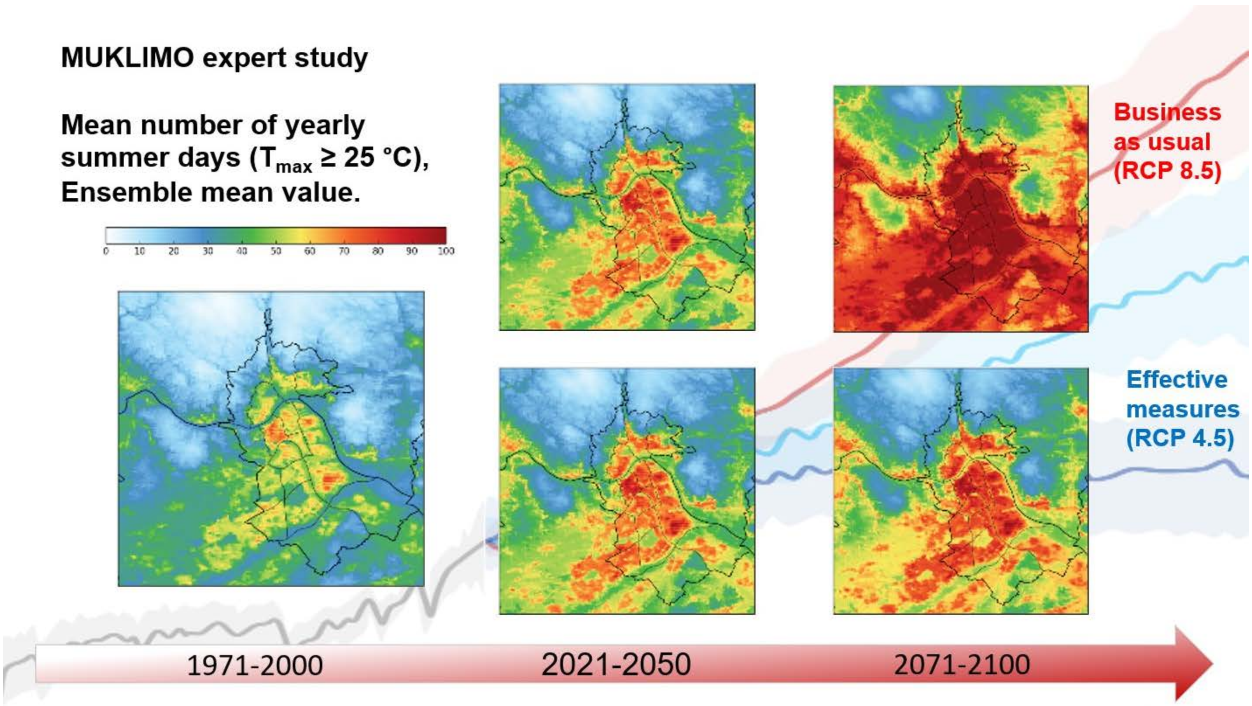

Figure 8: Urban heat island effects in Linz, Austria – expert study at a resolution of 100x100m^2

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2.2 Exposure Evaluation

The Exposure Analysis assesses who or what is affected by the hazard in place. Once the hazard characterization in the project area has been completed, 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 (people, buildings, infrastructures, etc.) grouped on the base of their behaviour under effect of the hazard into categories (called "vulnerability classes"), defined on the base of specific characteristics (i.e., age for people, structural-typological characteristics for buildings, etc.), able to influence the damageability of the elements exposed against hazards.

EU-GL recognises two types of exposure:

- **Baseline exposure** that is based on the current distribution of the elements at risk in the area of interest. Baseline exposure can be estimated by combining the available data on e.g. population distribution, land use and land cover. Exposure must be calculated separately for each element at risk type.
- **Future exposure** that is based on the planned distribution of the elements at risk in the future. In CLARITY, this will usually correspond to the planned project and the expected distribution of the elements at risk will have to be provided by the user or by an expert working on their behalf.

In CLARITY, the screening studies are always performed using the baseline exposure, whereas the expert studies use estimated future exposure when appropriate (for more information view Section 2.4 of D3.2).

2.3 Vulnerability Analysis

In addition to exposure, the vulnerability of the elements at risk to the current and to the expected future climate is assessed. The Vulnerability Analysis estimates how susceptible the element at risk is (be it people, buildings, infrastructure, objects, etc.) with respect to the hazard in question. In other words, vulnerability is defined as the probability that an element at risk, belonging to a specific a vulnerability class, experiences a level of damage, according a predefined damage scale, as a response to a hazard event of given intensity. It is expressed in terms of a vulnerability matrix that indicates which percentage of the elements of risk of a certain type belongs to which vulnerability class for which hazard in this area. An example of such matrix, for a generic element at risk category, is shown in **Table 3** below.

Table 3: Example of a vulnerability matrix for a specific vulnerability class of a given element at risk under effect of a specific hazard.

VULNERABILITY CLASS i				
Level of Damage	Hazard Intensity			
	HI 1	HI 2	HI 3	…
Low	5 %	20 %	50 %	…
Medium	10 %	30 %	70 %	…
High	20 %	50 %	80 %	…

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The vulnerability classes for the relevant elements at risk have been defined both for heat wave and flooding, defining also the different levels of damage for those elements. For instance, population as a risk element in the case of heat waves and was initially distinguished by age in three classes (under 14, 15 – 64 and over 65). Table 4 shows an example of a damage classification of people's health for heat waves. More information can be found in Section 2.5 of D3.2.

Table 4: People damage classification.

Level of damage	Description
D0	No damage
D1	Fatigue, discomfort
D2	Heat cramps, heat exhaustion
D3	Heat cramps, heatstroke
D4	Heatstroke, sunstroke
D5	Death

Due to lack of data, the **calculation of heat hazard impact at the screening level is performed with a single vulnerability class for all population groups**[4]. To account for adaptation to local climate conditions, two versions of vulnerability function were developed, one for the Southern Europe and another for central and Northern Europe.

Similar classification has been carried out also for the elements at risk in the case of flooding. In that context, two typologies of damages, namely direct and indirect costs, have been taken into account. The former is related to the restoration cost, while the latter is due to the loss of production. Five levels of damages have been identified for both typologies. Due to lack of available data at European level, **the quality of buildings is not accounted for in the screening studies**[4].

In the case of road transport infrastructures, it has not been possible to define vulnerability curves due to the lack of data and reliable statistics. Therefore, the **vulnerability assessment for the road infrastructure must be done by a technician with a profound knowledge of the different elements of the road**.

2.4 Risk and Impact Assessment

The Risk and Impact Assessment provides a structured method for analysing climate hazards and their impacts to provide the fundamental information for decision-making. In line with the updated approach as outlined in the IPCC-AR5, this evaluation is derived by the general relation

Risk/**I**mpact=**H**azard x **E**xposure x **V**ulnerability.

The risk and impact assessments consider the magnitudes and impacts associated with climate hazards identified in exposure evaluation. Here it should be mentioned that risk is a probabilistic measure that relates to a cumulative effect of all (likely) hazard occurrences, whereas the impact merely indicates the effects of specific reference events.

[4] Adding this type of functionality would be relatively simple for specific regions where the data is available. Please contact denis.havlik@ait.ac.at us if you are interested in improved screening models for specific regions.

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- **Risk assessments**: aims at defining a synthetic index/coefficient, representing the convolution of the probabilities of different hazard intensities (H), in relation to the exposure (E) and vulnerability (V) conditions in a given area. Such a risk index is useful to allow high-level comparisons between alternative project options but does not allow detailed quantification of impacts on considered elements at risk.

To obtain reliable results that can serve as a sound basis for decision making in the field of infrastructure development, risk assessment should be always based on numerical modelling procedures. Probabilistic quantitative risk assessments can be undertaken in the early phases of the asset lifecycle, with different levels of detail (including the spatial resolution of the models' output) depending on the availability of exposure and vulnerability. This requires running various scenarios and comparing the results with respect to the frequency of event occurrence and event magnitude by means of a probability distribution.

- **Impact scenario analysis**: as a complement to the risk assessment, by choosing in a "deterministic" way one or more reference events (among actually occurred past events or as a result of numerical hazard simulation models) the corresponding "impact scenario analyses" can be performed using numerical impact models, providing detailed damage evaluation on selected elements at risk following specific event(s).

Unlike the risk assessment, the impact scenario analysis represents a simulation of the expected impacts of a specific hazard (in terms of intensity, location, etc.), derived from the application of an impact model able to correlate hazard (H), exposure (E) and vulnerability (V) characteristics to produce a detailed quantification of damage on elements at risk considered (e.g. population, buildings). An analysis based on the output of the impact models can be used to support decision-making, e.g. by applying multi-criteria and/or cost-benefit analyses on a number of relevant impact scenarios. Probabilistic assessment and uncertainty evaluation are provided also in relation to impact scenario analyses, mainly related to the probability of occurrence of the hazard type and intensity at the location of the analysis.

CLARITY advanced urban screening incorporates several simple impact models that correlate heat hazard indices and population density with health impact and the pluvial flood hazard indices and different types of infrastructure with economic damage.

In the case of road transport infrastructures, we couldn't identify sufficiently accurate screening risk or impact models. Therefore, **the risk/impact assessment for the road infrastructure is done on the basis of an "informed decision"**, which means that there is an expert who knows the road section from the point of view of exposure and vulnerability and, with the help of the hazard information produced under CSIS, is able to assess the impact and the risk.

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2.5 Identification of Adaptation Options

In CLARITY project, **a list of 35 effective adaptation options** has been established through literature research and discussion with the stakeholders. This list is attached as an annex document of D3.3 and also available in CLARITY online services (**Figure 9**).

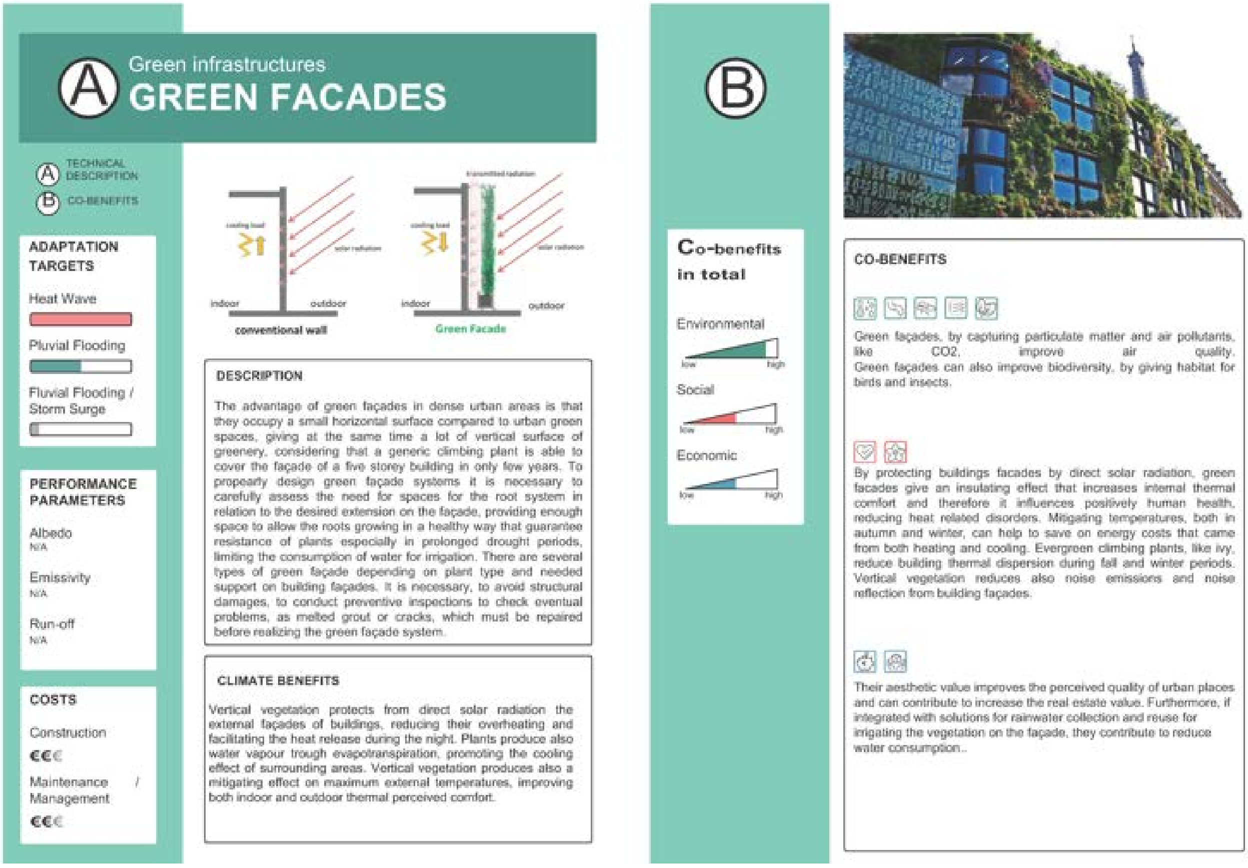

Figure 9: One of 35 effective CLARITY adaptation options for urban and traffic infrastructure.

For each of the pre-defined adaptation options, a set of parameters has been defined to facilitate the next step in the EU-GL workflow: adaptation targets, performance parameters, construction, retrofitting and maintenance costs and co-benefits. This information is available in Annex documents of D3.2 as well as in the CLARITY online tools.

In CLARITY screening workflows, "identification" of the adaptation options step allows the users to inspect these pre-defined adaptation options, study their characteristics and include the relevant ones in a shortlist for the specific project. This automatically includes the information related to benefits of the selected adaptation options in the study report, in terms of hazard, exposure and vulnerability reduction, as well as in terms of related socio-economic co-benefits (such as increase in liveability, biodiversity, and selection ability to respond to multiple hazards, etc.)

2.6 Appraisal of Adaptation Options

In the "appraisal" step, the costs, benefits and co-benefits of the adaptation options are assessed.

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In CLARITY screening workflow, this step has been simplified through definition of the “adaptation strategies” pertinent to vegetated areas, buildings, built open spaces and transport infrastructure (roads and railways). This is illustrated in Figure 10.

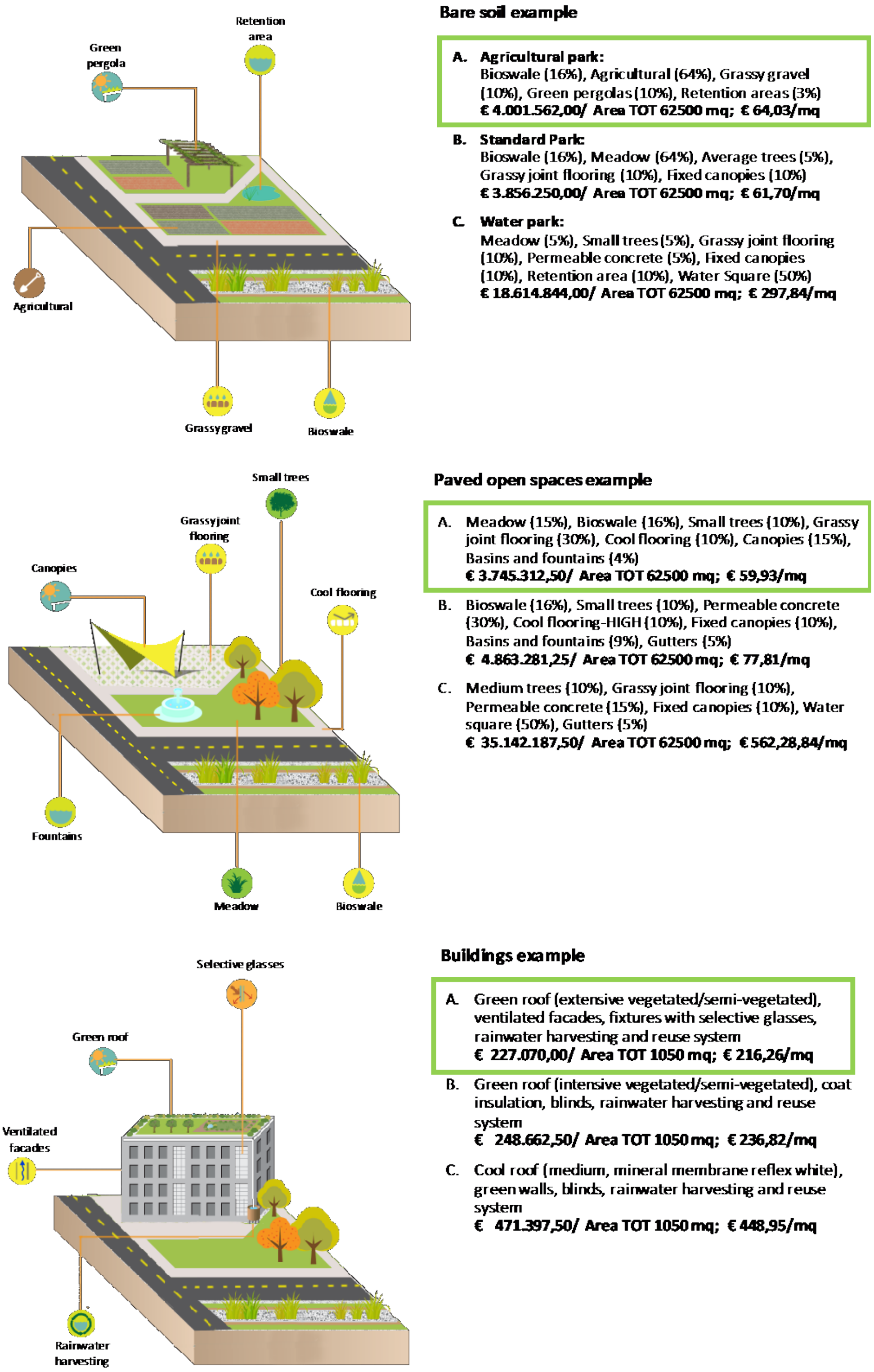

Figure 10: Example of alternative adaptation for specific land use classes (in brackets the percentage of application on the existing land use).

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Adaptation strategies in CLARITY online tools are defined in a way that a-priory eliminates the possibility of common mistakes. E.g., it is not possible to choose two conflicting adaptation options for the same type of elements at risk. Moreover, the combination of adaptation options in each adaptation strategy has been pre-selected by experts to provide optimal cost/benefit effects mitigating the heat hazard impacts, pluvial flooding impacts or both for one of the four land use (meta-)categories: vegetated areas, buildings, built open spaces and transport infrastructure (roads and railways).

By assigning an adaptation strategy to at least one of these land use categories, users can define an “adaptation project” and re-start the screening calculation. This results in a new estimate of heat and pluvial flooding impacts taking into account the beneficial effects of the chosen adaptation options.

2.7 Implementation/Integration of Adaptation Action Plans

Final step in the EU-GL methodology is integration of adaptation options in the project.

In the advanced urban screening workflow, this is interpreted as inspecting the costs and benefits of different adaptation projects and deciding which one to implement. This can be carried out through the collaboration between local end-users and experts from the CLARITY team.

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3 The Marketplace

The overall goal of a marketplace is to promote goods and services and to match offer and demand accordingly; myclimateservices.eu intends to serve the emerging market of climate services. Additionally, it aims to foster collaborations along the value chain increasing co-creation, co-development and innovation in various stages of service and project development.

3.1 Concept of the Marketplace

The concept of the Marketplace can be envisaged as follows:

1. The Marketplace gathers and presents climate services like data, digital tools, expert studies as well as tangible solutions for climate adaptation. Not only offers are presented, but also requests and best practices – these will be infrastructure related projects from cities, regions and enterprises searching for solutions or showcasing the successful utilization climat services.
2. Offers and requests will be matched and possible collaborations ignited.
3. The usefulness is increased by community features like the webZine that reinforces promotional content as well as event organization and management.

The **content is global** to enable technology and know how transfer beyond regions or states. However, there will be a strong regional focus on end user level oganized in "regional hubs" featuring local language, culture and regulatory framework conditions, simultaniously having access to the global marketplace database. The hubs will be curated by local partners and the webZine is crucial as display for the respective regional end user communities and their achievements.

The service allows for detailed describing individual climate services offerings on the marketplace site, finding collaboration partners or climate adaptation demands from other users' projects. Experts can promote their solutions, references and projects on the webZine; the editorial scope on different launched climate related topics provide a relevant framework for their contributions.

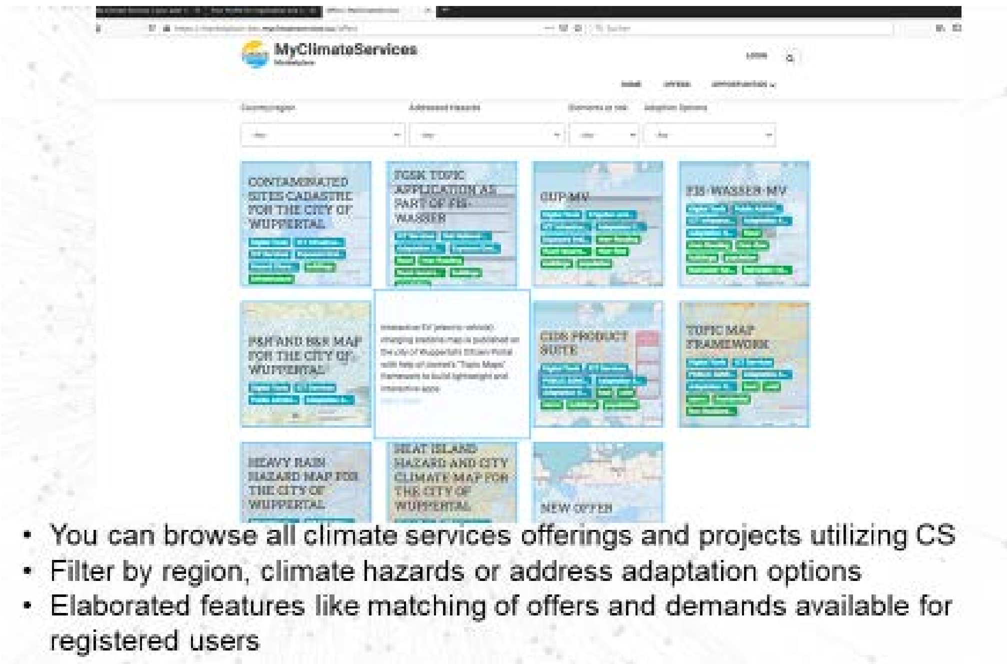

Figure 11: Climate services- make-up and offers

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3.1 Solution Offers and Projects

A Solution Offer is data, service or a product that can be introduced and advertised on the Marketplace and contributes to appraisal and/or implementation of Adaptation Action Plans in the CSIS and thus gives Solution Providers the possibility to promote their offerings. A Solution Offer can apply to one or more sectors, EU-GL step/modules and (e.g. in case of data) regions.

Solution Offers can consist of different Climate Services (advice, data, software) or represent a distinct Climate Service on their own. The screening tool part of the CSIS is an example of a Solution Offer. Another example would be a service for creating tailored Data Packages.

Additionally, Solution Offers also represent physical products and services like novel reflective materials, CO2-absorbant paint, climate-change-aware construction services, etc. Interestingly, such a physical Solution Offer could be used as Adaptation Option.

Solution Offers can build on one another (e.g. indices on data, localized services on more generic models) and a single Solution Offer can be provided by different organizations thus encouraging collaborations along the value chain.

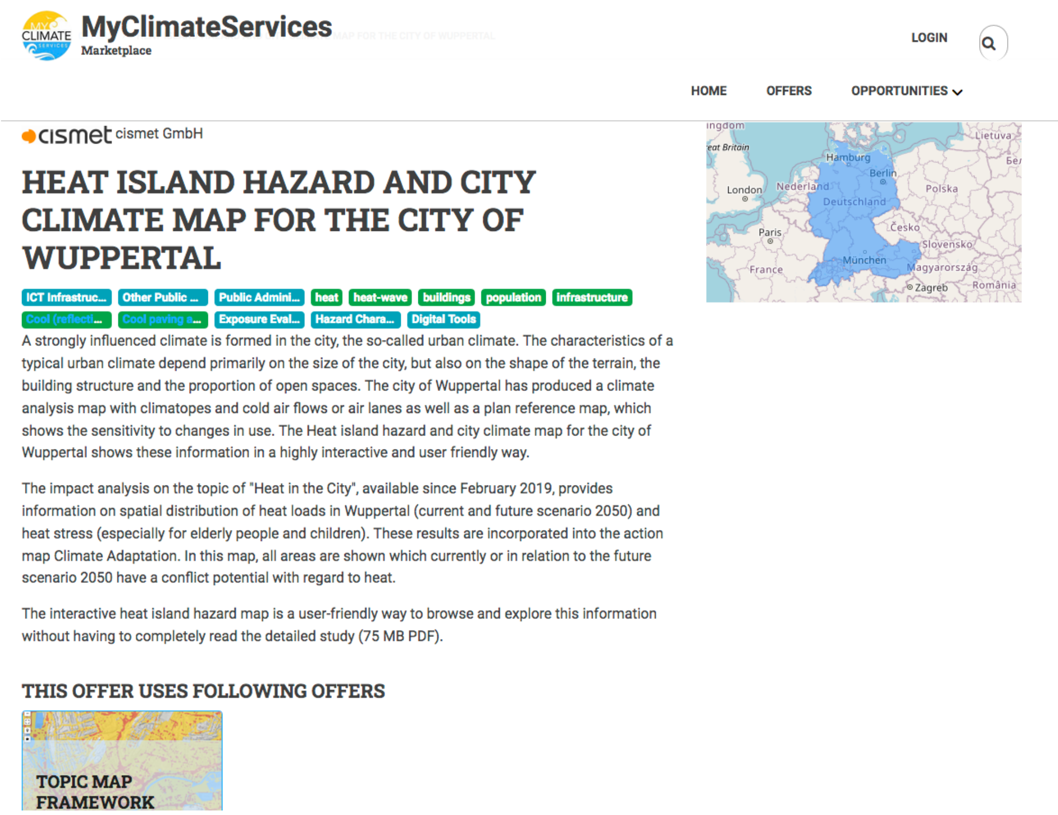

Figure 12: Marketplace - solution offer

The following video provides guidance for creating a solution offer:

- https://www.youtube.com/watch?v=M7UzC3OHiiw

A Project describes either a finished (urban) infrastructure measure as a reference for the implementation of one or multiple solution offers or is a drafted or on-going infrastructure project in demand of climate services or provision of specific adaptation options.

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Projects can comprise contributions from more than one organization and have demand for multiple services also depending from the project phase from intelligence gathering for planning to monitoring of implemeted measures.

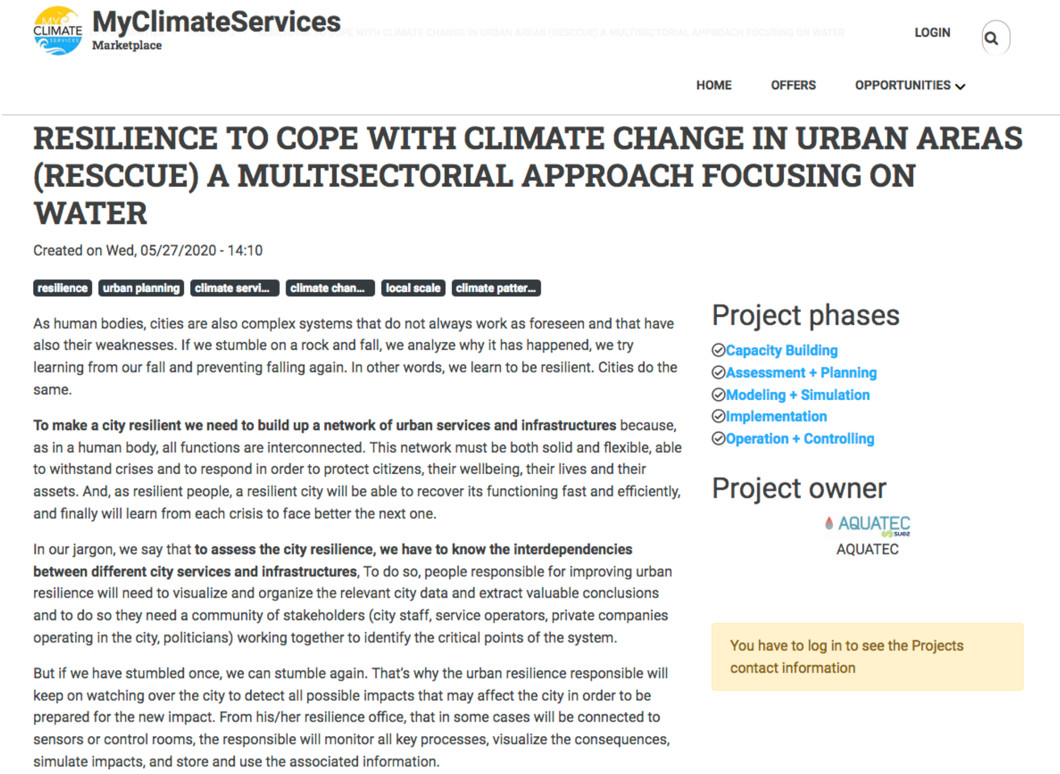

Figure 13: Marketplace - project

The following video provides guidance for creating a project:

- https://www.youtube.com/watch?v=EPJv2053zRU

3.2 User account and Organization Profiles

The Marketplace aims to foster new and unusual commercial and R&D collaborations. To achieve this some knowledge about prospective partners and trust between the parties is required. Therefore full functionality of the marketplace is available only for registered users including disclosure of contact data.

B2B contacts are closed between organizations (e.g. legal entities). For activities on the marketplace and matching of Solution Offers and a Project demanding the solutions an organization needs to be linked to the personal account. As a person you can be member of multiple organizations.

Also temporary or "virtual" organizations like working groups (e.g. planners and contractors) or project consortia can be established, set requests and showcase references.

Good practice for this can be read following this link:

- https://marketplace-dev.myclimateservices.eu/opportunities/projects/resilience-cope-climate-change-urban-areas-resccue-multisectorial-approach

The following video provides guidance for creating and maintaining a user account and organization profiles:

- https://youtu.be/PQOr0diQrPI

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3.3 The Climate Services Portal and Marketplace

The portal myclimateservices.eu is the single point of entry for the (digital) offerings of the CLARITY project:

Figure 14: The marketplace portal myclimatservices.eu

The portal home page displays latest social media posts and editorial and directly directs to articles featuring the actual editorial focus. Changing editorial foci will deal with diverse topics of climate adaptation in different regions as well as with sectors and direct visitors´ attention to Solution Offers and Projects and their actors.

By accessing the marketplace one can explore and insert solution offers as described above.

"Events" directs to the MyClimateServices event management site and offers the possibility to look for interesting events to attend and advertize and organize own events including direct connection with third party platforms for operating webinars and digital conferences. Also "event restrospect" like summary and conclusions, videos, presentations etc. can be managed via the website of the respective event. For organizers especially of small events like project presentations and workshops (virtual and analogue) there are two main benefits:

- embedding in the climate services environment and communities
- a single website to maintain planning announcing and reporting of a specific event

Adjustments to the agenda, speakers, even venue and time slot need to be taken care of only at one site. Organizers can assign event teams whose members can maintain the site as well and events can be fully public or only for members.

This link directs to an event website featuring the retrospect of a past event:

- https://events.myclimateservices.eu/2020/july/webinar-climate-services-emerging-market-latest-trends

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The portal also directs to the CLARITY Climate Screening Tool which is described in the next section.

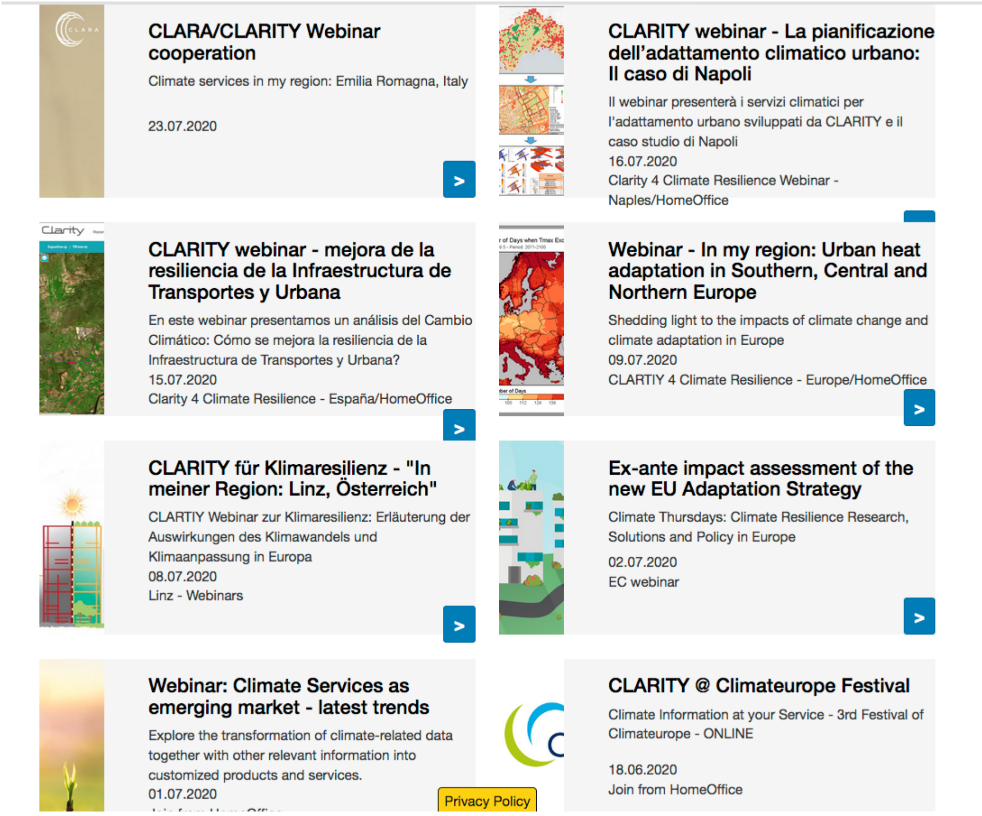

Figure 15: events.myclimateservices.eu

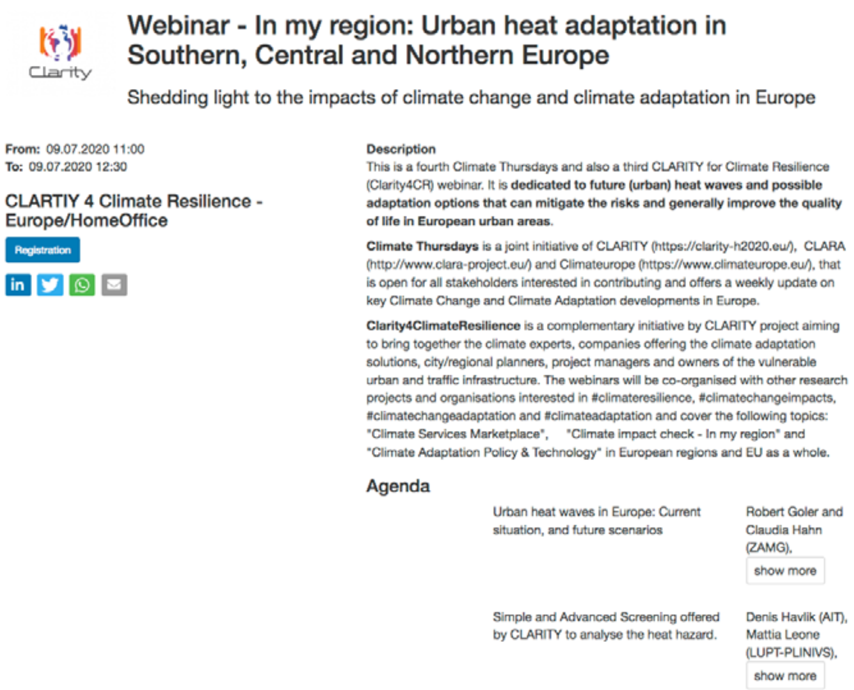

Figure 16: screenshot of an event website (partial)

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4 CLARITY Online Services

The CLARITY provides services at several levels of detail: online basic and advanced screening studies, online traffic screening studies and the offline expert studies.

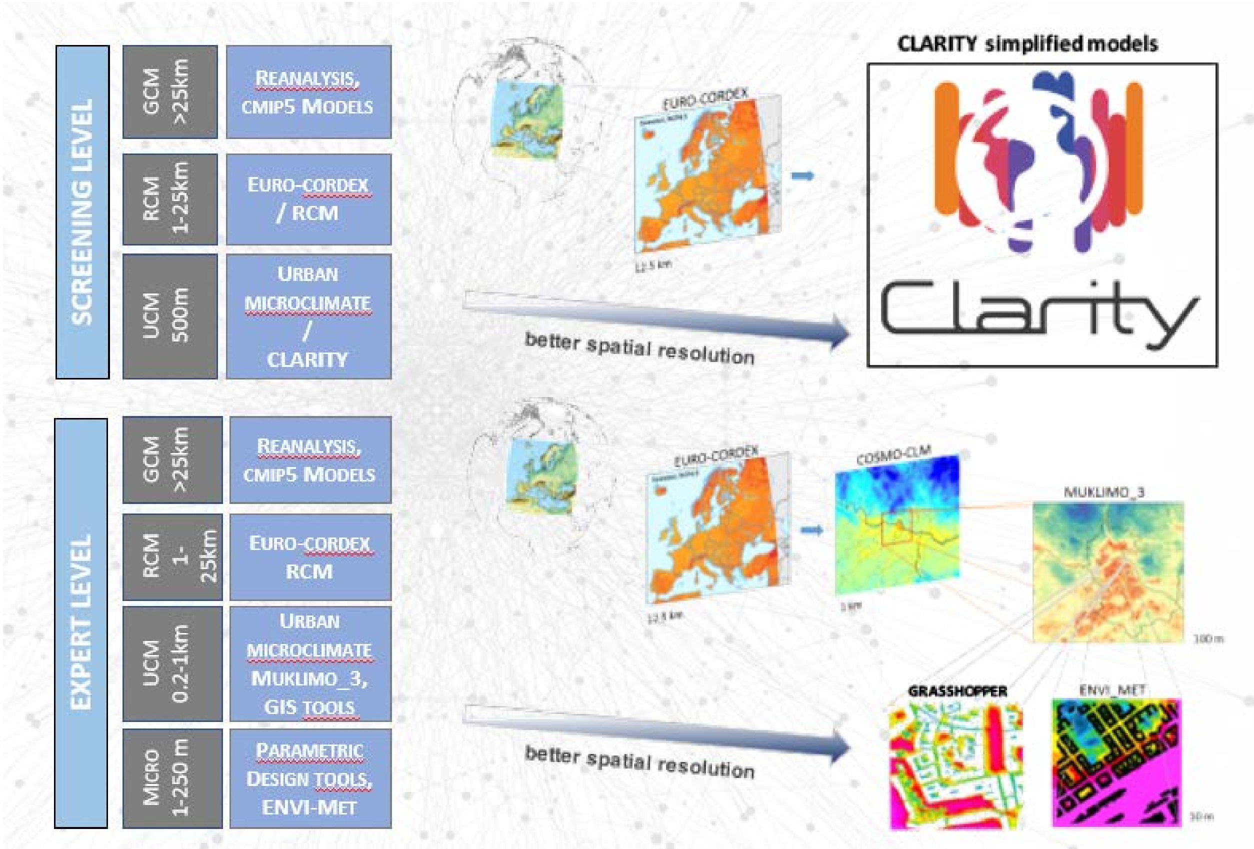

Figure 17: The CLARITY Screening levels

4.1 Basic Screening

The Basic Screening study type enables 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 is not enough to capture the urban climate variations. Additionally, this type of screening does not encompass impact calculations, but the comparison of the hazard intensity with positions of the elements at risk can be used as a proxy for risk/impact assessments.

Following video presents a general introduction to clarity online services and the basic screening study:

- https://www.gotostage.com/channel/8a129bbaf5ef40519cd825c902c8e67a/recording/ad4354466b2c4d18a4aa9cad7c11d365/watch

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4.2 Advanced Screening: Urban Infrastructure

The "Advanced Screening: Urban Infrastructure" study type permits the user to perform on the fly calculation of local hazards, exposure and impact for a selection of European cities and regions where the relevant input data is available. This type of screening is able to capture the urban climate variations, as its resolution reaches 500x500m^2. However, the calculations are limited to "urban heat islands" and "pluvial flooding" events.

Similar to the basic screening study, the advanced screening also offers the possibility to explore the characteristics of the main adaptation options anywhere in Europe. In contrast to the basic screening type this study also allows for assesses the impact of adaptation options.

For viewing an application of the advanced study type and a more detailed explanation concerning the advanced screening type's benefits compared to the basic screening, please watch this video

- **https://www.gotostage.com/channel/8a129bbaf5ef40519cd825c902c8e67a/recording/aacdd77e7bf94dc9bffa2d0eab4b9f73/watch**

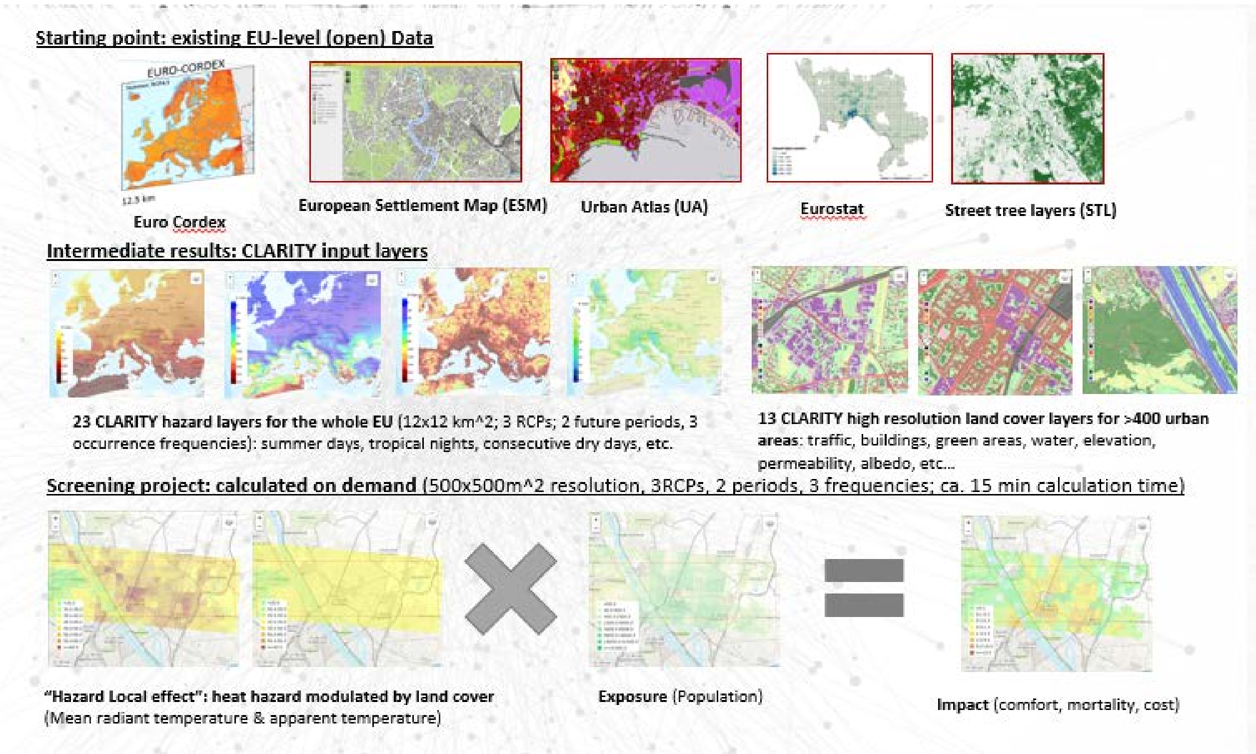

Figure 18: The workflow of a screening study

Please note that above mentioned video doesn't explain how to use the last three steps in the workflow, related to adaptation options. An updated webinar will be recorded in late August or early September 2020, published on CLARITY "climate adaptation" GotoWebinar channel https://www.gotostage.com/channel/climate-adaptation and included in the second version of this deliverable.

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4.3 Advanced Screening: Traffic Infrastructure

The Advanced Screening: Traffic Infrastructure is focused on screenings of traffic infrastructure. Currently the traffic screening is mainly targeting Spain, where better input data is available. A simplified version of the traffic screening is also available for other EU states.

Traffic screening is conceptually similar to the Advanced Screening: Urban Infrastructure but targets a different type of infrastructure and a different group of users. It further differs from the former in terms of the technology used. This screening study type also showcases how external applications can be embedded in the CSIS workflow.

A video tutorial explaining the transport infrastructure module is available at:

- https://www.gotostage.com/channel/8a129bbaf5ef40519cd825c902c8e67a/recording/c174d2a3534b41208e298123ded885f7/watch

An updated tutorial in English will be recorded in late August or early September 2020, published on CLARITY "climate adaptation" GotoWebinar channel https://www.gotostage.com/channel/climate-adaptation and included in the second version of this deliverable.

A fully-fledged written tutorial in English language is included as an annex document of this deliverable.

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5 Conclusions

The main objective of this deliverable is to present the guidelines for using the CLARITY online services, including the marketplace. The document itself is considered just part of the deliverable, with large portion of the actual work being invested in production of the online video tutorials explaining various aspects of the project:

- Methodology
- Marketplace
- Simple and advanced urban screening
- Transport screening

In addition to a video, a fully-fledged (written) tutorial of the transport screening module is also attached as an annex to this deliverable. Moreover, a rich library of video tutorials and other video materials produced by the project is available on https://www.gotostage.com/channel/climate-adaptation and will be further extended even after the project end, with several webinars being planned for September and October 2020.

A second version of this deliverable will therefore be issued in September 2020, mainly to provide links to additional and/or improved video tutorials that haven't been published yet.

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6 Acknowledgement

According to Article 38.1.2 of the model grant agreement, all the documents related to CLARITY (deliverables, presentations, papers, newsletters, leaflets etc.) shall contain the following statement: ***"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730355."***

7 References

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Annex I: Traffic module tutorial

User Guide- v1.0

" Climate risk Assessment in Transport Infrastructures "

29/06/2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730355

User Guide – Climate risk Assessment in Transport Infrastructures –

Description

This guide is a learning tool for conducting a case study on assessing climate vulnerability and risk in transport infrastructure through the Climate Services Information System (CSIS) developed under the CLARITY project. CSIS provides a decision support environment through a digital framework of dynamic interaction based on cloud data. The system offers a comprehensive set of climate services and products according to European standards and regulations for urban environments or for transport infrastructure. For transport infrastructure-oriented case studies, CSIS allows specific analysis options and access to a set of additional functionalities implemented through an integrated transport-specific module.

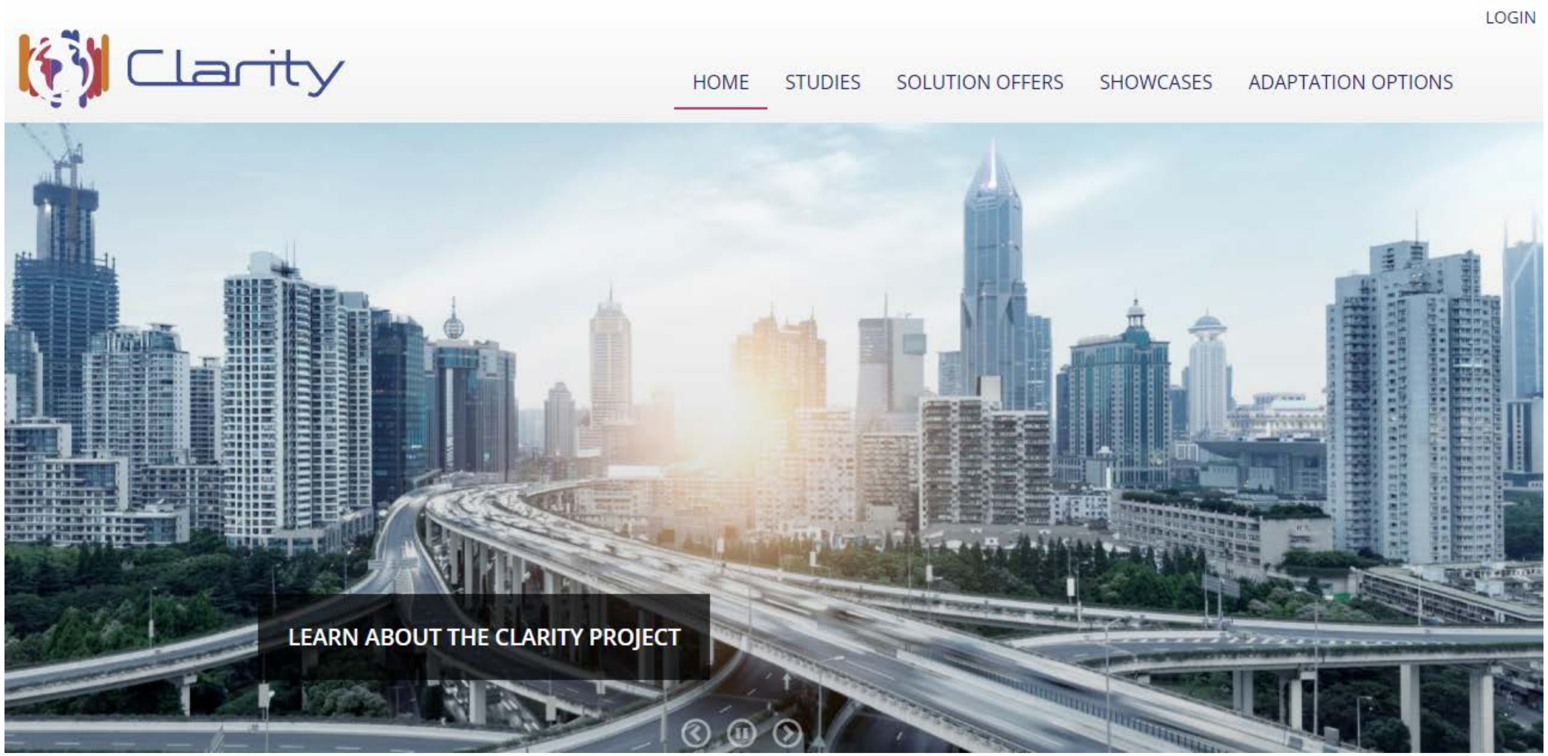
This case study is oriented to different users of climate services and decision makers for the planning and management of transport infrastructures, as well as for agents involved in infrastructure design and maintenance activities in medium to long term time horizons, or for the forecast of human and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

The following is a "step-by-step" presentation of the interaction options offered by the system and its associated functionalities that support the assessment of climate risk in transport infrastructures. Finally, the guide incorporates a glossary of terminology with associated infographics (Annex 1).

System Access

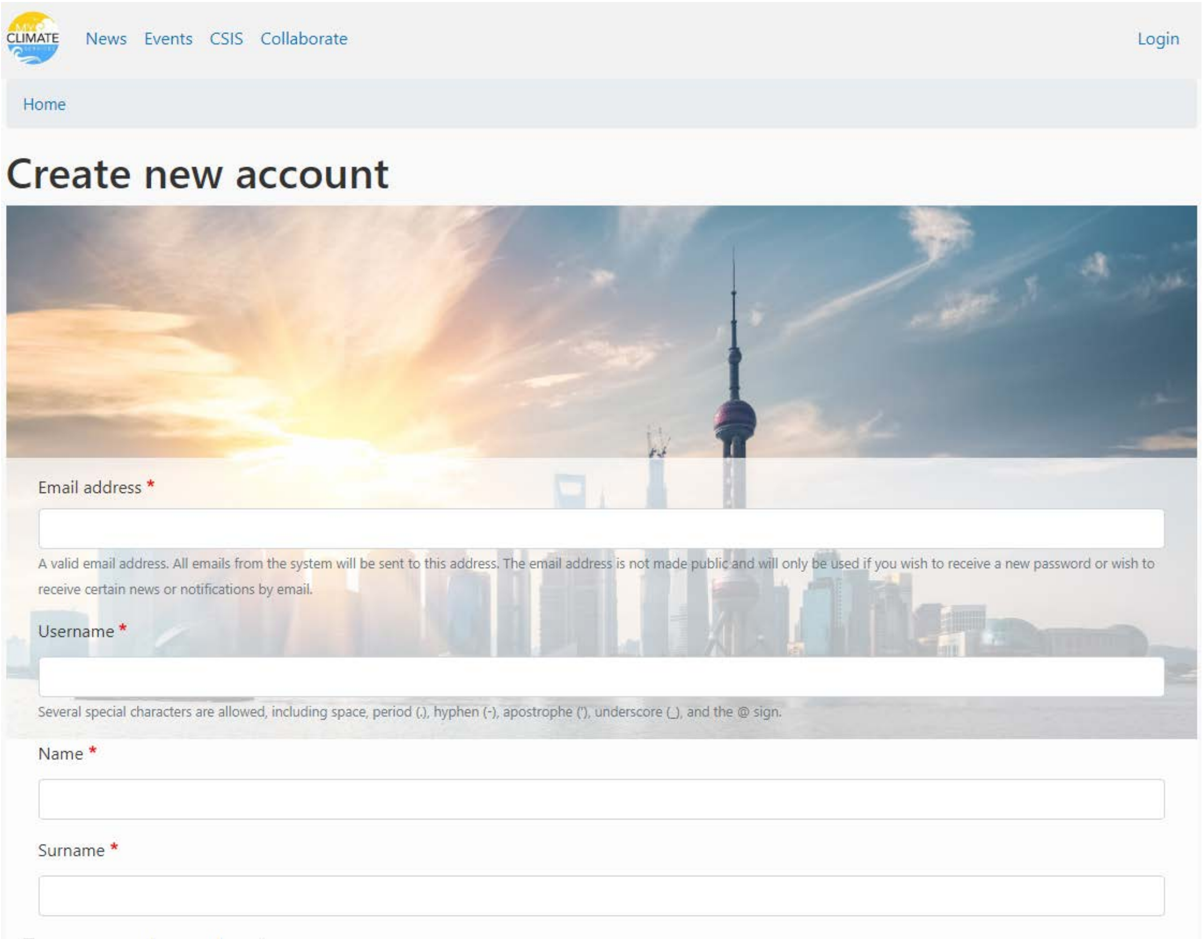
Users can access CSIS through the following address:
https://csis.myclimateservice.eu/

The initial screen of the system provides a general information framework of the CSIS: objectives pursued, climate services planned, information on the stages of their development and methodological framework. Users can also access public information on available case studies, solutions and adaptation measures that can serve as illustrative examples of the potential results of the system. This can be done by consulting the available options located in the top menu of the home screen.



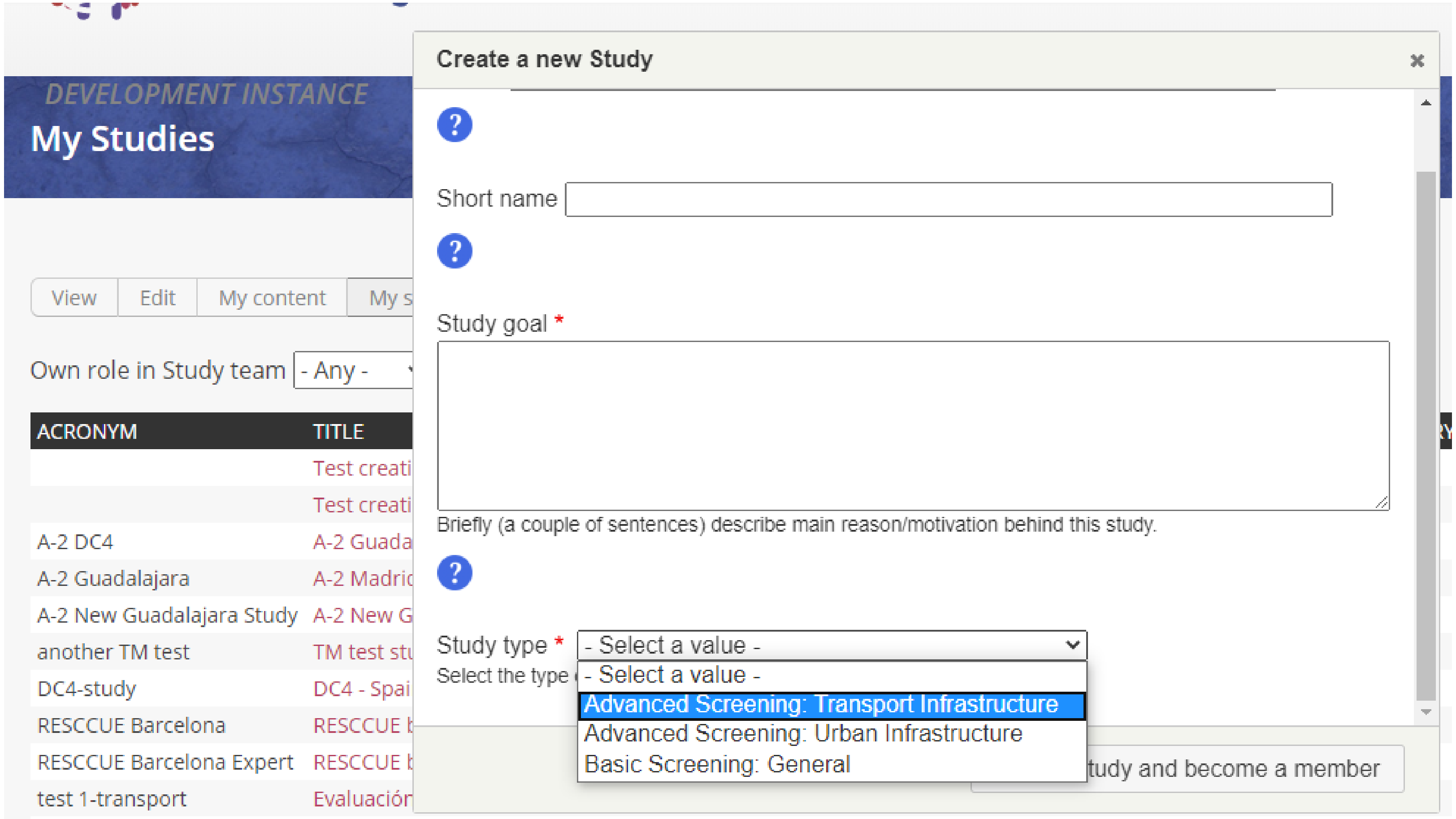
Create CSIS Account

Creating a user account in CSIS id one through the option LOGIN available in the upper right margin of the system's home screen. The user must enter the fields marked as mandatory, these are: e-mail, username, first name and surname. Finally, the user must accept the system's conditions regarding the use of personal data in order to complete the creation of the account.



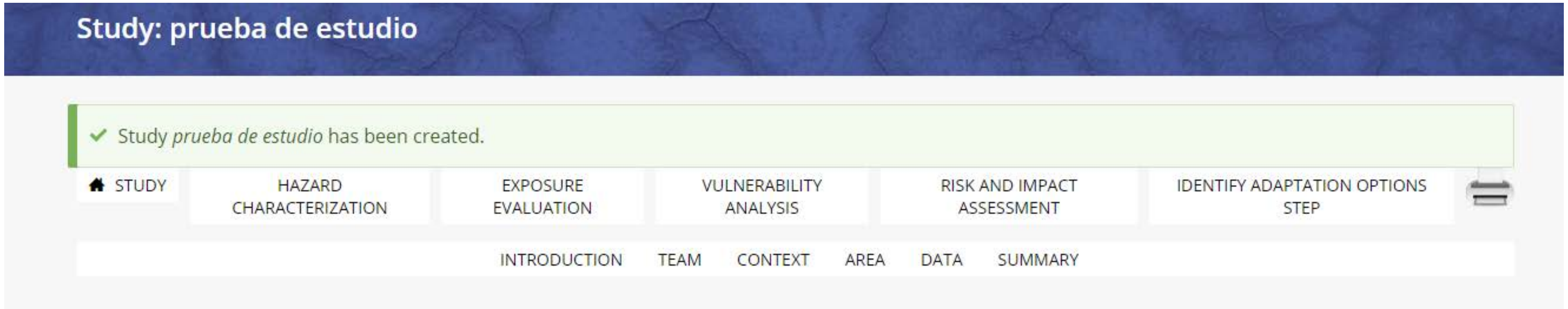
Create a new Study

For registered users, the CSIS allows the creation of a new climate risk assessment study. To do so, the user must go to the option "STUDIES/Create a new Study" available in the main menu on the top bar. The user can also access this address: https://csis.myclimateservice.eu/studies



Below, CSIS shows a set of general fields that the user must complete to start the study: title, short name, objectives and type of study. The first three fields are freely editable while the field "study type" offers the possibility to select between two options: advanced study or basic study. Select the option "Advanced Screening: Transport Infrastructure" and check the option "Create study and become a member".

CSIS then displays a success message in a new window along with the case study analysis options.

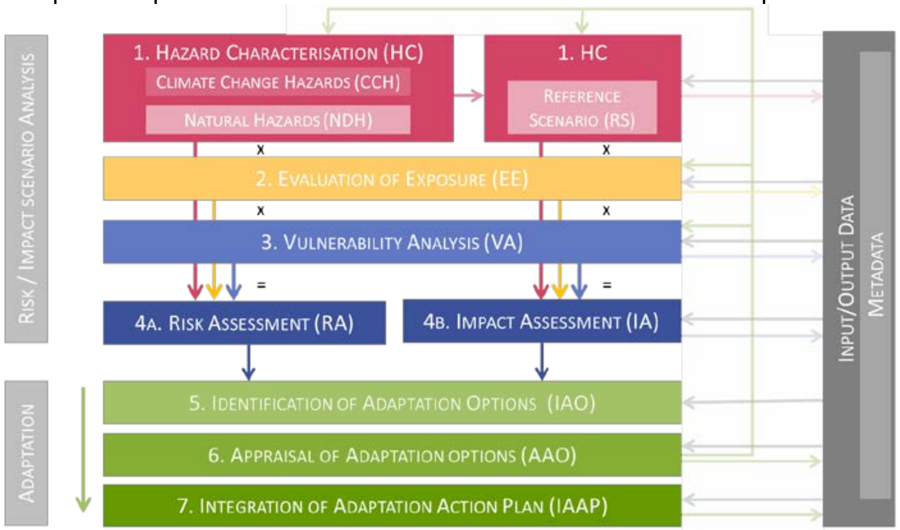


Edit the Study

Now the user must edit a set of fields in an organized way to start the study created. First, CSIS offers basic options to describe the generic framework of the analysis through the "STUDY" option, located on the left hand side of the top bar of the general operation menu.

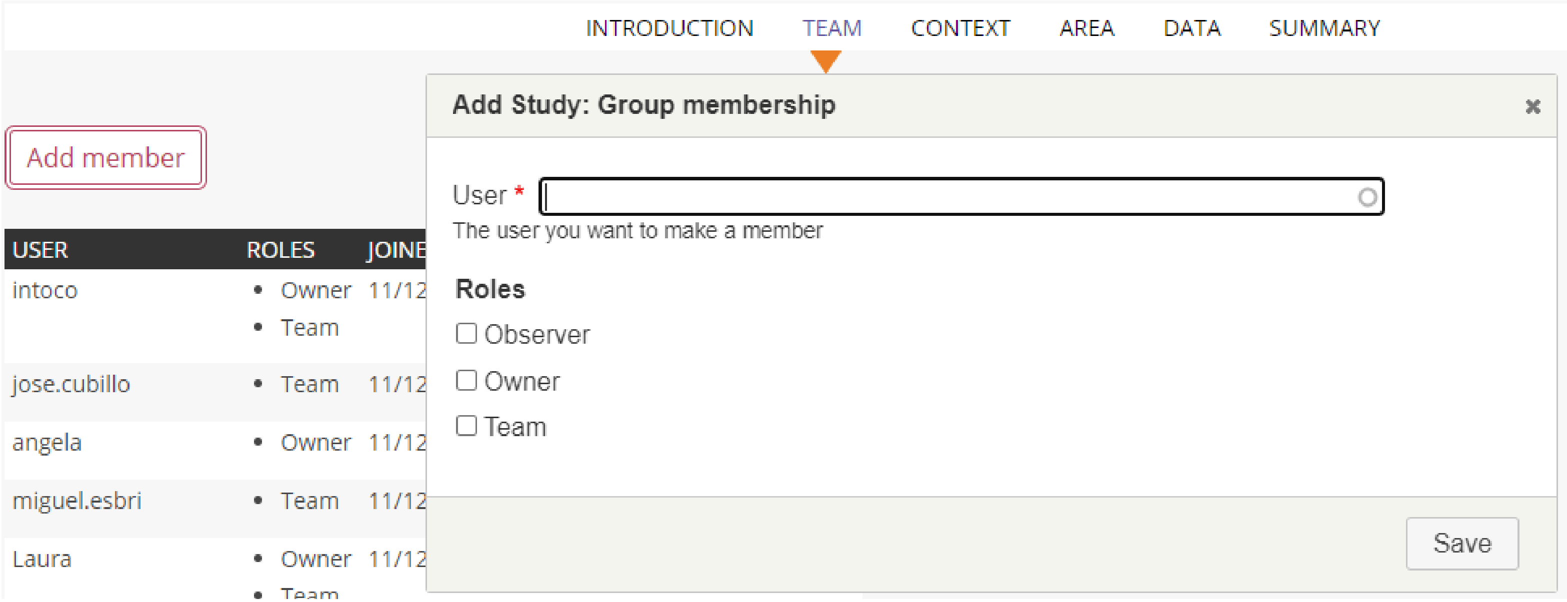
Once inside, the user will find the following default options:

- **Introduction.** This window displays general information about the Climate Risk Analysis Methodology, according to the procedures and workflow of the EU-GL and planned for the system environment in CLARITY. This methodology has been adapted from the approach of the IPCC 5th Assessment Report and includes 7 main steps; the first 4 steps are necessary to simulate risk and climate impact scenarios based on the analysis of hazards, exposure and vulnerability; while the last 3 steps try to identify and analyze adaptation measures to address the analyzed risks. Finally, the methodology includes the simulation of the effect of adaptation options and measures the variation in terms of risk/impact derived from their implementation.

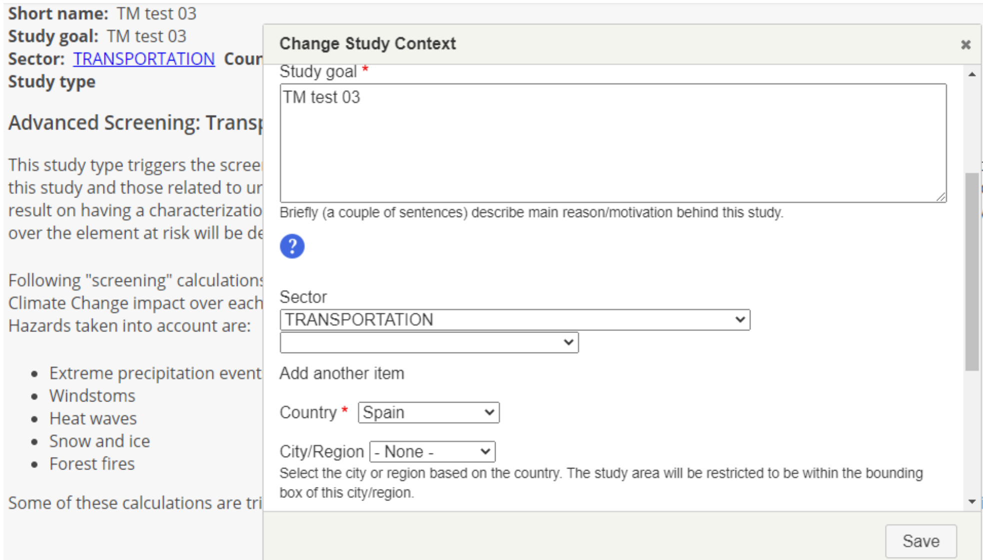


The user can edit this general content through the option "Change Description" available at the bottom of this screen, to incorporate the methodology used in their study as well as particular hypotheses and assumptions assumed in the development of the same.

- **Team.** By default, the user who creates the study appears on the Team. This user can register new members and team members to deal with the analysis. To do so, they must use the "Add member" button. Then, the user to include as a member must be iselected along with their role for (observer, owner or team). The last step would be to save this changes.

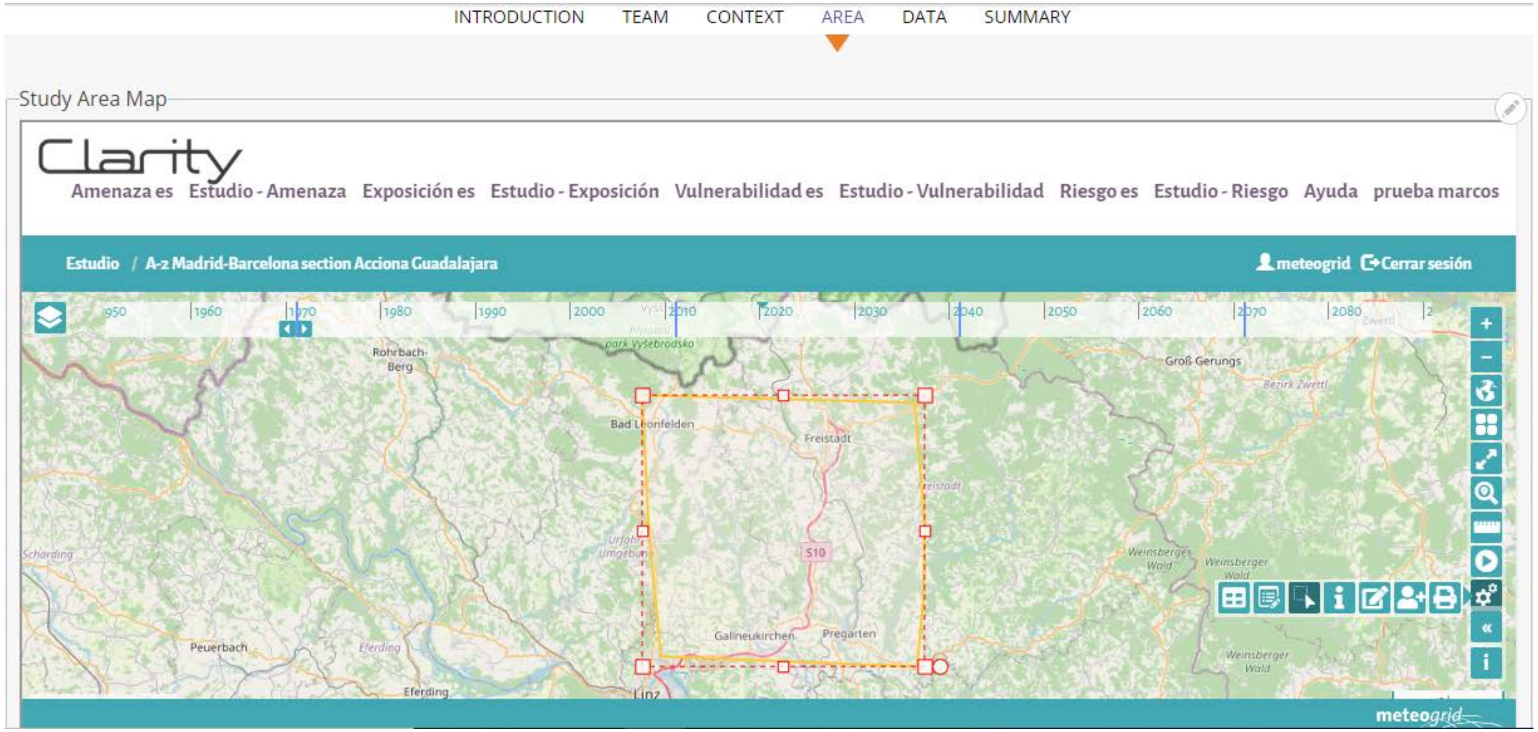


- Context. The user must then edit information about the context of the study. To do this, they must access the "Edit" option available at the bottom of this screen. Once inside, it is important that the user identifies the Sector being analyzed, in our case, -Transportation-. Next, they must indicate the general area of study, in our case, -Spain-. This identification provides a first geographical selection of the working environment in the system. The country and the city or region to be analysed can also be provided. The 'country' field is compulsory for CSIS to select the type of study to be carried out, as there is a particularisation for Spain and a more general case for selecting any other European country. CSIS later incorporates an additional study area selector to further characterize it. Within this section it is possible to select the Study Scenario, a combination of work variables that define a (impact) scenario - currently "there can only be one"; later on the

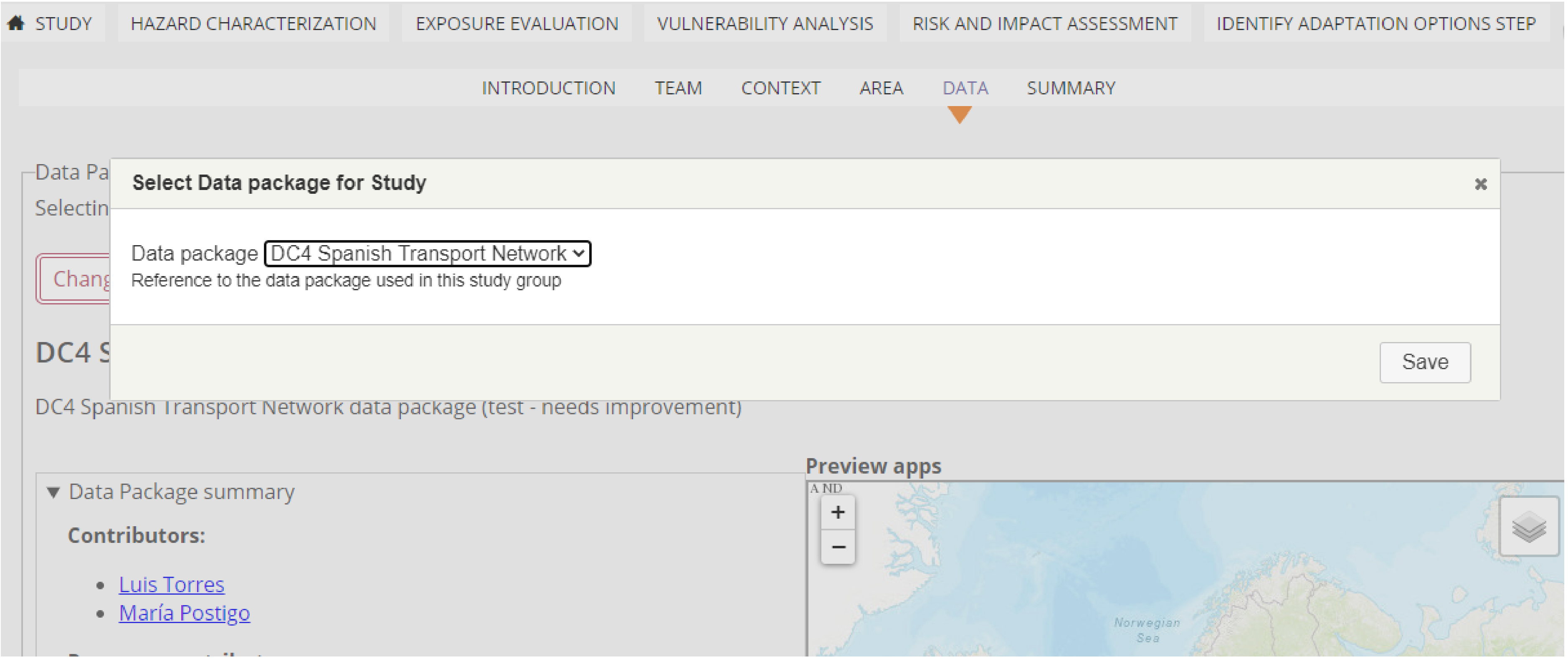


possibility of defining several scenarios and comparing them will be added. Finally, the user can save the changes through the "Save" option.

- Area. This screen incorporates advanced options for the dynamic selection of the area to be analyzed as it access the specific Transport Module. To select the study area, the user must go to the "Map of the study area" window that automatically appears on the screen. Afterwards, the user must access the "tools" icon available in the right-hand side menu and select the area selector (icon) from the drop-down menu. The system then creates a rectangular polygon in the centre of the map that the user is viewing. This polygon can be modified. To do so, the user must position the cursor over it, click on it and drag its margins until the geometry is adapted to the desired analysis area. Once positioned, the changes must be saved for consideration in the study. To do this, the user must click on the area selector again.



- Data. Now the user can select the Data Package they want to use in the climate analysis. For our case study the package -DC4 Spanish Transport Network- was selected and saved.



- **Summary.** CSIS displays the summary of the general information of the case study, together with the image of the selected area, and allows this information to be downloaded as a PDF report.

  Once the general information fields of the study have been edited and the spatial analysis framework defined, the CSIS system user will be able to start the climate analysis stages in a sequential way: exposure, vulnerability and climate risk study, together with the identification of possible adaptation measures.

INTRODUCTION TEAM CONTEXT AREA DATA SUMMARY

Study Summary

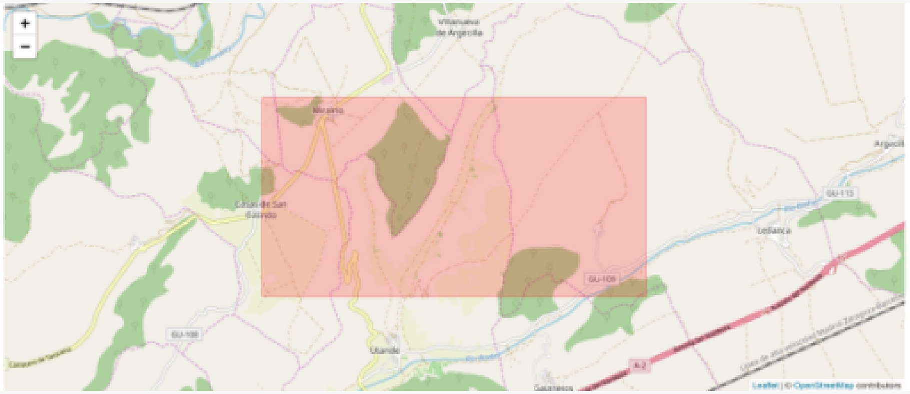
Short name: A-2 Guadalajara
Study goal: Assess Climate Change effects on A-2 highway near Guadalajara

Study type: Advanced Screening: Transport Infrastructure

This study type triggers the screening process that estimates the impact of the considered hazards on road elements and road traffic. A key difference between this study and those related to urban infrastructure is the highly specialized knowledge of the user that will make use of the study, likely an engineer. This will result on having a characterization of both vulnerability and exposition done by an expert based on their own experience. Lastly, the impact of Climate Change over the element at risk will be determined based on the information submitted to the system.

Study area

Report image



Edit image comment

Analyze the Climate Hazards

The first step in building an adaptation strategy is to identify the hazardous conditions in the project area, in relation to a range of climate variables and hazards. This should be done for both the baseline/observed climate and the projected future climate in the study area. For each climate-related hazard, the system provides one or more relevant indices, such as probability of occurrence or exceedances above threshold values. The indices are calculated for a defined climate period and the climate variables can be combined with other parameters to assess the characteristics of more complex natural hazards, such as landslides or floods. Based on the evolution of the indices and the supporting contextual variables, the possible evolution of the hazards considered in the study should be assessed using the criteria of an expert in the field. At present the system does not show automatic evaluation of hazards although this may be revised in the future if deemed necessary from the user's point of view. As stated above, the analysis of the hazard must be based on expert judgement at present.

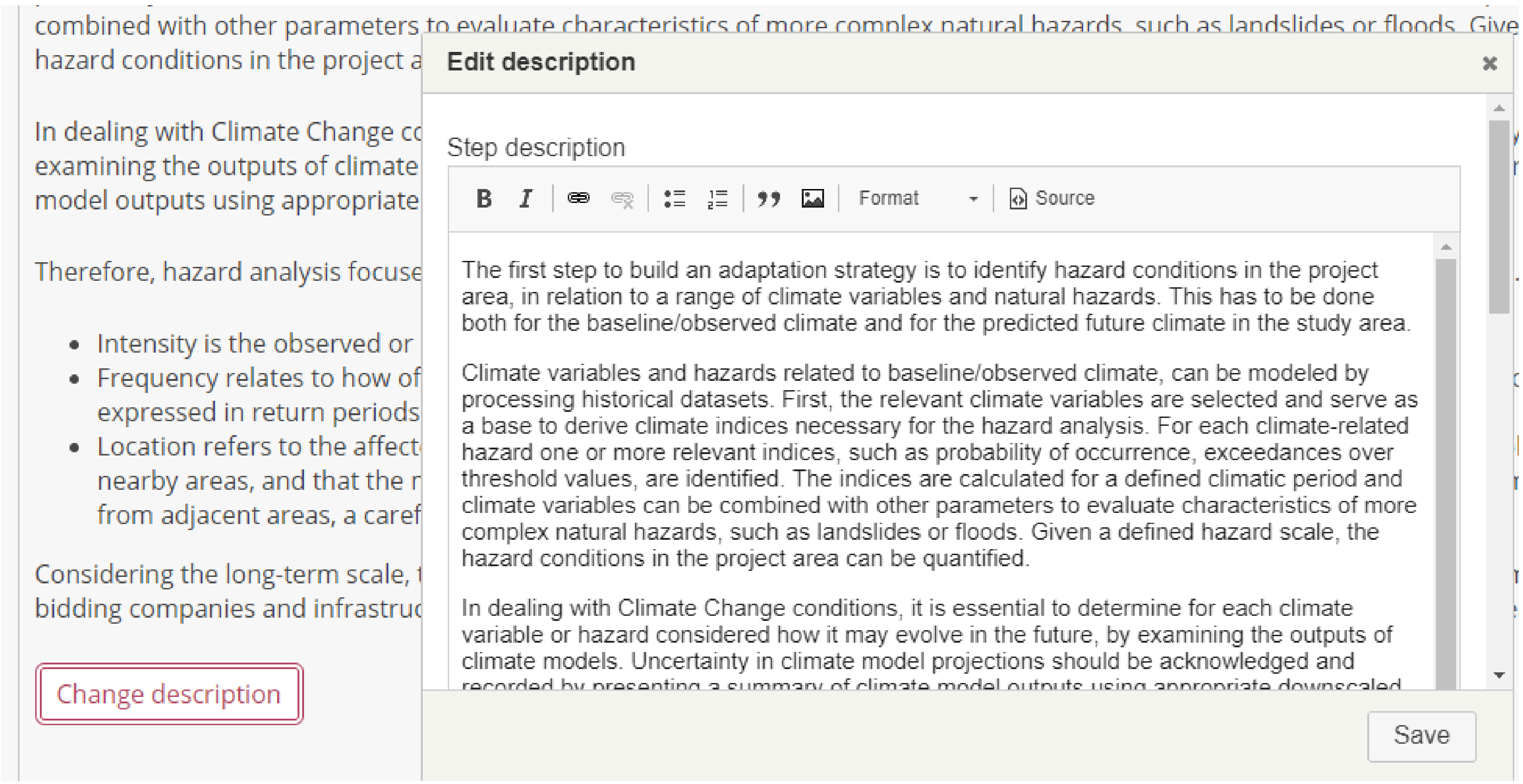
When working with climate change conditions, it is essential to determine for each climate variable or hazard considered how it may evolve in the future, by examining the results of climate models and recognizing the associated uncertainty from the evolution of related climate indices. Hazard analysis therefore focuses on three main characteristics: intensity, frequency and size or location of the natural hazard.

- Intensity is the observed or potential magnitude of a given natural hazard.
- Frequency relates to the recurrence with which a natural hazard of a particular intensity is likely to occur, or has occurred, in a given location. This probability is often expressed in return periods.
- Location refers to the geographical area affected. It should be considered that the evolution of a climatic episode in nearby areas may affect elements such as drainage or land use conditions in the project area.

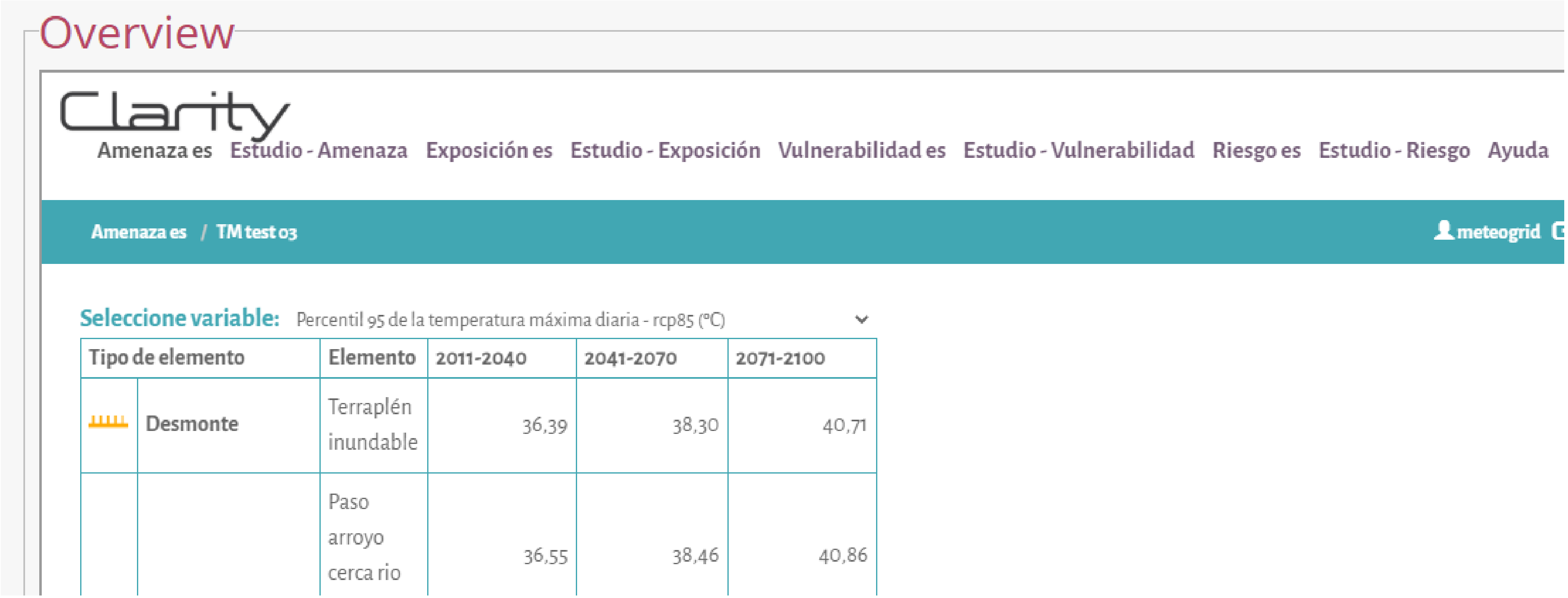
Taking into account the long-term scale, the relevant information is the climate data provided on a decadal scale. This type of approach is intended to provide support to infrastructure bidders and designers (most elements of road infrastructure have a lifetime of more than 30 years).

The user can initiate the analysis of climate hazards through the "Threat Characterization" option located in the upper main menu.
The system then displays the following analysis options:

- Introduction: information can be found about the objectives of this phase of the study and the expected results, such as the description of the intensity, frequency and location of the climate hazards. This information comes by default although editing is allowed. To do so, the user must access the option "Change Description", then they can enter the changes and save them through the option "Save".



- **Data**: the user will be able to select through this window the set of climatic data available to address the hazard analysis; in this case, climatic indices related to the different hazards are shown.
- **Table:** In this window the user can analyze the evolution of the indexes associated with climate hazards for each element created. By selecting the desired variable, the user can view the climate values for each time horizon in a tabular form.



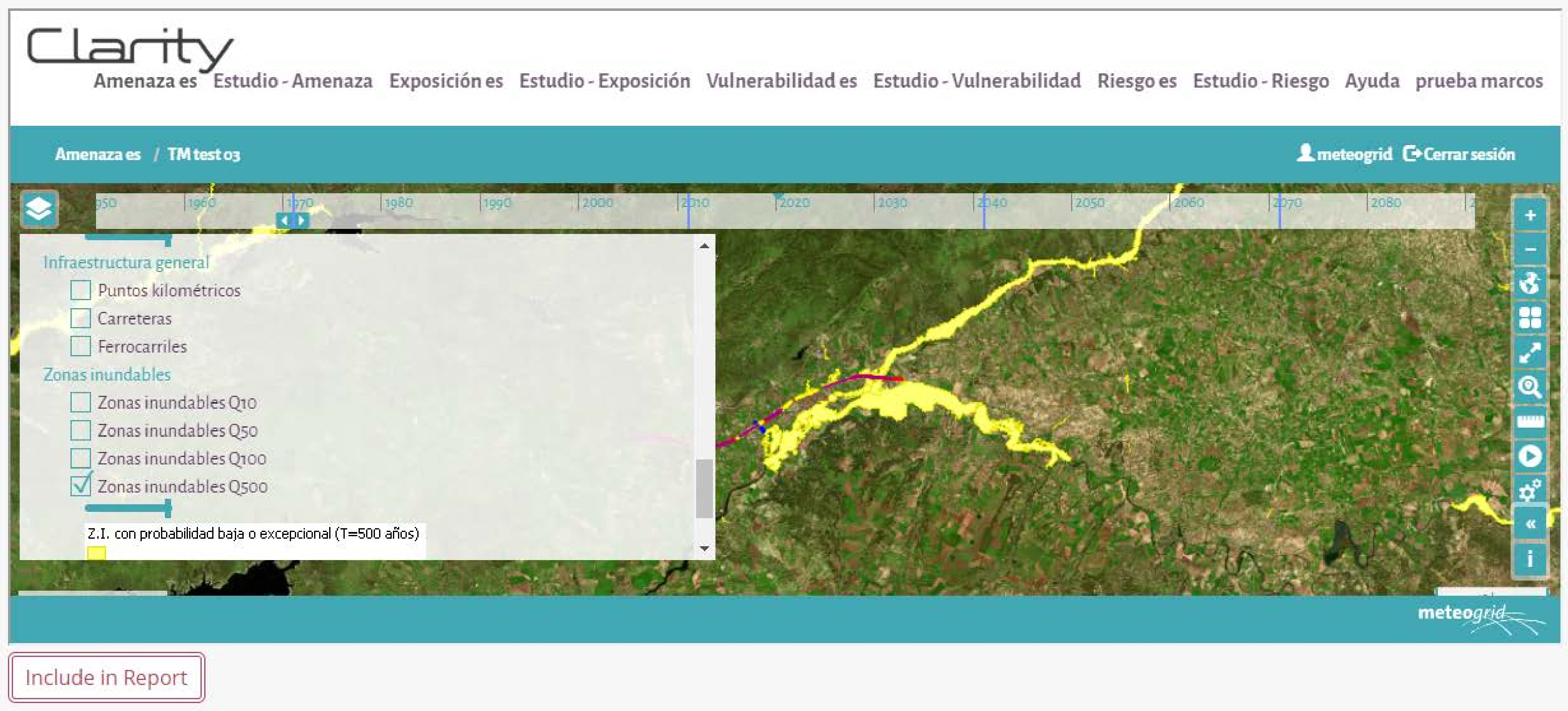
Tipo de elemento		Elemento	2011-2040	2041-2070	2071-2100
	Desmonte	Terraplén inundable	36,39	38,30	40,71
		Paso arroyo cerca rio	36,55	38,46	40,86

- Maps: This option allows the user to view maps of the indicators associated with climate hazards (indicators for a given CPR)[1] selected on the previous screen. To do so, the user must operate on the transport module window that appears automatically on the screen. Afterwards, the user must access the layer menu (icon) located in the upper right-hand corner of the window and select the layer(s) to be displayed[2]. 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. Finally, the user can save their selection through the option "Include in Report" available in the lower left margin of the screen.

[1] The set of climate threat indicators in the Spanish case are provided by AEMET (State Agency for Meteorology in Spain) through the Adaptecca(*) platform available for the RCP4.5 and RCP8.5 emissions scenarios and for the near (2011-2040), medium (2041-2070) and distant (2071-2100) future. *To consult the metadata of the climate indicators click here: http://escenarios.adaptecca.es/info

[2] The system also allows the loading of other layers not available by default or pre-calculated (variables, climate indicators or reference layers) that the user wishes to analyze. In this case, the user must request it from the Transport Module developer.

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.



- Twins: Information on similar case studies in Europe is available to the user for consultation and consideration. The system allows the introduction of a search radius for each type of threat. This option will be populated with new case studies as the tool evolves and is used.

- **Summary**: The user can refer to a summary of the hazard assessment carried out in the previous steps. This summary shows both the information that can be published in each of the windows collected in this work module and the selected infographics, such as tables, graphs or maps that have been included in the report ("Include in Report" option in the Tables and Maps windows).

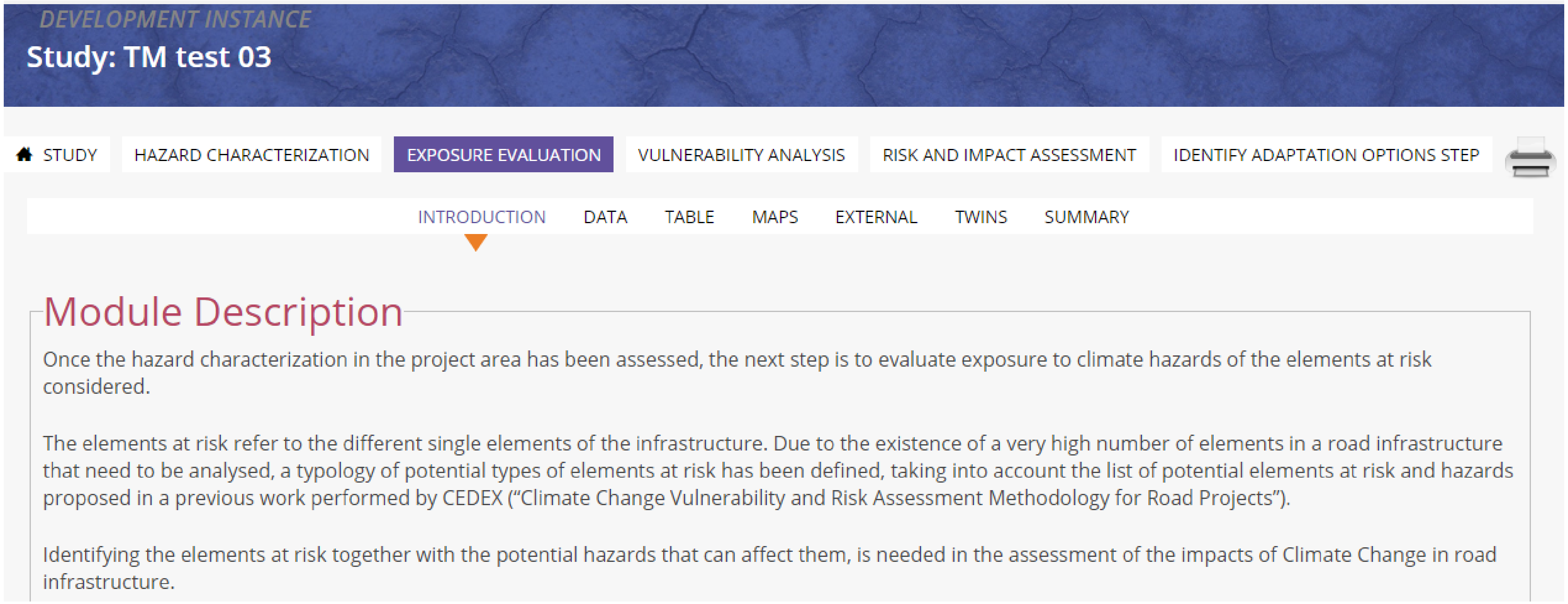
Analyze the Exposure

Once the hazard has been characterized in the project area, the next step is to assess the exposure to the climate hazards or set of elements located in the hazardous areas. Due to the existence of a very high amount of elements in a road infrastructure that needs to be analyzed, a general typology of the potential types of exposed elements has been defined, taking into account previous work done by CEDEX ("Methodology for the evaluation of vulnerability and risk of climate change for road projects").

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.

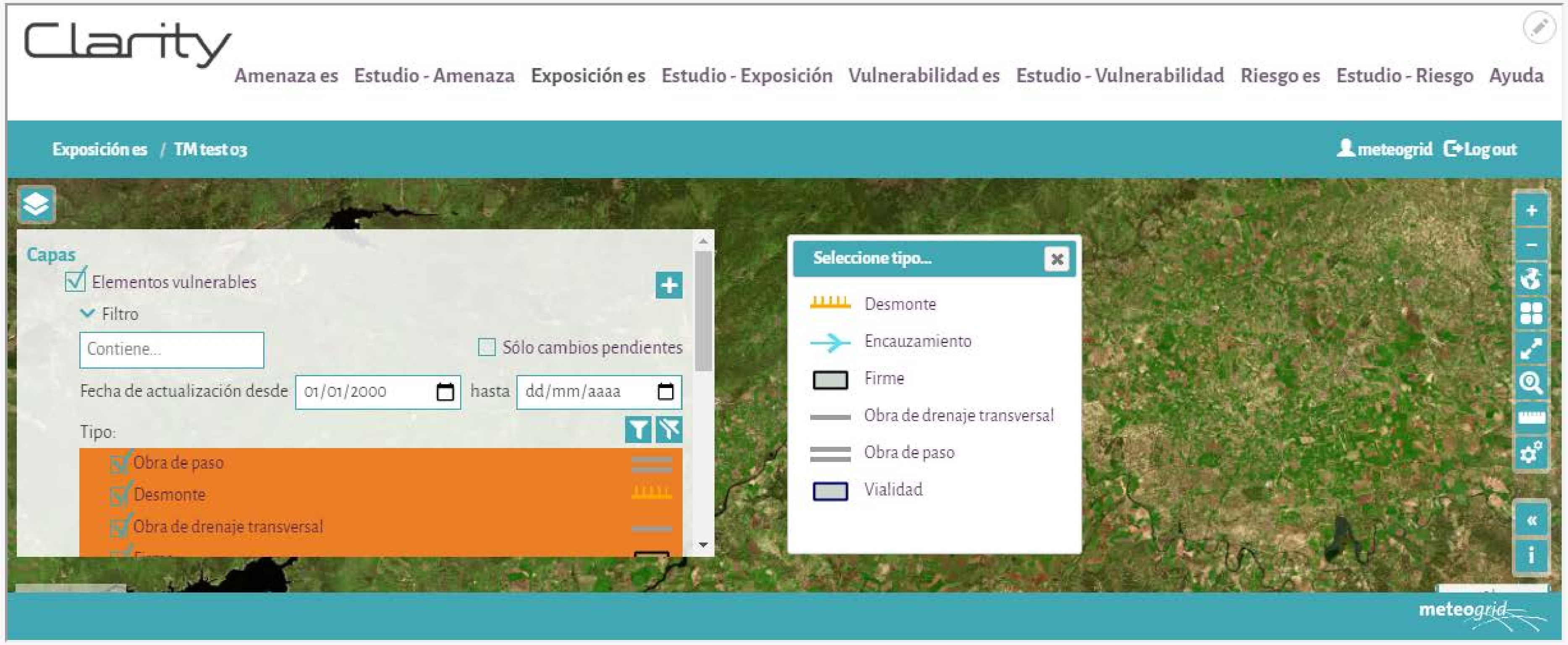
To start the analysis of elements exposed to the selected climatic hazards, the user must go to the general menu of the study created in CSIS and click on the option "Exposure Assessment" located in the upper menu of the screen.



The system then offers the following analysis options:

- Introduction: This screen provides a theoretical framework about the objectives of this phase and the expected results, such as the identification of the set of elements that could potentially be threatened by the hazards considered. By default, the module incorporates a general description that can be edited by the user. To do that, the user should access the "Change description" option, modify the content and "Save" the changes made.
- Data: the user can select through this window the set of data and resources available to address the exposure analysis.
- Table: this screen 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.
- Maps: This screen offers the possibility of analyzing the set of elements potentially exposed to the climate hazards considered and for the selected area of analysis. To do so, the user must go to the Transport Module window that appears automatically on screen. For this phase, the Transport Module incorporates online editing functions for georeferenced elements. The user will be able to create, display and modify the set of potentially exposed elements. To do this, the following steps must be taken:

1. access the drop-down menu of layers that appears on the left margin (icon) and click on the option "add" (icon).
2. select the type of element* to create, e.g. firm.



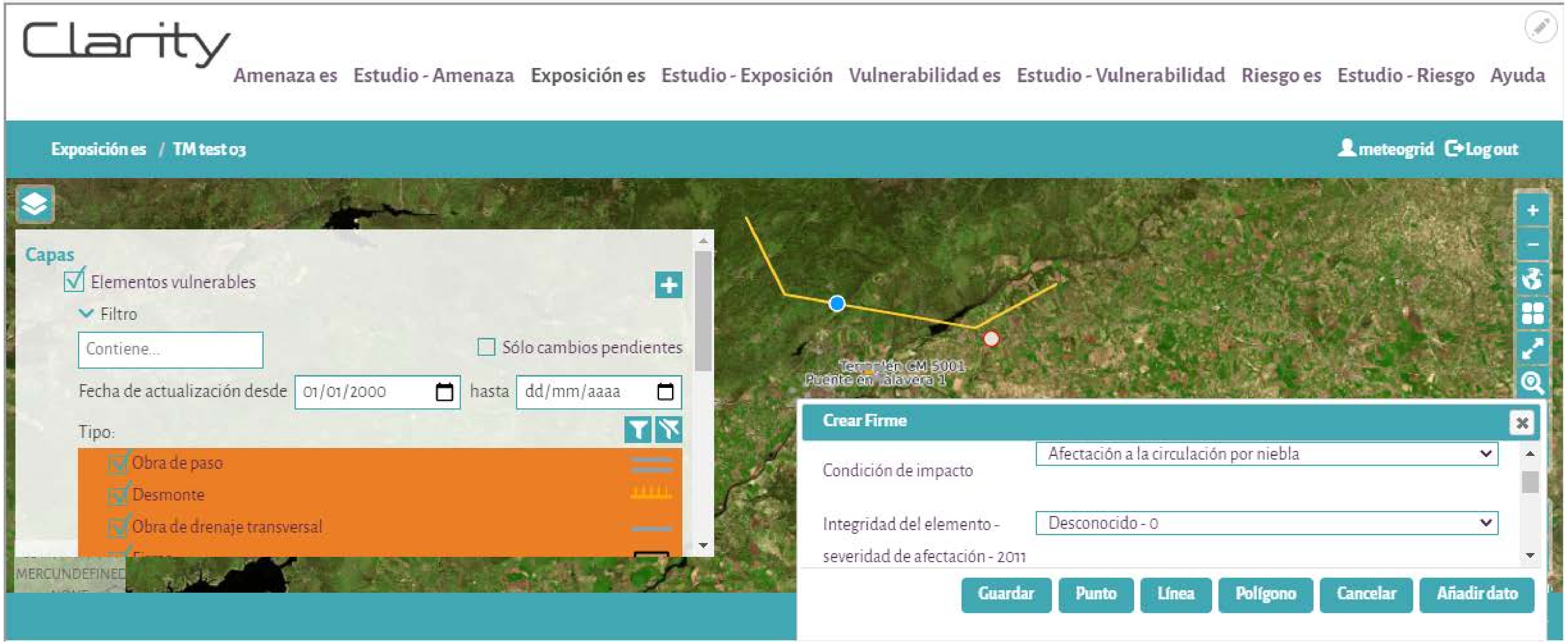
(*) A glossary of terms is available in Annex 1 where you can consult the description of each type of element

3. Edit the attribute box of the created element that appears automatically on the screen. These attributes are:

-General descriptive fields: name, address, comments

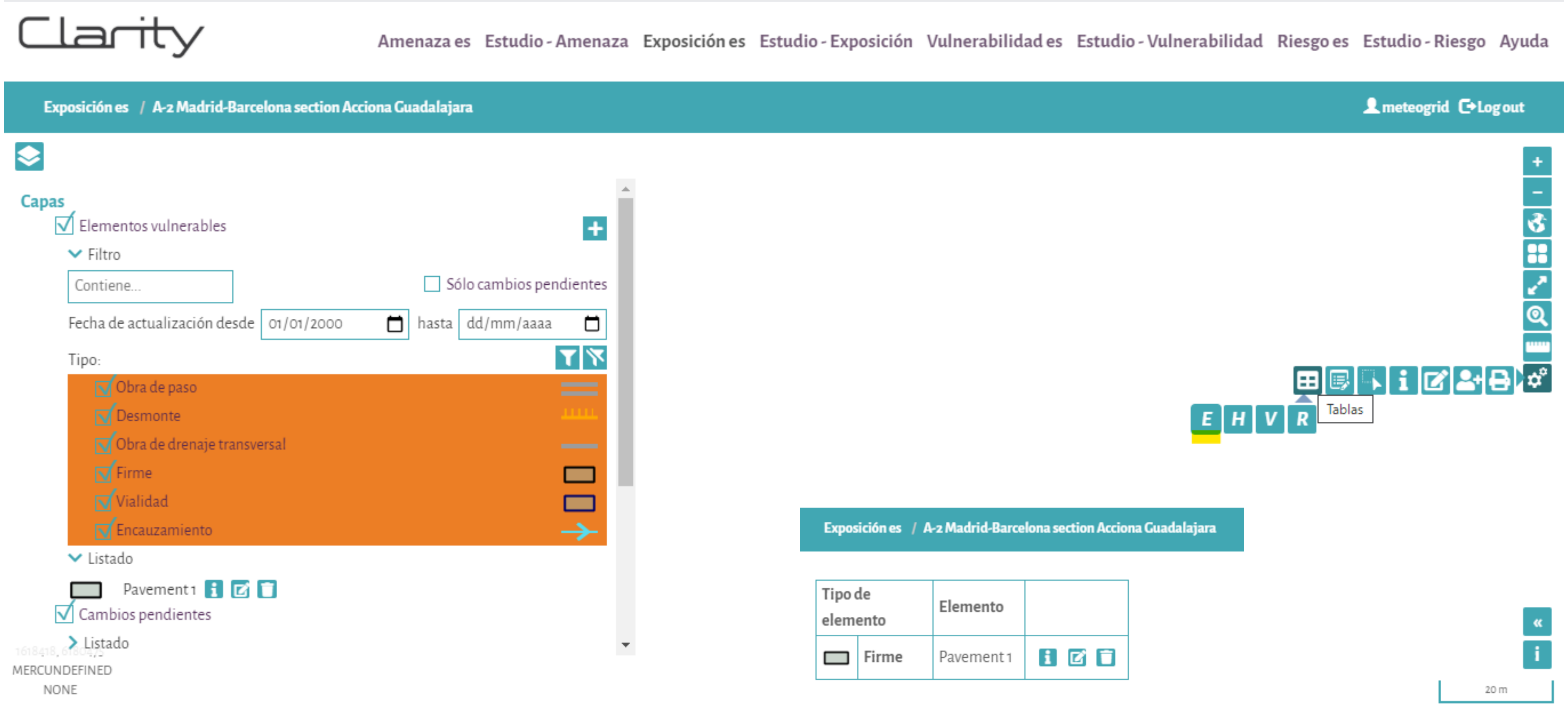
-Selection fields for the associated impact. The Transport Module shows by default the impact module that, in general, is associated to the type of element selected. However, it allows the selection of other options under the criteria of the user who performs the analysis. To do this, the user must access the drop-down menu and select one of the options available for the "Impact Condition" attribute.

- Fields of analysis of the severity and probability of affectation for the components: (1) element integrity and (2) circulation conditions for each period of analysis. To complete these attributes, the system offers the user quantification options by selecting default values from the drop-down menu associated with each attribute.



4. Delimit the geometry of the element. To do that, the user must click on the geometry to be represented (point, line or polygon) that appears at the bottom of the editable attributes box. In our example, we select -line.
5. Modify the geometry. The system then creates a default geometry in the center of the display screen. The user can modify the initial layout to fit the shape and dimension of the element. To do that, just select the original geometry and move the points to be modified.
6. Save the created element.

Although the system allows through the "Tables" option of the transport module (icon) to access the list of created vulnerable elements, its use is not recommended since there are direct access options from the "Table" window in CSIS.



- Twins: Information on similar case studies in Europe is available to the user for consultation and consideration. The system allows the introduction of a search radius for each type of exposed element considered in other studies. This option will be populated with new case studies as the tool evolves and is used.

- Summary: The user can refer to a summary of the exposure assessment carried out in the previous steps. This summary shows both the information that can be published in each of the windows included in this work module, as well as the selected computer graphics, such as tables, graphs or maps that have been included in the report ("Include in Report" option in the Tables and Maps windows).

Analyze Vulnerability

Once the current and future climatic conditions in the Project area are known, and the main potential hazards for each element of the Project are identified, the vulnerability assessment will 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 characterised 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 behavior 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 general 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 figure 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 referrs 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 refers to the set of phenomena of different nature (meteorological, service or functional) that influence and determine the mobility or flow of vehicles.

For example, if such an event occurs (e.g. rain in 24 hours and the vulnerability of a concrete clearing is being analysed), we have to answer two questions in two cases:

Case 1. Element integrity.

- Severity: how affected is the slope? For example, if the manager's experience is that when there is rain of xx mm/h small repairs must always be made to the slope, in that case the severity would be "moderately low".

- Probability: is it likely that the slope will be affected to the extent indicated above? In this case, the answer would be "very likely" (because the manager tells us that whenever there is rain of xx mm/h small repairs must always be made on that slope...).

Case 2. Traffic conditions·

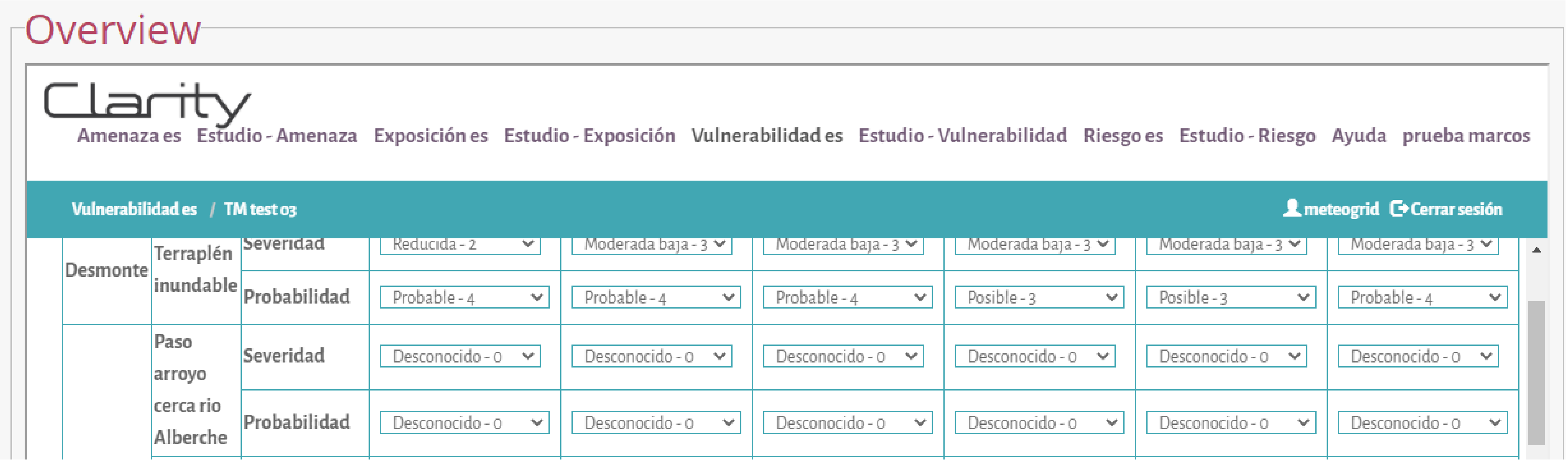
- Severity: how affected is traffic by the impact on the slope every time it rains? For example, if the manager's experience is that when it rains xx mm/h the traffic is rarely affected, then the severity would be "reduced".

- Probability: is it likely that traffic will be affected to the extent indicated above? In this case, the answer would be "possible" (because the manager tells us that on certain occasions when there is rain of xx mm/h there are mobility problems).

To approach the climate vulnerability study for each of the exposed elements that have been previously created, the user must access the option "Vulnerability Analysis" located in the upper menu of the screen.

At this stage, CSIS offers the following options:

- Introduction: this screen offers a theoretical framework about the objectives of this phase and the expected results, such as the evaluation under expert criteria of the vulnerability of the set of potentially threatened elements according to a scale of predefined values. By default, the module incorporates a general description that can be edited by the user. To do this, the user must access the "Change Description" option, modify the content and "Save" the changes made.
- Data: the user will be able to select through this window the set of data and resources available to approach the vulnerability analysis.
- Table: this option allows the user to quantify the vulnerability of each exposed element under expert criteria and in a tabular way. This 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 access the option:
  - "send" to save the changes and values introduced in each case, located in the lower left margin of the transport module window
  - "Include in Report" for consideration in the final vulnerability report, located at the bottom left of the screen.

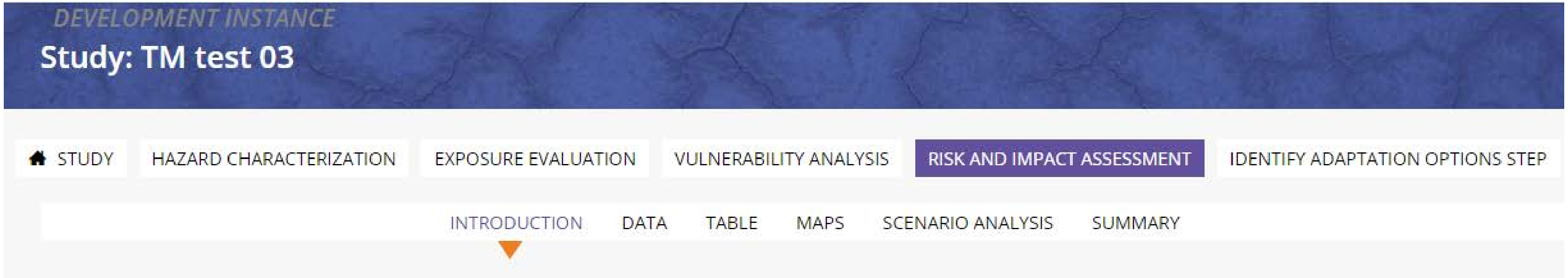


- Summary: The user can consult a summary of the vulnerability assessment carried out in the previous steps. This summary shows both the information that can be published in each of the windows included in this work module, as well as the selected infographics, such as tables, graphs or maps that have been included in the report ("Include in Report" option in the Tables and Maps windows).

Analyze the Risk

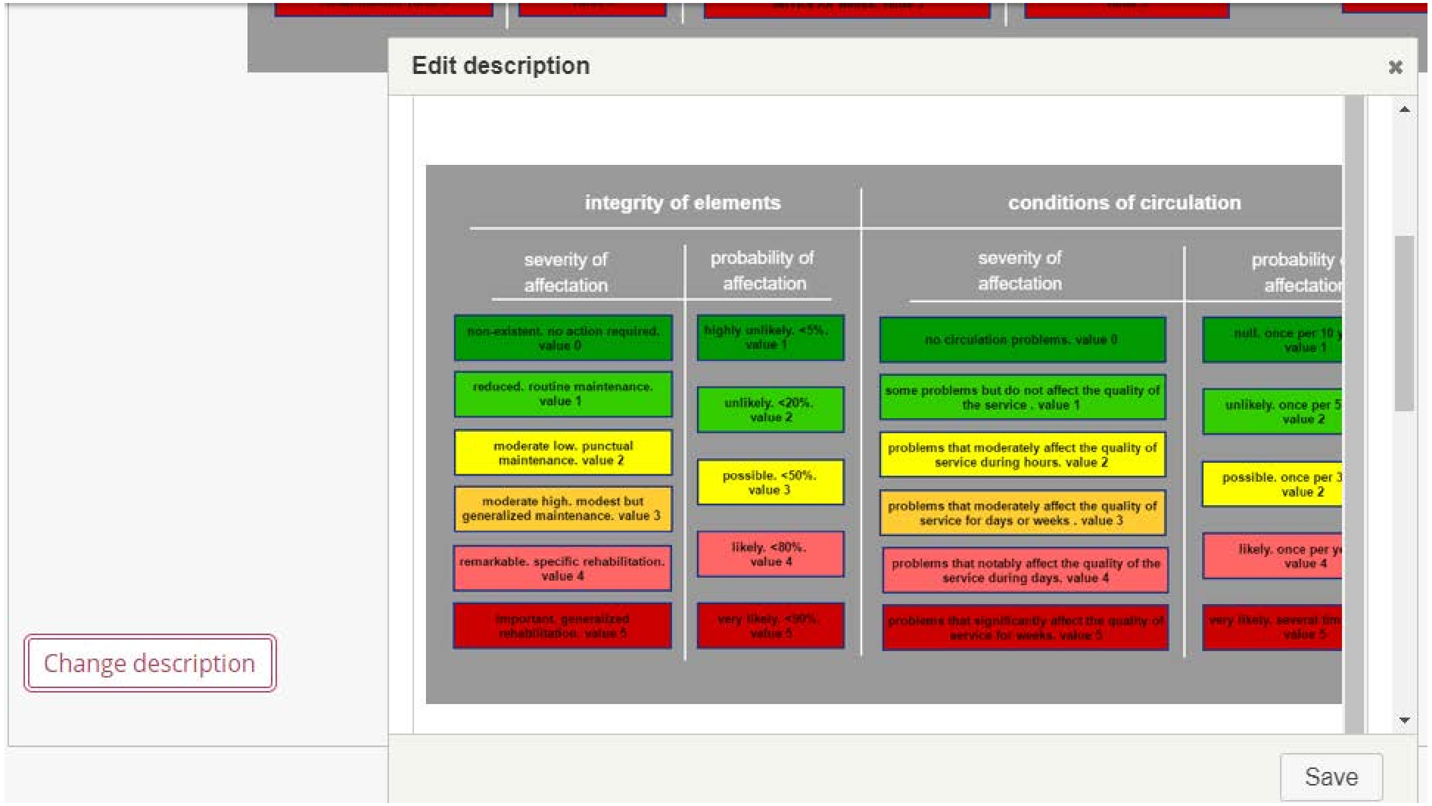
This module calculates the climate risk associated with the elements considered as a function of the vulnerability parameters introduced in the previous module. The level of risk is automatically calculated in the system by combining the possible level of affectation with the probability of occurrence 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.

To do this, the user must access the "Risk and Impact Assessment" option located in the upper menu of CSIS.

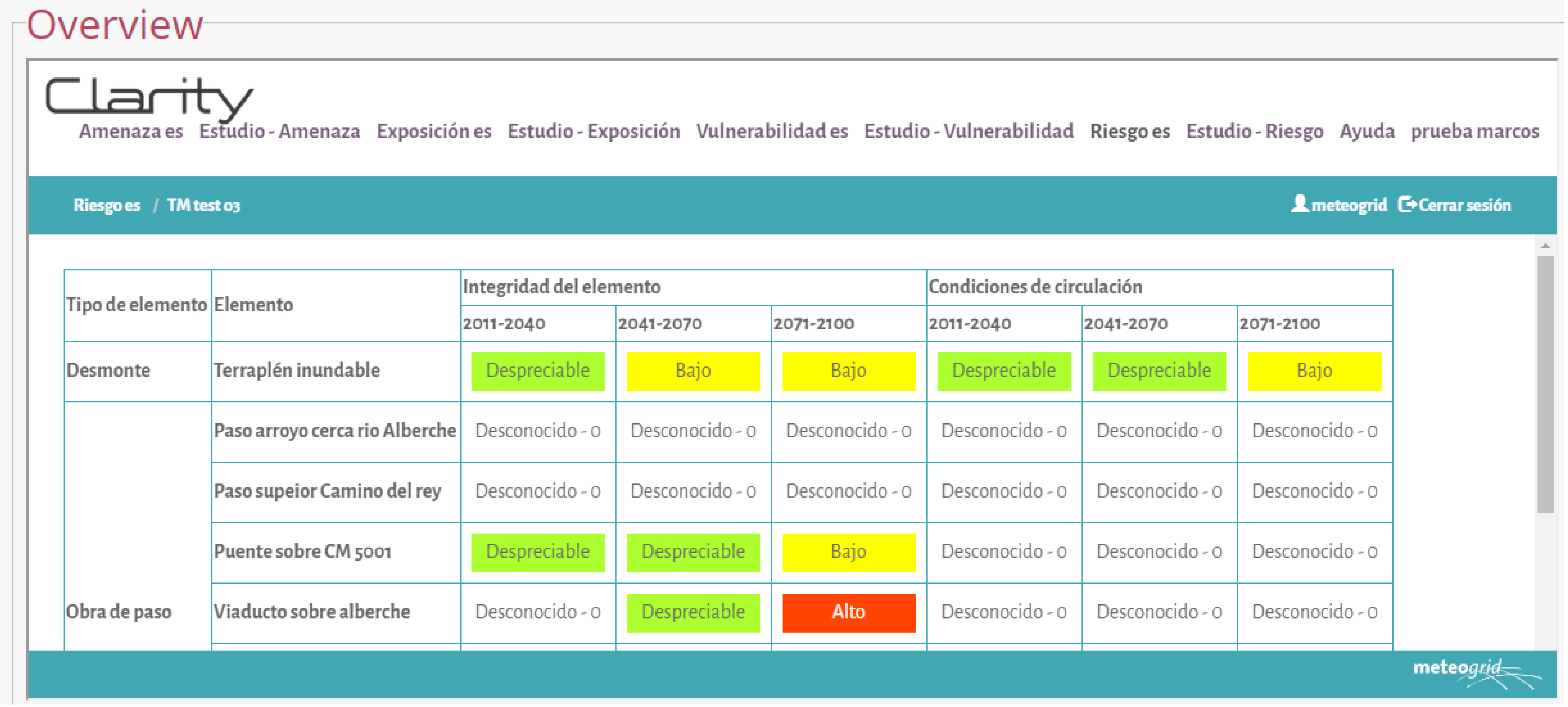


CSIS offers the following user options:

- Introduction: this screen provides a theoretical framework about the objectives of this phase and the expected results, such as the risk assessment for the set of elements analysed according to a scale of predefined values. By default, the module incorporates a general description that can be edited by the user. To do so, the user must access the "Change Description" option, modify the content and "Save" the changes made.

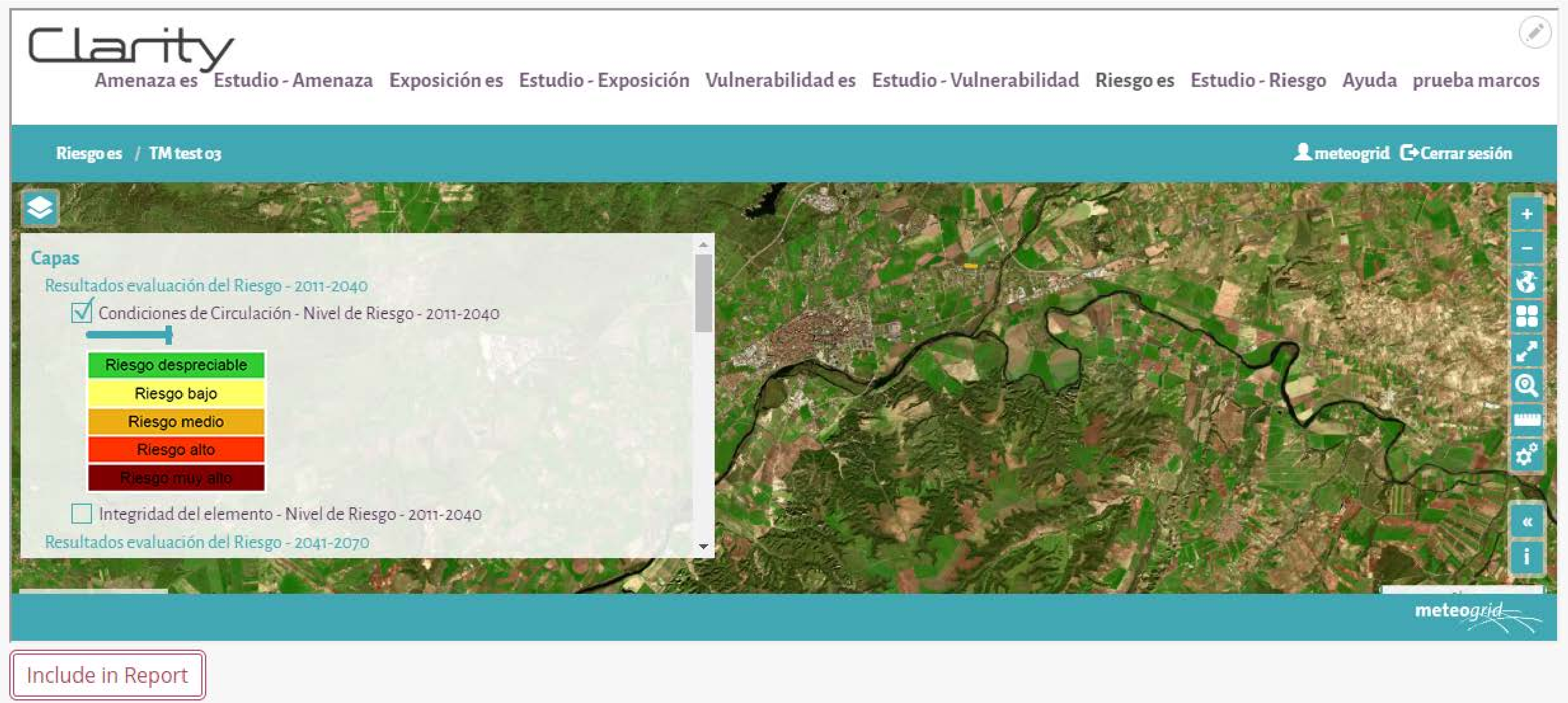


- Data: the user can select through this window the set of data and resources available to address the risk analysis.
- Table: this option allows the user to quantify the climate risk for each exposed element under expert criteria and in a tabular way. This analysis is carried out for the integrity of 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"). If the user is satisfied with the resulting values, they must access the "Include in Report" option, located in the lower left margin, for consideration in the final climate risk report.



Tipo de elemento	Elemento	Integridad del elemento			Condiciones de circulación		
		2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Desmonte	Terraplén inundable	Despreciable	Bajo	Bajo	Despreciable	Despreciable	Bajo
	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
Obra de paso	Viaducto sobre alberche	Desconocido - 0	Despreciable	Alto	Desconocido - 0	Desconocido - 0	Desconocido - 0

- Maps: the user can also visualize the elements on the map with the final climate risk values for each moment analyzed and for the 2 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. If the user wishes to incorporate the resulting maps, they must access the "Include in Report" option located in the lower left margin of the screen.



Finally, the user can also modify the risk values through the vulnerability modification options by returning to the vulnerability module.

- Scenario Analysis: CSIS offers the user options for analysis of impact indicators by time horizon and CPR considered (e.g., heat wave mortality rate). These options include the generation of tables and graphs on these indicators. Once analyzed, the user can access the saving options ("Include graphic in report" and/or "Include tables in report") located in the lower left margin of the screen. This option is not available within the transport module.
- Summary: The user can consult a summary of the risk assessment carried out in the previous steps. This summary shows both the information that can be published in each of the windows included in this work module, as well as the selected infographics, such as tables, graphs or maps that have been included in the report ("Include in Report" option in the Tables and Maps windows).

Identify Adaptation Options

Once the risk has been assessed, CSIS offers the possibility of identifying concrete measures for adaptation to climate change as the final phase of the study. Adaptation options in the transport sector can generally be divided into engineering (structural) and non-engineering options. "Do not act", or "maintain a business-as-usual approach" ("do nothing" option) should also be retained as a possible option. In various circumstances, the findings of impact, vulnerability and adaptation assessments may indicate that doing nothing (without climate protection) is the best course of action.

<u>Design Standard Options (Engineering Options)</u>

Subsurface conditions

The stability of any type of infrastructure crucially depends on the materials on which it is built. In the case of transport infrastructure, an important factor pertains to the degree of soil saturation and the expected behavior of the soil under saturated conditions. The type, strength, and protection of subsurface conditions and materials may have to be increased to control and prevent soil saturation from damaging transport infrastructure. The composition of the subsurface materials can be adjusted to account for changing climatic conditions. Availability of water for compaction during construction may be an issue in some areas where rainfall is projected to diminish.

Material specifications

All materials have their own set of properties and will exhibit different behavior under different environmental conditions. The strength of these materials may have to be increased to withstand increased or decreased moisture contents. The protection of these materials (for example, against increased moisture and salinity) may have to be enhanced to preserve the expected lifetime of the transport structure, or other materials may need to be used. For example, because of increased salinity, steel reinforcements and culverts may be replaced with less corrosive materials.

Cross section and standard dimensions

The design of each component of the transport infrastructure reflects design standards adopted by the agency that is sponsoring or regulating the infrastructure. These standards tend not to change rapidly and may not be responsive to changes in climate conditions. For example, standards may need to be revised to increase the slope of pavement in areas where one can expect a need to remove more water from the road. Similarly, standards (or guidelines) pertaining to road elevations or the vertical clearance of bridges over waterways may have to be revised upward to withstand more extreme flood conditions.

Typical practice is to use historical climate information as a basis for determining engineering specifications. Using forecast data and trends, rather than historical trends, can assist the engineer to design for future climate conditions.

Drainage and erosion

When water represents a key challenge for the design of a given transport infrastructure, then particular attention must be paid to standard designs pertaining to drainage systems, open channels, pipes, and culverts to reflect changes in future expected runoff or water flow. Further, it may be appropriate to include a provision for use of superfluous drainage water for domestic or irrigation purposes.

<u>Non-Engineering Options</u>

Maintenance contracting and early warning

For transport infrastructure that is already in place, increasing maintenance contingency budgets in areas where climate change impacts are acute will allow more intensive supervision and monitoring of the most vulnerable areas. This can reduce road closures and more serious consequences of disasters. Furthermore, maintenance planning systems can include early warning systems to anticipate extreme events so that crews and contractors can be prepared for an upcoming high rainfall event and possible landslides. On the one hand, this will ensure that forced road closures are kept to a minimum. On the other hand, preemptive road closures may minimize losses of property and life. This suggests the presence of a trade-off between increased capital costs today with less operating expenditures and damages in the future.

Alignment, master planning, and land use planning

Roads influence development patterns. Once a road is built into an area, economic growth and community development are encouraged by this access. It is therefore important to consider whether roads are opening up development in areas that are hazard prone. Melting permafrost areas, for example, are prone to increasing landslides. Where realignment is a plausible adaptation solution to protect transport infrastructure, care must be given to understanding the implications of resettlement of populations and economic activities. Realignment can imply resettling populations in other vulnerable areas, creating another more serious problem. Such interventions are not easily handled within the scope of a project.

Environmental management

Harnessing the services provided by environmental experts can moderate the damages from floods, droughts, landslides, and others, por example by reforesting a hilly area to prevent a road section from being damaged by a landslide. Adjustments can also be made to environmental management plans that are usually prepared for road development projects (for example, selecting more drought- and heat-tolerant indigenous species during post-construction rehabilitation works).

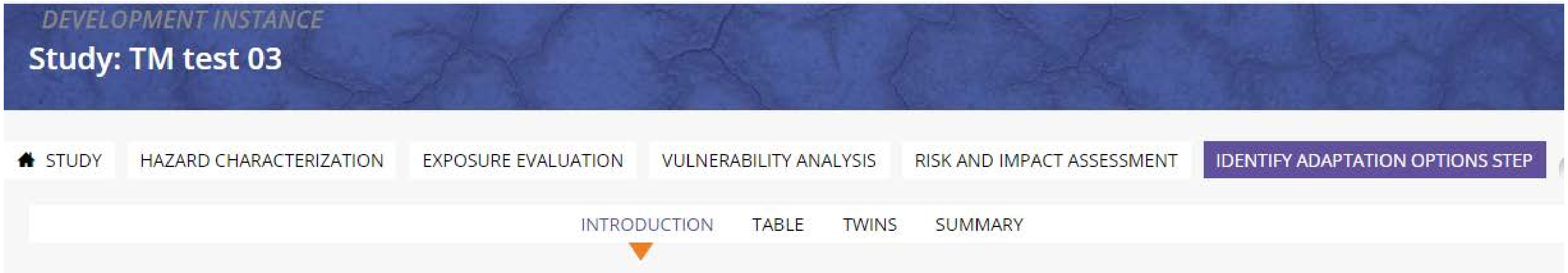
Furthermore, it is important to assess and reduce the impact that a road development may have on the region's vulnerability. Environmental impact assessments often focus on the environmental impact of a given road. However, this can result in inadvertent maladaptation, such as exacerbating existing floods or droughts, or causing urban heat island effects. This should be assessed at both the project and policy levels.

Do Nothing Option

In some cases, it is plausible that sufficient risk allowance has been built into the project to account for climate change, or that the nature of the changes is too uncertain or minimal, or that the consequences of climate change are too severe to justify in situ adaptation. In the latter circumstance, a best course of action may to be to allow the infrastructure to deteriorate and be decommissioned. In other cases, the up-front capital investment associated with any technically feasible adaptation option may be so large as to outweigh any possible benefits associated with the climate proofing of the infrastructure. Not investing in adaptation in the context of a particular project may be the best course of action (from both a technical and economic assessment).

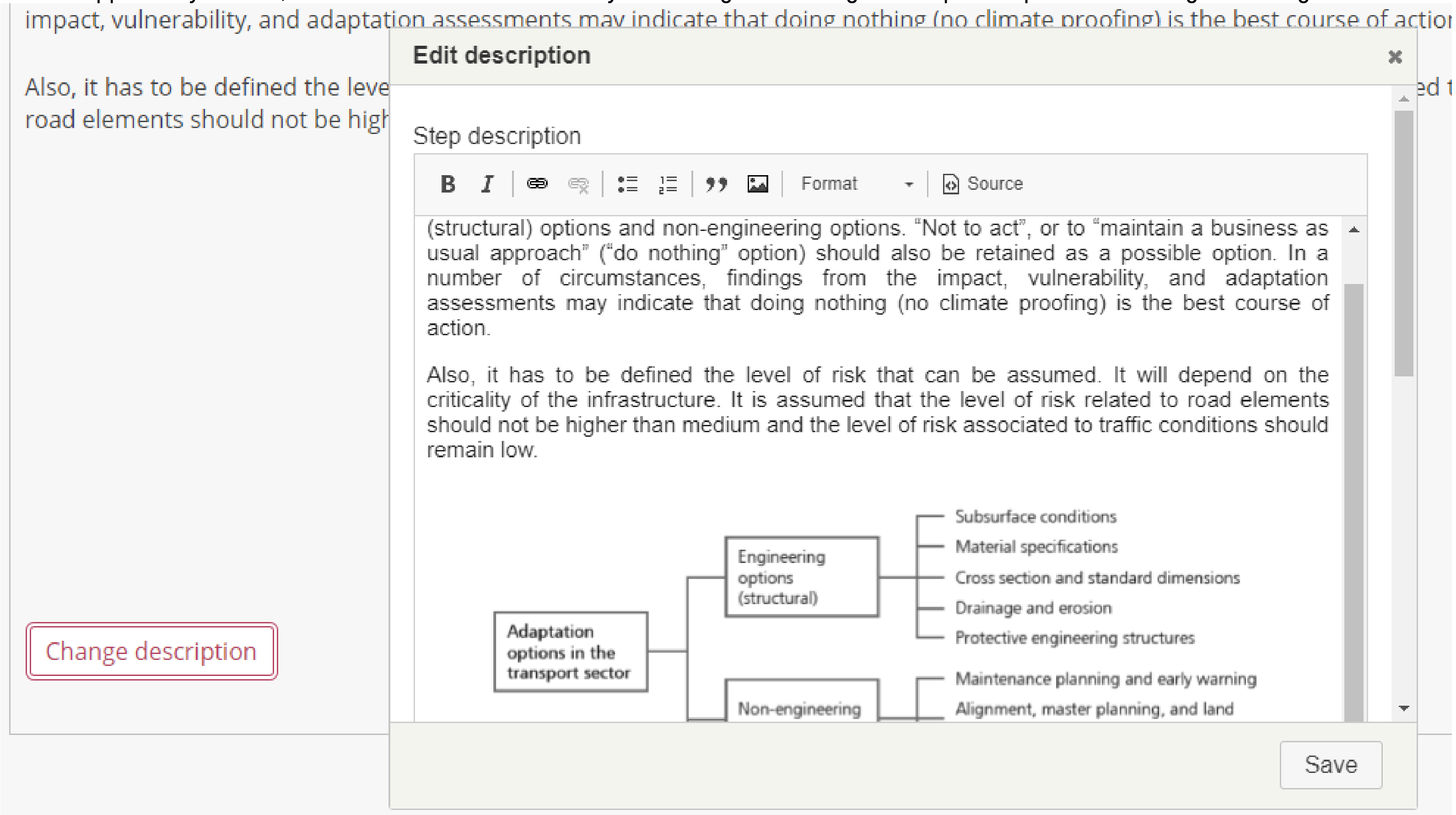
A generic battery of adaptation options considered in this framework for road infrastructure studies can be found in Annex 2.

In addition, the level of risk that can be assumed must be defined. It will depend on the criticality of the infrastructure. It is assumed that the level of risk related to road elements should not be higher than average and the level of risk associated with traffic conditions should remain low.

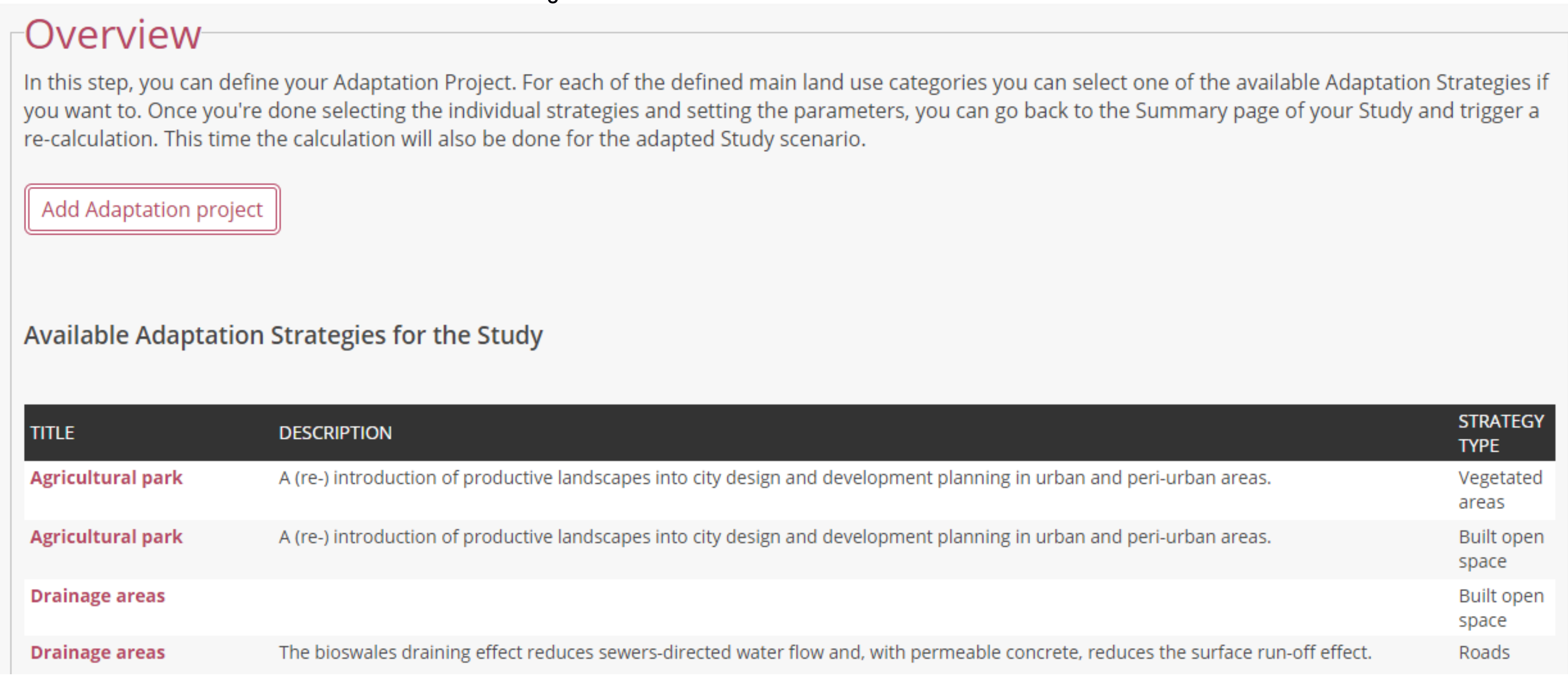


To do so, the system incorporates the following options:

- **Introduction**: this screen provides a theoretical framework on the objectives of this phase and its expected results, such as the identification of structural and non-structural measures, the definition of circumstances without climate protection and the levels of risk admissible without intervention. This information appears by default, however the user can edit it by accessing the "Change description" option and saving the changes made.



- **Table:** In this step, the user can define an adaptation project by creating a new project. To do this, access the "Overview" window and click on "add fitting project". Afterwards, the user must edit the available fields and save the changes. The user can also select one of the available Adaptation Strategies if desired. Once you have finished selecting the individual strategies and setting the parameters, you can return to the Summary page of your study and activate a new calculation. This time, the calculation will also be performed for the Adaptive Study scenario. The adaptive road strategy to consider can be selected afterwards and the changes saved for consideration.



Overview

In this step, you can define your Adaptation Project. For each of the defined main land use categories you can select one of the available Adaptation Strategies if you want to. Once you're done selecting the individual strategies and setting the parameters, you can go back to the Summary page of your Study and trigger a re-calculation. This time the calculation will also be done for the adapted Study scenario.

Add Adaptation project

Available Adaptation Strategies for the Study

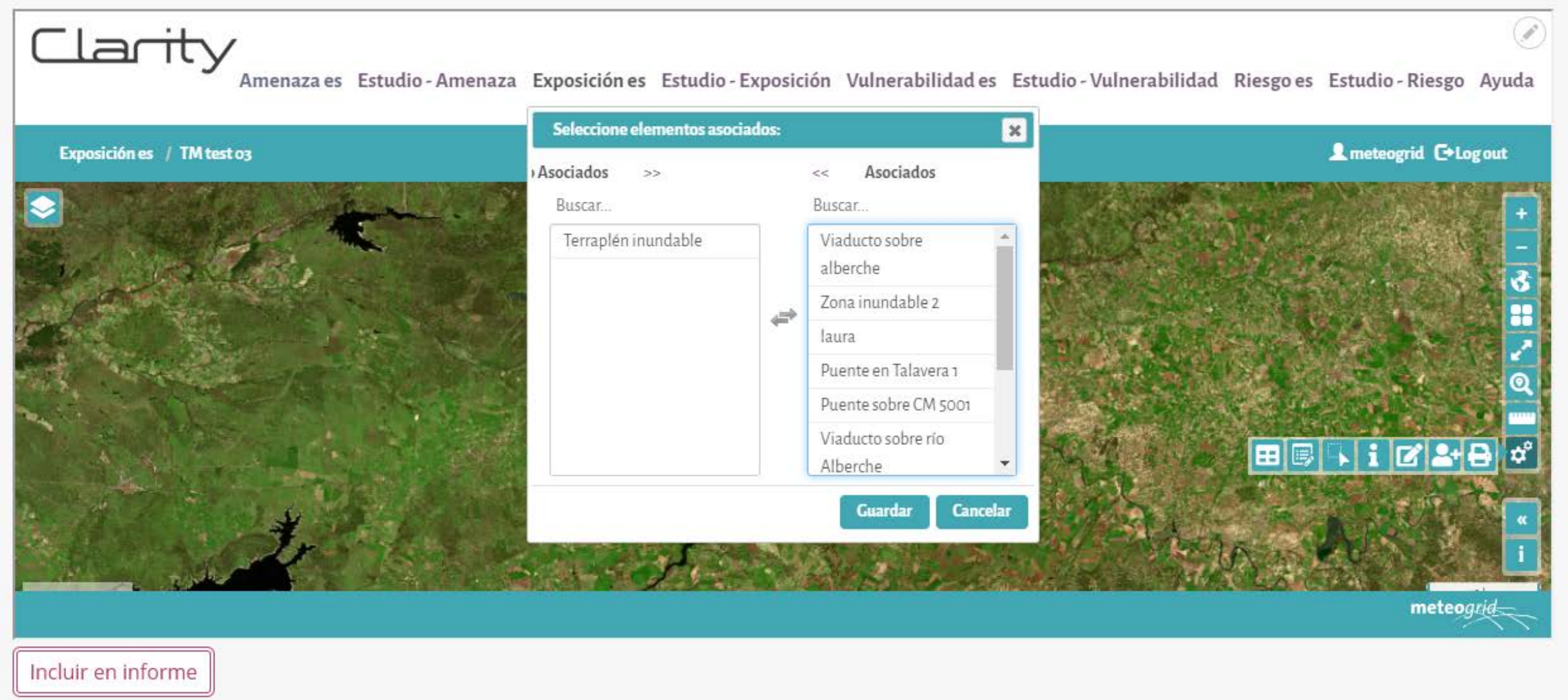
TITLE	DESCRIPTION	STRATEGY TYPE
Agricultural park	A (re-) introduction of productive landscapes into city design and development planning in urban and peri-urban areas.	Vegetated areas
Agricultural park	A (re-) introduction of productive landscapes into city design and development planning in urban and peri-urban areas.	Built open space
Drainage areas		Built open space
Drainage areas	The bioswales draining effect reduces sewers-directed water flow and, with permeable concrete, reduces the surface run-off effect.	Roads

- Twins: Information on similar case studies in Europe is available to the user for consultation and consideration. The system allows the introduction of a search radius to consult measures implemented in other studies. This option will be populated with new case studies with the evolution and use of the tool.
- Summary: The user can consult a summary of the adaptation options selected in the previous steps. This summary shows both the information that can be published in each of the windows collected in this work module, as well as the selected infographics, such as tables, graphs or maps that have been included in the report ("Include in Report" option in the Tables and Maps windows).

In addition to the above, the transport module offers the possibility for the user to evaluate the level of risk assumed by their project or infrastructure after implementing the adaptation measures selected above. This evaluation is made under expert judgement and to address it the user must

- Create a new study.

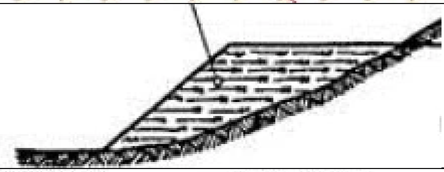
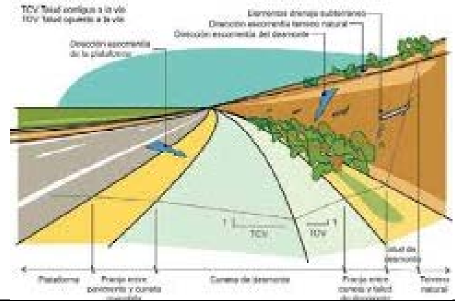
- Associate to this new study the exposed elements created in the initial analysis except the element on which the adaptation measures have been implemented. To do this, the user must access the "Maps" option in the "Exposure Analysis" module and click on the "Associate/dissociate elements" option (icon) located in the "tools" options of the main menu on the right-hand side. Then the element that is dissociated from the rest must be selected. In our case, for example, we dissociate the "Floodable embankment".

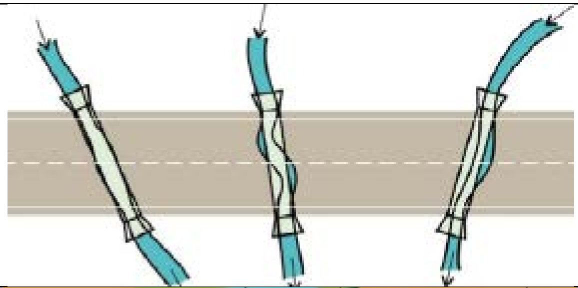
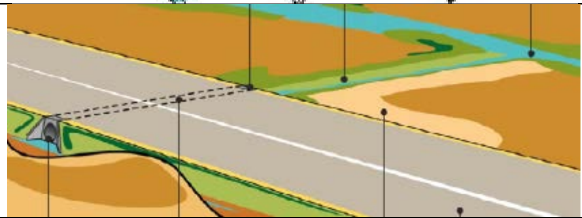
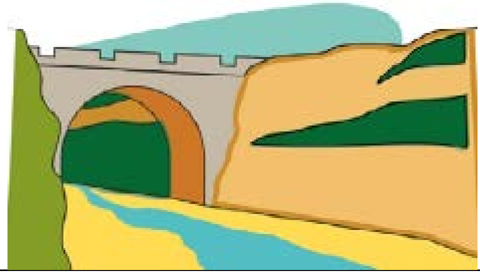


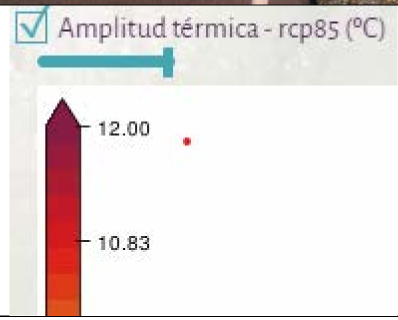
-To create again a dissociated element on which the risk is intended to be recalculated after the implementation of the selected adaptation measures. To do this, the user must access the drop-down menu of layers that appears on the left margin (icon) and click on the option "add" (icon). Then, the user must follow the steps indicated in the "Maps" screen of the exposure module until the new element is created. For example, in our case, we will call it "Adapted Floodable Embankment".

-Analyze vulnerability and risk as explained in the "Vulnerability Analysis" and "Risk Assessment" Modules respectively. The values of vulnerability and risk should be maintained for the elements for which no adaptation measures are applied, while for the adapted element the user will be able to quantify its level of associated risk again under expert judgement.

Annex 1 Glossary of Terms

GROUP	TÉRM	DEFINITION	CROQUIS
Elements	Clearance	Earth excavation carried out around the track in order to lower the level of the ground, reducing its height and achieving an adequate support plane for the execution and support of the work.	
	Embankment	Set of land with which the land around the track is filled in order to raise its level and obtain an adequate support plane for the execution and support of the infrastructure.	
	Slope	A surface inclined with respect to the horizontal plane that is permanently adopted in the land adjacent to the track, in order to resist the pressure exerted by the earth located behind it.	
	Channelling	Channels that intercept the water before it reaches the road and lead it to sites chosen in advance, where a transversal work can be built and the crossing carried out. They are necessary on significantly flat terrain, where runoff is torrential and there are no defined channels.	

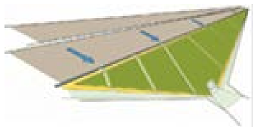
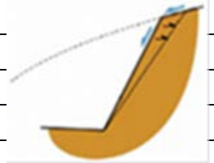
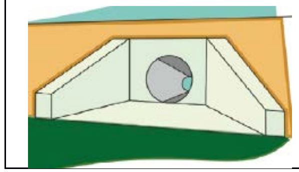
	Transversal drainage works	Infrastructure or pipe system whose purpose is to give way to water, restoring and facilitating the continuity of the path of the channels intercepted by the track. Drainage works can be: -Transversal -Longitudinal	
	Firm	Road surface or pavement that supports road traffic.	
	Roadside	A set of activities and functions carried out on road infrastructure with the aim of preventing effects derived from hydrometeorological events of a dangerous nature for traffic, mainly present in the winter season.	
	Works of passage	Construction that allows to save a geographic accident and makes possible the transverse drainage of the superficial waters under another infrastructure, like a road, highway or railroad.	

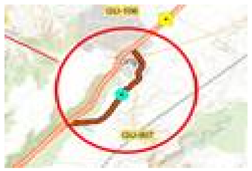
	Signalling	Set of elements intended to inform, order or regulate the movement along the road. Two basic types can be distinguished: -Vertical. Formed by symbols or legends on plates supported by specific devices. -Longitudinal. Formed by symbols painted on the road surface itself.	
System processes	Hazard	Potentially adverse phenomenon characterized by intensity, recurrence and location parameters. In the current framework, the hazards to be analyzed are derived from climate change and their expression is given through indexes, whose objective is to offer a representative value of the phenomenon through hydrometerological parameters, such as temperature, precipitation, humidity, wind, among others.	
	Exposure	Set of elements (road infrastructure components) of different nature located in areas with potential climate hazard/s.	
	Vulnerabilidad	The probability that an item will experience a level of damage, according to a predefined scale, in response to a hazard event of given intensity. Vulnerability is determined through two basic parameters: -Severity. The level of effect of climatic conditions according to a predefined 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 are, in turn, evaluable for two main properties or parameters: (1) Element integrity refers to the functional and structural state of the road component that allows it to be used properly for the	

		purpose for which it is installed or constructed. (2) Traffic conditions referring to the set of phenomena of different nature (meteorological, service or functional) that influence and determine vehicle mobility.	
	Risk	Projected damage to the integrity of the road element or to traffic conditions as a result of considering the level of threat, exposure and level of vulnerability analyzed for a given time horizon. The level of risk associated with each analysis will have a scale of value: depreciable risk, low risk, medium risk, high risk, very high risk.	

(*) Images: http://www.carreteros.org/normativa/drenaje/5_2ic2016/apartados/4.htm

Annex 2 Adaptation Options

ADAPTATION		RELEVANT HAZARD	VULNERABILITY CHANGE	COST		CO-BENEFITS
				NEW	RETROFIT.	
	Afforestation of slopes with drought-resistant	Falling materials and erosion as a consequence of intense rainfall	++	€	€	Improves stability of slope Biodiversity Air quality
	Implementation of erosion control blankets or other type of protection (drains, berms, anchors, gunite or others)	Falling materials and erosion as a consequence of intense rainfall	++	€€	€€	Improves stability of slope
	Reduce the slope of the cut	Falling materials and erosion as a consequence of intense rainfall	+++	€(Soft soils) €€ (Rock soils)	€€ €€€	Improves stability of slope
	Improvement of road maintenance resources	Falling materials and erosion as a consequence of intense rainfall	++		€€	Improves road performace Social and economical importance
	Improve of longitudinal and transversal drainage	Insufficient transversal drainage due to intense rainfall	+++	€€	€€€	Improves drainage

ADAPTATION		RELEVANT HAZARD	VULNERABILITY CHANGE	COST		CO-BENEFITS
				NEW	RETROFIT.	
	Alternative mixtures (modified bitumen) for bituminous pavements and surface courses	Formation of pavement rutting as a result of elevated pavement temperatures	++	€€	€€	Improves ride quality for the driver
	Porous pavements	Traffic conditions due to intense rainfall	++	€€	€€	Improves ride quality for the driver (no splash and spray)
	Increase surveillance of the section in case of unfavourable weather conditions	Traffic conditions due to snow	++	€€	€€	Improve road management Social and economical importance
	De-icing agents that cause the least possible damage to pavements and the environment.	Traffic conditions due to snow	++	€	€	Improve road management Social and economical importance Less affection to environment
	Allow alternative routes in case of road closure	Traffic conditions due to snow	++	€	€	Improve road management Social and economical importance