REACHOUT

shaping climate resilient cities

D3.7: Guidelines for climate service tools

John Tarpey, Jenny Tröltzsch, Natalia Burgos Cuevas, Katriona McGlade (Ecologic Institute), Nieves Peña, Saioa Zorita Castresana (Tecnalia), Denise McCullagh (UCC), James Michael Strout (NGI), Sophie van der Horst, Eva Boon, Hasse Goosen (CAS), Andrea Staccione, Jaroslav Mysiak (CMCC), Thijs Endendijk (VU-IVM), Gundula Winter, Daan Rooze, Sarah Judith Wright, Gaby Langendijk, Ad Jeuken (Deltares), Agnieszka Czachowska (Sendzimir Foundation)

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D3.7 Guidelines for climate service tools

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Contributors: John Tarpey, Katriona McGlade, Jenny Tröltzsch, Natalia Burgos Cuevas (Ecologic Institute), Nieves Peña, Saioa Zorita Castresana (Tecnalia), Denise McCullagh (UCC), James Michael Strout (NGI), Sophie van der Horst, Eva Boon, Hasse Goosen (CAS), Andrea Staccione, Jaroslav Mysiak (CMCC), Thijs Endendijk (VU-IVM), Gundula Winter, Daan Rooze, Sarah Judith Wright, Gaby Langendijk, Ad Jeuken (Deltares), Agnieszka Czachowska (Sendzimir Foundation)

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1 Introduction

The REACHOUT project has developed a Triple-A Toolkit that provides a flexible platform to support cities with the uptake of climate services aimed at urban adaptation and climate resilience (see Figure 1). The climate services that have been developed in the REACHOUT project have been updated and tested through a wide range of co-creation activities throughout the duration of the project (See D3.1). This report presents an overview of all the tools that have been included in the Triple A Toolkit. It provides an overview of the main features of the tools and includes links to the guidelines on how to use and apply them. As such, this report builds on two previous reports which provided guidelines on the tools after the first (D3.5) and second (D3.6) production cycles. These deliverables have fed into the development of the Triple-A toolkit marketplace, an online platform which summarises the project's tools and services as well as their key features.

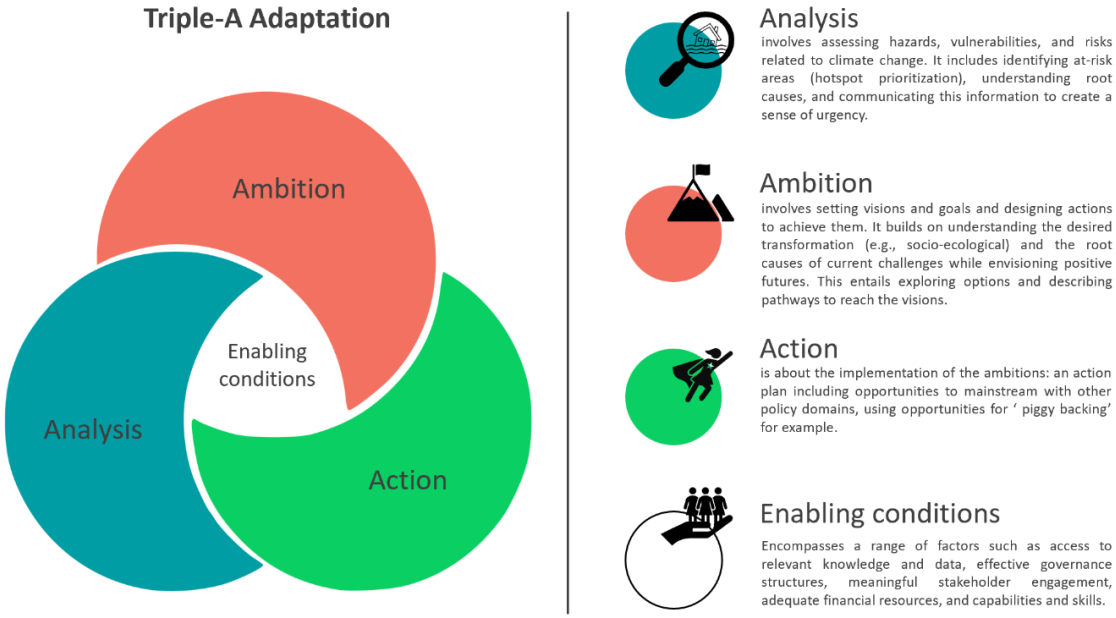


Figure 1. REACHOUT Triple-A framework for adaptation

In the following report, the REACHOUT tools are presented according to a template (Chapter 3). In the first part of the template, we summarise general information about the tools, which would be relevant to municipal representatives, local consultants and service providers. This section describes the tool, as well as the type of tool (i.e. is it a technical tool, a soft tool, or workshop facilitation) and access model (free vs. licensed). It also describes the target users of the tool as well as the relevant sectors and geographic scale. The overview also connects to the Urban Adaptation Support Tool, to provide a link to a framework that municipalities may already be following. This section briefly touches on the complexity of the tool in terms of understanding, using, and interpreting outputs, as well as the complementarity with other tools and general benefits. Finally, there is also information about user stories, and experiences from the REACHOUT city hubs.

In the second portion of the template, the Guidance section, more technical information is provided in order to offer some information on the tools potential implementation. This includes the readiness of the tool (according to Technology Readiness Levels) and comparison with other tools in terms of strengths/weaknesses and added value. This section

also presents the climate hazards a tool or service covers. The guidance also provides technical information on the tools methodology, as well as required data inputs and the outputs that can be expected (including e.g. visuals, maps, etc.). There is also further information provided in terms of contact, technical references, and other documentation available.

Chapter 3 covers not only the a range of "soft" and "technical" tools, but also three important consultancy services that aim to support the process of developing and implementing user-driven climate services. These services are designed to facilitate collaboration, enhance understanding of climate risks and opportunities, and ensure that the tools are used for climate action are both practical and effective.

In Chapter 4, there is a brief description of videos that were developed in parallel to this report, as a means of highlighting some examples of how tools can be implemented in cities in response to two key climate hazards: floods and urban heat. The videos aim to support the promotion and uptake of the climate services tools in REACHOUT and to provide a visual interpretation of the guidelines for tools in this report.

In the final chapter of the report, we present a summary of the REACHOUT project's efforts in integrating diverse climate adaptation tools into the Triple-A Toolkit. Key highlights include the need for a shift beyond risk-based approaches toward more holistic, opportunity-driven strategies that support long-term urban resilience. This chapter also describes the Triple- A toolkit, a flexible web-based platform to help cities integrate climate services across policy domains.

2 Overview of tools

The table below presents an overview of all of the tools and services covered in the REACHOUT project, as well as the City Hubs that used them, and their relation to the Triple-A framework. We see that the majority of the tools cover either the Analysis or Action phase, with a smaller representation of the Ambition phase. Interestingly, many tools are useful simultaneously for Analysis and Action, presenting valuable potential synergies for end-users.

Table 1 Overview of REACHOUT tools within final production cycle

Tool name	Tool developer	Cities involved	Triple-A		
			Analysis	Ambition	Action
Pluvial flood hazard and risk assessment in urban areas (C3S)	CMCC	Milan, Athens, Logroño, Gdynia	x		x
Assessment of Risk management capabilities	CMCC	Milan	x	x	x
Climate Resilient City Tool (CRCTool)	Deltares	Lillestrom, Gdynia, Athens			x
FloodAdapt tool	Deltares	Cork	x	x	x
Crowdsource module for climate hazard mapping	CAS	Cork	x		(x)
Climate impact diagrams	CAS	Logroño	x		
Social Vulnerability Tool	UCC	Cork, Milan, Athens, Logroño, Gdynia	x	x	x
Thermal Assessment Tool (Heatwaves service)	Tecnalia	All cities	x		
Thermal Assessment Tool (Heatmap service)	Tecnalia	Logroño, Milan, Athens	x		
Climate stories	NGI / CAS	All cities	x	x	x
Adaptation pathway generator tool	Deltares	Cork			x
The Adaptation Pyramid	CAS				x
Climate Resilient Development Pathways (CRDPs)	Deltares	Cork			x
Theory of change (ToC)	Tecnalia			x	x
ARCH RPVT: Resilience Pathway Visualisation Tool	Tecnalia	Logroño			x
Dynamic Integrated Flood Insurance (DIFI) model	VU-IVM	Amsterdam	x		x
Real Estate Asset Climate Testing (REACT) tool	VU-IVM	Amsterdam	x		x
NBS measures	Sendzimir Foundation	Gdynia			x
NBS Adaptation tool	Sendzimir Foundation	Gdynia		x	x
NBS workshops	Sendzimir Foundation	Gdynia		x	x

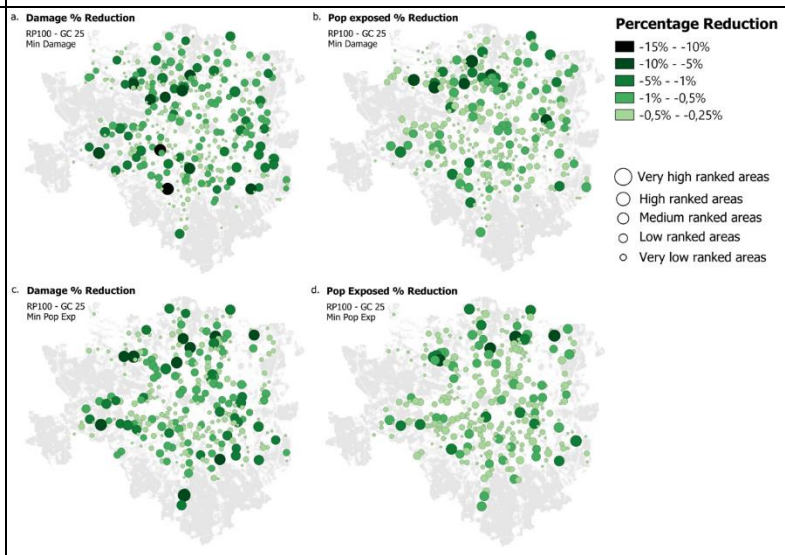
3 Tool descriptions

In this section we provide the details of the REACHOUT tools. Each tool is described in an overview, followed by guidance on how to use it. The tool descriptions will be used to feed into the project website to present the REACHOUT toolkit. Potential users are encouraged to visit the triple A toolkit online (www.triple-a-toolkit.eu).

Climate service tools for resilient urban areas

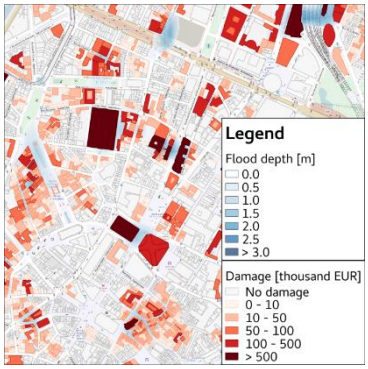
3.1.1 Pluvial hazard & risk assessment and adaptation

Overview	
Name of tool	Pluvial hazard & risk assessment and adaptation
Tool access model Type of tool	The tool is composed of a licensed tool to model flood hazard and by a consultancy service to identify and pre-process input data, develop NbS and adaptation scenarios development, and compute damage and population exposed in the different NbS scenarios. This is a technical tool, that can be used to both facilitate workshops and support co-creation of the service tailored for each city.
Tool description (overview)	Tool designed to help local authorities to explore pluvial hazard & risk from extreme convective precipitation events and subsequent flooding due to surface rainwater accumulation which the existing urban drainage system is unable to absorb. The tool delineates the areas prone to flooding under different rainfall intensities and persistence and estimates the damage to physical assets such as buildings' structures and content. The tool is amendable to inform adaptation measures such as green urban regeneration and natural water retention measures by means of green roofs and green urban areas. The application of the tool is amendable to help users to identify existing green urban infrastructures and identify areas suitable to extend them, while controlling for the potential to reduce flood damage or share of affected population.
Target user(s)	Local stakeholders, Staff of regional authority The tool is best suited for use by technical staff associated with local authorities and/or decision-makers involved in urban planning, climate adaptation strategies, civil protection, early warning systems, impact-based forecasting, and insurance. The tool is also suitable for research purposes.
Sector	Buildings, disaster risk reduction, financial, urban, and water management.
Geographical scale	Regional, municipal, and/or building The tool can work at any scale to provide information at the building level but is best suited for regional, municipal, and building-level applications.

Geographical area	All - The tool can be applied in urban areas, including the EU and its outermost regions as well as outside of the EU.
Urban Adaptation Support Tool (UAST) step(s) of relevance	2. Assessing risk and vulnerabilities 3. Identifying adaptation options 4. Assessing and selecting adaptation options
Main graphic	 Source: Staccione et al (2024)
Benefits of using the tool	The tool enables a better appreciation of pluvial hazards and risks and empowers the users to design solutions to boost local resilience. The benefits vary across the user groups, for example urban and regional authorities gain insights into climate risks as an input to climate adaptation and disaster risk reduction strategies; businesses draw insights about how their exposure to physical climate risks and local action groups obtain insights about how the neighborhood green regeneration strategies contribute to reducing the risks. The results of the tool contribute to building a knowledge base of climate related impacts & risks.
Complementarity	The tool is complementary to other climate-related urban hazard & risk assessment services (e.g., Thermal assessment tool), serve as an input for other services such as dynamic integrated flood insurance or community flood resilience support system model and help to identify tailormade adaptation & DRR solutions.
Complexity and user requirements	The complexity is variable and depends on the extent to which the users frame the analysis. It is **low** if the users access the service from a dedicated platform which allows to run the models and assess performance of some risk mitigation solutions. It is **medium to high** if the users prefer to run the underpinning open-source models and control the implementation of the green regeneration strategies and green infrastructure design. *Overall level of complexity: Medium (customized approach)*

	With support from experts/researchers. The tool should be used with a thorough introduction to the tool. Ideally, the user should hold intermediate knowledge of spatial analysis and GIS and Python and/or R for data processing and visualisation, scenario development, and running simulations.
User stories & hub experiences	MILAN city hub has implemented the full application of the tool along with the extension to analyze the green infrastructure network. Other cities such as Athens, Gdynia and Logrono are preparing for the application of the tool.
[Examples – case studies]	Manuscript focusing on Milan submitted and under review
Guidance	
Triple-A Toolkit	The tool can be used in the following Triple-A phases: **Analysis phase:** Pluvial hazard & risk assessment – impact in terms of damage and population affected **Action phase:** Identification, evaluation, and prioritization of adaptation measures – green regeneration, nature-based solutions and urban green infrastructures (spatial connectivity)
Readiness for use	TRL 7 and 9, depending on the components = Tool tested in several case studies
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** • The tool is highly customizable and can be applied with local priorities and a variety of data, including open and European scale (allowing comparability) or local data, including at a very detailed level (scale of meters, from minutes to hours). **Weaknesses:** • Customization often requires local knowledge and data pre-processing. The tool generally requires some knowledge of urban hydrology and computational skills for spatial and rainfall data processing, scenario development, and running of simulations (GIS and R and/or Python). • The tool does not consider the time evolution of flooding nor the direct consideration of storm sewer systems. Integration: The tool can be well integrated with vulnerability assessment tools to assess and visualize risk and to support the identification and prioritisation of solution locations. The tool is connected to other tools and frameworks through the REACHOUT Triple-A toolkit. To assess the co-benefits of nature-based solutions, the Thermal Assessment Tool and the Social Vulnerability Tool in the REACHOUT Triple-A toolkit would be ideal

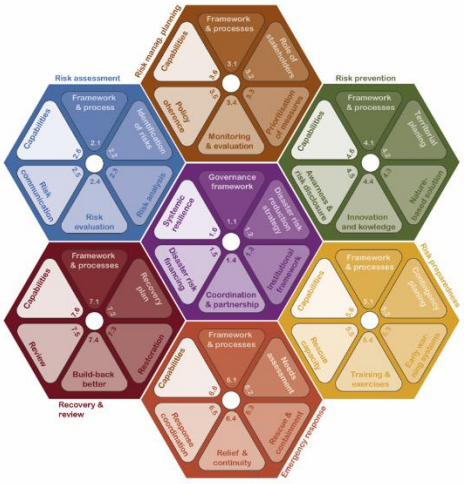
	candidates for integration. The model could also be integrated with fluvial and coastal flood hazard tools.
Cost/effort for implementation	This tool is ready for use in any location in the world. Basic use of the tool requires little effort, on the order of 3 to 5 person-days. However, advanced use of the tool varies widely depending on the specific needs and level of analysis performed, including harmonisation and pre-processing of local data, statistical analyses of rainfall, processing of climate change scenarios, and selection of greening scenarios. Such an analysis can vary from approximately 10 person-days to several person-months. The pluvial flood module has a fee for full-version use. Prices vary from 3 to 20 €/Km2 per year based on the required resolution.
Climate hazards covered	Extreme precipitation; other (urban flood)
Inputs needed	• local observational records – precipitation hourly and sub hourly data (in alternative Copernicus Climate change service – ERA5 reanalysis) • high resolution digital elevation model (ideally LIDAR), • high resolution urban green areas and impervious surface (optional, obtainable form Copernicus land monitoring service) The tool can use input data taken from standardized datasets including at the European and global scale (e.g., Copernicus datasets for land use and climate data, OpenStreetMap for building information, Eurostat for census and socioeconomic data). However, based on specific user goals and needs, all analyses can be customized using local input data. *Difficulty level of inputs needed: Low – Medium difficulty*
Methodology	**First**, hourly or sub-hourly rainfall intensities and likelihoods are estimated from the local observational records or downscaled ERA5 reanalysis data. **Second**, using the rainfall intensity as input for the hydrostatic inundation model Safer-RAIN [1] makes it possible to delineate flood prone areas and depth of accumulated flood water for each probabilistic scenario (equivalent to return period of 5, 10, 25, 50 and 100 years). **Third**, using the hazard delineation, expected damage to physical structures is estimated using conventional and country/region specific stage-damage model and high-resolution population grid. Expected annual damage and population affected are estimated by aggregating impacts over modelled intensities/likelihoods. Building footprints are obtained from Open Streetmap and building classes are identified by using land cover data. **Fourth**, using high resolution urban green spaces as input for spatial morphological pattern analysis [2], the green infrastructure network is identified and analysed **Fifth,** building upon various scenarios of urban green regeneration such as green building conversion or extending green spaces, the

	performance of risk reduction measures is determined by re-running the hazard & risk model with altered inputs. *Difficulty level of use of approach: High difficulty (requires technical knowledge & expertise to run the open-source models)*
Outputs	**Maps show:** areas prone to pluvial hazard & risk, e.g., flood extension, depth and economic damage (see figure below – source [3]  *Figure 2: Estimated direct tangible damages per thousand EUR for an extreme rainfall event.* Source: [3] - areas suitable for green urban regeneration – based on the specific urban policy objectives **Tables and figures containing** annual expected damage and population affected, performance of green regeneration scenarios *Difficulty level of preparing the outputs: high difficulty*
Contacts	Jaroslav Mysiak, Jeremy Pal, Andrea Staccione Euro-Mediterranean Centre on Climate Change Risk Assessment and Adaptation Strategies division
Guidance and other documentation	[1] Mediero, L., Soriano, E., Oria, P., Bagli, S., Castellarin, A., Garrote, L., Mazzoli, P., Mysiak, J., Pasetti, S., Persiano, S., Santillán, D., Schröter, K., 2022. Pluvial flooding: High-resolution stochastic hazard mapping in urban areas by using fast-processing DEM-based algorithms. J. Hydrol. 608, 127649. https://doi.org/https://doi.org/10.1016/j.jhydrol.2022.127649 [2] Staccione, A., Candiago, S., Mysiak, J., 2022. Mapping a Green Infrastructure Network: a framework for spatial connectivity applied in Northern Italy. Environ. Sci. Policy 131, 57–67. https://doi.org/https://doi.org/10.1016/j.envsci.2022.01.017 [3] Essenfelder, A.H., Bagli, S., Mysiak, J., Pal, J.S., Mercogliano, P., Reder, A., Rianna, G., Mazzoli, P., Broccoli, D., Luzzi, V., 2022. Probabilistic Assessment of Pluvial Flood Risk across 20 European Cities: A Demonstrator of the Copernicus Disaster Risk

	Reduction Service for Pluvial Flood Risk in Urban Areas. Water Econ. Policy. https://doi.org/10.1142/S2382624X22400070 [4] Staccione, Essenfelder, A.H., Bagli, S., Mysiak, J., 2024. Connected urban green spaces for pluvial flood risk reduction in the Metropolitan area of Milan. Sustain. Cities Soc. https://doi.org/10.1016/j.scs.2024.105288 *Links to data sources needed as inputs:* - SaferPlaces: Global Platform AI-based Digital Twin Solution for Flood Risk Intelligence - Copernicus Pluvial Flood Risk Assessment in Urban Areas

3.1.2 Assessment of Risk management capabilities

Overview	
Name of tool	Assessment of Risk management capabilities
Tool access model Type of tool	It is a free tool that can be use by cities to conduct a self-assessment of their adaptation and disaster risk management capabilities. Additionally, a consultancy service that make use of the tool and its scorecard can be offered to facilitate an independent evaluation. This is a soft tool that can be used to facilitate workshop and support co-creation of adaptation/resilience pathways.
Tool description (overview)	This tool is used to guide review and/or self-assessment of risk management capabilities. Originally developed for the purpose of the country peer review under the Union Civil Protection Mechanism and adapted to different scales such as regional and local ones, the tool can assist the authorities in assessing where they stand with adaptation & disaster risk reduction and identifying major gaps or opportunities for improvement. The tool addresses all climate-related hazards & risk or a selection of thereof and is useful to assess progress made in risk governance, planning, coping capacity and recovery from climate related shocks. The tool is meant for local to national authorities, action groups, civil society organizations or other organized groups contributing to climate adaptation & disaster risk reduction strategies and plans.
Target user(s)	Key target users include policy makers at different territorial levels (from local to regional and national), practitioners involved in disaster risk reduction and climate change adaptation. The tool can also be used by a wide range of stakeholders, such as sectoral representatives (e.g. managers of critical infrastructures), and civil society organisations involved in DRR/CCA.
Sector	The tool is designed to support comprehensive assessments of adaptation and disaster risk management capabilities adopting a holistic approach from a cross-sectoral perspective. Therefore, it is not sector specific.
Geographical scale	The tool is applicable at different levels: municipal, regional, national.
Geographical area	The tool can cover all geographical EU regions.
Urban Adaptation Support Tool (UAST) step(s) of relevance	UAST steps of relevance: Preparing the ground for adaptation, (3) Identifying adaptation options, (4) Assessing and selecting adaptation options, (5) Implementing adaptation, (6) Monitoring and evaluating adaptation.

Main graphic	 Source: [1]
Benefits of using the tool	Within the city hub context, this tool can be applied and used as a part of collaborative inclusive assessment of initial conditions or progress made on adaptation in urban context. The tool stimulates shared learning and knowledge sharing, awareness building and extensive dialogs/consultations
Complementarity	The tool is complementary to all other REACHOUT tools and can be applied to any of them.
Complexity and user requirements	Application of the tool requires extensive knowledge of urban planning instruments, policy priorities and capabilities. Overall level of complexity: low
User stories & hub experiences	In Milan, this framework was applied to investigate the local cross-sectoral processes of identifying, analysing and evaluating the risk of the most relevant climate-related hazards insisting on the municipal territory, as well as to identify if and how this process is mainstreamed in existing disaster risk reduction and climate adaptation strategies and plans. The results for Milan can be downloaded here. It is currently being applied to a wildfire risk review in Greece. Additionally, the tool has been tested in 10 Italian cities. Its application in six major Italian cities is available here.
[Examples – case studies]	Application in six major Italian cities, other link (CMCC)
Guidance	
Triple-A Toolkit	The tool can be used in the following Triple-A phases: **Analysis phase:** assessment of adaptation & disaster risk reduction (DRR) capabilities **Ambition phase:** collective review of progress made and monitoring of achievements on climate adaptation and disaster risk management **Action phase:** identification of gaps and opportunities for improvement of climate adaptation & disaster risk reduction strategies and plans

Readiness for use	TRL 9
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** • Flexibility and adaptability to different contexts and scales. • Comprehensiveness. • Compared to previous frameworks, this tool stands out for being well-structured, comprehensive, and flexible. Its peculiar characteristics have enabled its broader application, proving capable of supporting analysis in a variety of contexts and at different scales. Due to its clear structure and flexibility, the framework has also proven to be a useful working tool to facilitate stakeholders' engagement and collaboration among actors in the DRR/CCA field, promoting the co-creation of evidence-informed adaptation/resilience pathways and the adoption of a whole-of-government and whole-of-society approach. **Weaknesses:** • Due to its comprehensive structure, a certain level of skill and expertise is needed to be effectively understood and utilised.
Cost/effort for implementation	Cost to customise the tool: none. The tool can be applied to other municipalities/regions/countries. Effort to apply the tool in other municipalities/regions/countries: effort depends on the specific needs, level of analysis, and stakeholders' engagement. An average effort can be estimated around 1-2 PM.
Climate hazards covered	The tool is not hazard-specific. It can be used to cover all climate hazards.
Inputs needed	• urban policies & regulation, objectives of the urban adaptation & regeneration, • policy implementation reports, • existing risk assessments, • any other assessments of potential risks & opportunities of accelerated climate change adaptation *Difficulty level of inputs needed: Low – Medium difficulty*
Methodology	The analytical framework is a technical guidance for a peer review. Peer reviews and self-assessments are well established instruments of policy analysis. They are widely used at different governance levels – from national to local – and for many different policy domains (e.g., environmental protection, civil protection capabilities, etc). ISO standard 22392:2020 embraced Guidelines for conducting peer reviews of community resilience. The ultimate aim of peer reviews is to foster systematic assessments of performance and identification of best practices and gaps, in a transparent and inclusive (whole-of-society) way. Peer reviews foster cooperation and exchange of good practices, promote mutual learning, and

	contribute to an integrated approach to climate adaptation & disaster risk management. The analytical framework guides the fact-finding desk and in-field visits, it needs to ensure that all aspects of risk management are addressed during an inclusive stakeholder consultation process. The framework also needs to be flexible and adaptable to specific focus and context for which peer review is requested. *Difficulty level of use of approach: Low – medium difficulty*
Outputs	Comprehensive review report, including identified gaps and opportunities for improvement *Difficulty level of preparing the outputs: Low-medium difficulty*
Contacts	Veronica Casartelli, Euro-Mediterranean Centre on Climate Change, Risk Assessment and adaptation strategies division
Guidance and other documentation	UCPM Peer review program website Analytical framework (CMCC) Procedural guidance (CMCC) [1] Mysiak, J., Casartelli, V., Torresan, S. (2021). Union Civil Protection Mechanism - Peer Review Programme for disaster risk management: Assessment Framework. https://civil-protection-humanitarian-aid.ec.europa.eu/system/files/2022-01/peer_review_-_assessment_framework_sep_2021.pdf See also UCPM Peer review program (https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/peer-review-programme_en)

3.1.3 Climate Resilient City Tool (CRCTool)

Overview	
Name of tool	Climate Resilient City Tool (CRCTool)
Tool access model Type of tool	Free tool which needs a consultancy service to set-up, but it is free to use afterwards. It is a technical Tool that can also be used to support workshops & for co-creation of climate services.
Tool description (overview)	The Climate Resilient City Tool (CRCTool) aims to support collaborative climate adaptation planning and to promote multi-disciplinary dialogue on adaptation options to increase urban climate resilience. The tool contains a database of over 50 adaptation measures including descriptions, pictures of best practices and references for further reading. The CRCTool is easy to use by both experts and non-experts in the field of urban planning and adaptation and can be used in a workshop setting with multiple stakeholders as well as behind a desk. Tools functionalities allow the users to locate the measures on a map and explore and compare adaptation options for a project area. It provides information on the effectiveness of measures to reduce stormwater flooding, urban heat stress and drought. Additional information on construction and maintenance costs is also available. The CRCTool encourages the use of Nature Based Solutions; traditional grey measures are included to enable comparison.
Target user(s)	Researcher, staff of regional authority, stakeholder, citizen. This tool is specifically of interest to urban planners, urban decision-makers, and municipalities. The configuration of the tool can be made user-specific by adding or hiding modules in the tool.
Sector	Biodiversity, buildings, disaster risk reduction, financial, health, transport, urban, water management.
Geographical scale	Municipal + building scale. The maximum project area is 1x1 km. The tool is most commonly used for exploring and planning adaptation options at the district level. Typically, small project areas are chosen to represent various urban typologies, facilitating the scaling up of findings. In this way, the CRCTool is also relevant for regional authorities.
Geographical area	Currently, the tool is only available for cities that have been part of CRCTool projects, but it can be applied in the entire EU. See more information below.
Urban Adaptation Support Tool (UAST) step(s) of relevance	3. Identifying adaptation options **4. Assessing and selecting adaptation options**

Main graphic	
Benefits of using the tool	• Create conceptual designs to increase the climate resilience of a certain area that meet defined adaptation targets and are spatially explicit • Support development of local climate adaptation plans and strategies and urban master plans by allowing exploration and testing the feasibility of the plans and strategies based on concrete adaptation measures • Explore and compare potential adaptation options for an area • The tool is user friendly and can be used by both experts and non-experts
Complementarity	The CRCTool can be used in combination with all tools and services that produce maps on climate hazards like the Community Flood Resilience Tool and Heat Tool. The tool can also be used in combination with the Social Vulnerability tool.
Complexity and user requirements	• The CRCTool has been developed as open source. A free not calibrated version of the CRCTool is freely available online. The tool is very user friendly therefore the complexity of using the tool is low. • The tool configuration must be done by trained users and has medium complexity. • The complexity of creating a new version of the tool based on the source code is high. *Overall level of complexity: Medium*
Link to tool webpage	https://crctool.org Documentation can be found on: https://publicwiki.deltares.nl/display/AST/Climate+Resilient+City+Tool+and+KBS+Toolbox+Home
User stories & hub experiences	• In Gdynia the CRCTool is being customized to support multiple potential climate adaptation projects in the city. In the planned workshop climate adaptation will be centered around social vulnerability. • In Lillestrom the CRCTool has being set up for specific redevelopment locations to support the dialogue between the

	city and project developers on how to redevelop areas and contribute to the climate resilience of the city. • In Athens the CRCTool will be configured to support the planning of Urban NBS for climate resilience for a large redevelopment project.
[Examples – case studies]	Lillestrom: https://lillestrom.crctool.org/en/ Gdynia: https://gdynia.crctool.org/en/ Athens: https://athens.crctool.org/en/
Guidance	
Triple-A Toolkit	The CRCTool is used in the Action phase. The CRCTool supports the identification, evaluation, and prioritization of adaptation measures.
Readiness for use	TRL 9 The tool has been used in projects to inform Nature-Based Solutions design decisions.
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** • The tool supports open adaptation discussions amongst stakeholders, based on a visually intuitive environment. • It is open and free to use. • It indicates the effectiveness of NBS, supported by a water-balance model. **Weaknesses:** • The tool excludes hydraulic processes such as flow routing. In terms of integration, the tool works particularly well in combination with other vulnerability assessment tools to assess and visualize urban heat island hotspots. It is connected to other tools and frameworks through the REACHOUT Triple-A toolkit. For instance, the heat maps of the Heat Assessment Tool and the vulnerability maps of the SVI-Tool can be inserted as a layer into the CRCTool.
Cost/effort for implementation	Deltares provides the replication service for other areas for low cost, estimated in 5-7 person-days. If local data is not available, the tool is set up with global and/or EU datasets. When incorporating local datasets, extra time is required for harmonizing datasets (2 days). Further time investments are running the hydrological model (2 days), preparing the online environment (2 days) and selecting/calibrating measures (1 day).
Climate hazards covered	Extreme precipitation, mean precipitation, Extreme heat

Inputs needed	Data needed to use the tool: • Local rainfall (timeseries) • Local evapo(transpi)ration (timeseries) • Land use type (map) • Vegetation of unpaved areas • Type of Sewer System • Storage capacities • Pumping capacities • Infiltration capacities • Surface water levels • Pumping capacity • Groundwater level • Construction cost (unit prices) • Maintenance cost (unit prices) *Difficulty level of inputs needed: Medium difficulty*
Methodology	The CRCTool is developed around a central interactive map window that displays base layers like a map and/or aerial photograph that is used as spatial reference. On top of these base layers semi-transparent thematic maps can be displayed like an elevation map, flood or heat stress maps that help to understand the climate challenges in an area and to choose effective locations for interventions. Based on the extent of the project area and properties of the project area that are given in by the user (e.g. soil type, land use scale of interest and relevant climate hazards) a list of adaptation measures is ranked by their effectiveness. The ranking method is based on key figures and a set of rules to combine technical feasibility, site suitability, system capacities and location suitability [1]. The adaptation measures can be drawn on the map as polygon, line or point element and the measure appears in list of applied measures. Based on the main properties of the measure, like water storage depth and contributing area climate resilience and cost Key Performance Indicators are calculated and shown in the user interface. The main KPI's are storage volume, return time factor, additional groundwater recharge, additional evapotranspiration, heat reduction, cool areas, construction costs and maintenance costs. The hydrological KPI's are based on a multi reservoir model: the Urban Water Balance model (https://publicwiki.deltares.nl/display/AST/Urban+Water+balance+model). The effect on heat stress is based on statistical relations and the cost figures are based on unit costs. Results from the model are stored in lookup tables that are accessed by the frontend of the tool to ensure fast result while using the tool. Configuration of the tool for a specific city entails: • Creating a new instance of the crctool.org, e.g. athens.crctool.org • Adding local thematic map layers to the map window • Simulations with the Urban Water Balance Model based on local data to create lookup tables

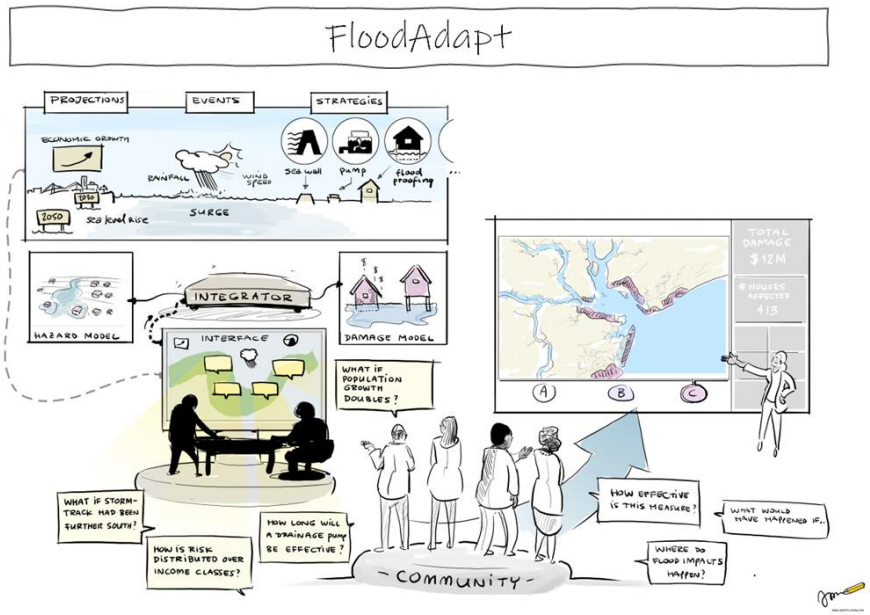
	• Optionally, translations of all items in the user interface can be created. • Optionally, unit cost based on local cost and currency can be incorporated *Difficulty level of use of approach: Low difficulty*
Outputs	The result of the CRCTool is a conceptual design of a project area with different climate adaptation measures that increase the climate resilience of the area. The results can be saved and exported as: • A project file that can be opened again in the CRCTool (json) • A pdf file that contains: • the map of the selected adaptation measures, • a summary table with all KPI's on the level of the project • A summary table with all KPI's per type of measure • List of applied adaptation measures including a description and images • A geospatial file with the project area and all applied measures and main KPI's (geojson) • A table listing all individual adaptation measures, their properties and KPI's (csv) The outputs can be used for: • communication with a diversity of decision-makers and stakeholders • As input for project pre-feasibility reports • As input for project feasibility phase and project refinement by designers and engineers  *Figure 3: Example for output of CRCTool*

	 *Figure 4: Example for output of CRCTool* *Difficulty level of preparing the outputs: Low difficulty*
Contacts	Contact email address: crctool@deltares.nl
Guidance and other documentation	The tool: https://crctool.org Documentation: https://publicwiki.deltares.nl/display/AST/Climate+Resilient+City+Tool+and+KBS+Toolbox+Home Publications: McEvoy S., F.H.M. van de Ven, R. Brolsma, J. H. Slinger,Evaluating a Planning Support System's use and effects in urban adaptation: an exploratory case study from Berlin, Germany,Sustainability 2020 https://doi.org/10.3390/su12010173 McEvoy S (2019) Planning support tools in urban adaptation practice. PhD thesis, TU Delft, https://doi.org/10.4233/uuid:48b7649c-5062-4c97-bba7-970fc92d7bbf or https://repository.tudelft.nl/islandora/object/uuid%3A48b7649c-5062-4c97-bba7-970fc92d7bbf McEvoy S, FHM van de Ven, MW Blind, JH Slinger (2018) Planning support tools and their effects in participatory urban adaptation workshops, Journal of Environmental Management, Volume 207, 1 February 2018, Pages 319-333, https://doi.org/10.1016/j.jenvman.2017.10.041 Van de Ven FHM , RPH Snep, S Koole, RJ Brolsma, R van der Brugge, J Spijker, T Vergroesen (2016) Adaptation Planning Support Toolbox: Measurable performance information based tools for co-creation of resilient, ecosystem-based urban plans with urban designers, decision-makers and stakeholders, Environmental Science & Policy, Volume 66, 2016, Pages 427-436, https://doi.org/10.1016/j.envsci.2016.06.010

	[1] Voskamp IM, Van de Ven FHM (2015) Planning support system for climate adaptation: Composing effective sets of blue-green measures to reduce urban vulnerability to extreme weather events. Building and Environment 83, p 159-167. http://dx.doi.org/10.1016/j.buildenv.2014.07.018

3.1.4 FloodAdapt

Overview	
Name of tool	FloodAdapt
Tool access model Type of tool	It is a free tool, but consultancy services are offered optionally to help set up the tool for a new location, which requires some hydrodynamic and hydrological background, and technical and statistical knowledge. It is a technical tool. Customizing and refining the tool is best done in co-creation with its users. It is also suited to generate information on flooding scenarios for stakeholder workshops.
Tool description (overview)	FloodAdapt is a decision support tool intended to accelerate climate adaptation actions by making it easier for local and regional agencies to understand their flood risk under different future conditions. It can be used to assess compound flooding, that means any combination of marine, rainfall and riverine flooding, with or without the added effects of future sea level rise, changes in rainfall patterns and storminess and socio-economic developments. The user interface of the FloodAdapt tool makes powerful and efficient flood hazard and impact models easily accessible to users without a computational modeling background. It helps users to define, simulate and visualize flooding scenarios and their impacts and to explore effective strategies to reduce flood risk. Scenarios consist of user-defined or historical weather events, projections of future sea level, climate and socio-economic developments, and user-defined adaptation strategies such as floodwalls, levees, pumps, urban green infrastructure, raising, floodproofing and buying out homes.
Target user(s)	Researchers, staff of local or regional authorities, practitioners working in flood risk management
Sector	Buildings, coastal areas, disaster risk reduction, urban
Geographical scale	Regional, municipal, building level
Geographical area	All coastal, all outermost
Urban Adaptation Support Tool (UAST) step(s) of relevance	Steps of the UAST supported by the tool: 2. Assessing climate change risks and vulnerabilities 3. Identifying adaptation options 4. Assessing and selecting adaptation options Primary step of the UAST to which the tool shall be associated: 4. Assessing and selecting adaptation options

Main graphic	 *Figure 5: Illustration of the components of FloodAdapt with the community at its centre*
Benefits of using the tool	The tool aids long-term planning and climate adaptation goals of cities. It can be used, for example, • to prioritize areas for flood risk adaptation, • to develop flood-risk informed zoning plans, • to pre-screen potential adaptation strategies, and • to create visuals for stakeholder engagement. Once set up for the city, the tool empowers city staff to explore different future scenarios and strategies and to create powerful maps of future flood risk for community engagement without the need to hire consultants. It is useful for a first screening of options before the assessment of promising options is put out for tender.
Complementarity	FloodAdapt can be used to assess the effectiveness of adaptation options and thus support the design of **adaptation pathways**. FloodAdapt can be used to aggregate flood impacts and risk for areas and groups and can link well with the **Social Vulnerability Index Tool**.
Complexity and user requirements to use the tool?	The city needs data on topography, bathymetry and building assets and their potential maximum damage and flood damage functions for the initial set up of the tool in a new city. *Overall level of complexity: Medium* *With a thorough introduction to the tool, e.g. a one-day training, users are typically proficient at using a FloodAdapt application. No previous knowledge is needed for the use of it.*
User stories & hub experiences	In Cork, the FloodAdapt tool has been set up to support the city council in its long-term flood risk management planning. This decision support system makes it easier to understand flood risk under different scenarios and test various adaptation options. The results can be used to inform adaptation pathways development.

[Examples – case studies]	Not yet available
Guidance	
Triple-A Toolkit	The tool can be used in the following Triple-A phases: **Analysis phase:** Impact assessments for status quo and different future scenarios **Ambition phase:** Prioritization of areas for adaptation **Action phase:** Screening and exploring different flood adaptation options, this is prior to and not instead of detailed feasibility and design studies for adaptation
Readiness for use	TRL6/7
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** • The tool is highly customizable and can be set up in any location with global or local data. • The underlying models are physics-based. • Non-expert modellers can easily interact with state-of-the-art flood hazard and impact models. • The tool allows for compound flood assessments (concurrent pluvial, fluvial and/or coastal flooding). • The tool can assess a range of adaptation measures and any combination thereof. • The tool produces informative impact metrics and infographics. • The tool gives insights into equity aspects of flood risk and costs and benefits. • The tool can assess different future states including effects of sea level rise, rainfall increase, socio-economic growth and urban development. **Weaknesses:** • Customization often requires local knowledge and data. Setting up the tool for the first time in a new location requires some technical, hydraulic and statistical knowledge. The tool does not consider urban drainage systems. • It is currently only available as desktop-based version. What-if scenarios take a few minutes to evaluate, but risk assessments may take several hours.
Cost/effort for implementation.	The tool needs to be configured for each location. A simple set up without validation of the underlying models can be made with ~2 person days. Pre-processing local data and calibrating the underlying models can take several person weeks.
Climate hazards covered	Extreme precipitation, river flooding, relative sea level, coastal flooding
Inputs needed	Once the tool has been set up once for a city, no additional data is needed. The initial implementation requires data on topography, bathymetry and building assets and their potential maximum damages and flood damage functions. *Difficulty level of inputs needed: Medium difficulty*

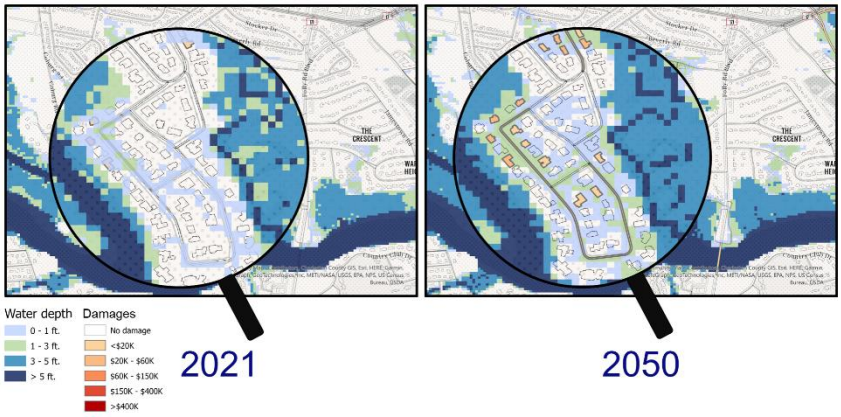
Methodology	*Text adopted from the User Manual and shortened (see references):* The FloodAdapt tool helps to translate community-oriented questions on future flood impacts and risk into scenarios that can be evaluated by models through the system's user interface. Scenarios are defined in the FloodAdapt tool as a combination of a future projection of climate, sea level rise or socio-economic change, a hydro-meteorological event and an adaptation strategy. The scenarios are fed to the core of the system – the integrator. The integrator automatically translates the user-selected projection, event, and strategy into the required changes in the flood model and damage model inputs. For example, if the user draws a flood wall, the integrator modifies the flood model input file to include the coordinates and elevation of the new flood wall. This means that once the flood and damage models have been set up for a city or community in the implementation phase, the users do not need to be experienced modelers themselves to perform simulations and explore the flooding and impacts for a range of scenarios. The FloodAdapt tool uses the open-source physics-based compound flood model SFINCS[1], which can accurately predict compound flooding due to surge, rainfall, and river discharge at a fraction of the computation time typically required by physics-based models. The damages to individual buildings and roads are modelled with Delft-FIAT and – when social vulnerability data is available – aggregates these damages over vulnerability classes. *Difficulty level of use of approach: medium difficulty* The user needs some basic understanding of the input data that define an event, a projection and a strategy. The user interface itself guides the user and provides information on what to do. The user manual or a one-day training course have proven to be sufficient to become a proficient user.
Outputs	The flood model creates flood maps in geotiff format, and the damage model saves the tabulated damage data per building and aggregation group to csv or Excel files respectively. In addition, the damage data is saved as shapefile to be imported in GIS applications. The FloodAdapt tool has an export function to prepare a pre-formatted ArcGIS project file that spatially displays the flood depths, damages at asset level, inundation on roads, and aggregated damages with layer formats as in the image below. 

	Figure 2. Example results from the FloodAdapt tool comparing flooding (blue hues) and damages to buildings (orange hues) for a major tide event under current and future sea level. *Difficulty level of preparing the outputs: medium difficulty* The user needs some basic experience with GIS software. The FloodAdatpt tool itself provides all data in GIS compatible formats and exports results to an ArcGIS package file so the data can be opened with pre-defined layer formatting.
Contacts	Gundula Winter Deltares gundula.winter@deltares.nl
Guidance and other documentation	*User Guidance* Introduction Video

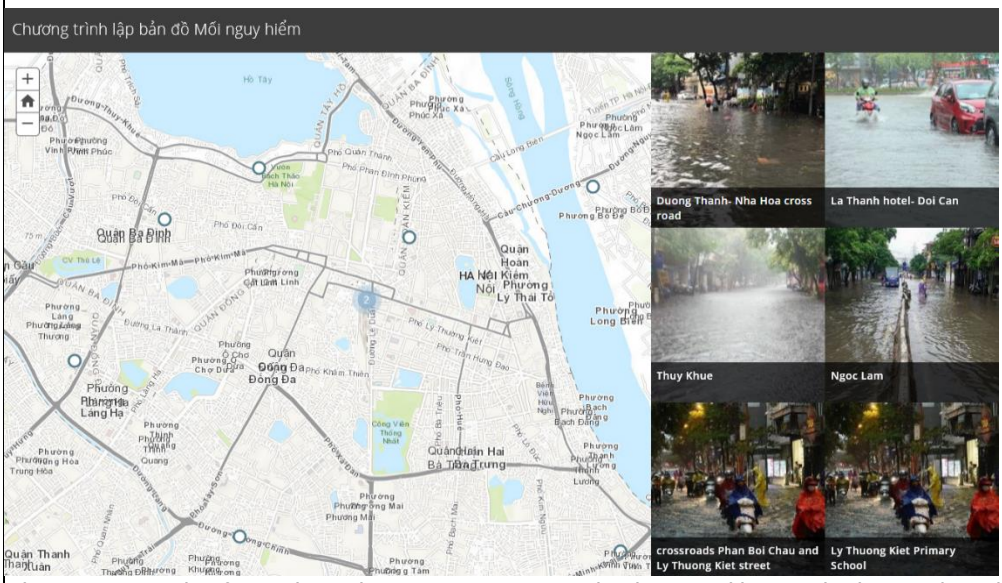
3.1.5 Crowdsource module for climate hazard mapping

Overview	
Name of tool	Crowdsource module for climate hazard mapping
Tool access Type of tool	This tool can be configured using either free or commercial software licenses. Both technical and communication aspects are crucial to its success. Developing the tool is only the first step—the real challenge lies in encouraging people to actively engage with it and complete the form. Without user input, the tool remains an empty shell.
Tool description (overview)	The crowdsource module visualises publicly generated climate data in a digital map. Finding ready-to-use spatial data on climate hazards and vulnerable locations can be a challenge. Local crowdsourcing presents an opportunity to collect this information through methods such as community mapping. Citizens or specific user groups are asked to map climate information via a questionnaire. The resulting dataset can be used to validate technical data or help to prioritise actions. Besides collecting data, the crowdsource module engages citizens and initiates discussion, helping to raise public awareness about climate adaptation.
Target user(s)	The tool's results would be valuable for researchers and practitioners, while its primary target users for input are citizens and students.
Sector	The tool is not sector-specific but is most likely focused on the built environment and the surroundings of citizens.
Geographical scale	The geographic scale of a crowdsourcing module can range from local to entire cities or metropolitan regions. At the neighborhood level, it could collect data on issues such as urban heat islands, areas prone to flooding, or green space accessibility. At the city-wide scale, it might engage citizens to map broader climate-related impacts. Regional metropolitan modules could address interconnected systems, such as water management, urban sprawl, or shared transportation networks, emphasizing the need for coordinated resilience strategies. The scale of the module is critical to ensuring that data reflects the specific dynamics of urban environments, helping cities adapt to the impacts of climate change while prioritizing the well-being of their citizens.
Geographical area	All areas can be covered.
Urban Adaptation Support Tool (UAST) step(s) of relevance	1. Preparing the ground for adaptation 2. Assessing climate change risks and vulnerabilities 4. Assessing and selecting adaptation options 6. Monitoring and evaluating adaptation

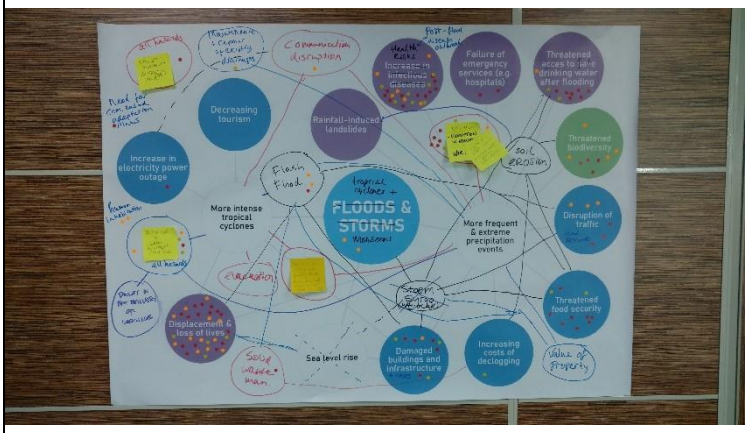
Main graphic	 *Figure 6: Crowdsource module in Cork, filled by UCC Geography students.* Source: [1]
Benefits of using the tool	The Crowdsource tool is particularly useful for city representatives wishing to plan adaptation action in growing urban centers as it allows to: • Identify areas vulnerable to a climate hazard of interest for the city e.g. heatwaves, flooding. • Validate existing flood/heat maps. • Involve citizens, stakeholders and local organizations by giving them an active role. • Provide the opportunity to use intangible knowledge of citizens to complement scientific knowledge.
Complementarity	The crowdsourcing tool could be used to complement and verify output from other tools such as the Pluvial flood hazard and risk assessment, FloodAdapt tool in urban areas (C3S) and the Thermal Assessment Tool. In addition, the crowdsourcing module can be embedded into the climate stories to support communication.
Complexity and user requirements	Medium – There are both free and commercial software licenses available for tools that support crowdsourcing. If a city has no software available, a license may be costly. An example of a commercial tool that can be used is ArcGIS online [2]. A tool based on open-source components is also a possibility but requires programming skills. *Overall level of complexity: Medium*
Link to tool webpage	Cork's Climate Change Vulnerability (2022) (https://climadapserv.maps.arcgis.com/apps/mapviewer/index.html?webmap=8ba487b09b2140639079f4069188c4fa)
User stories & hub experiences	The tool has been used by students of the university of Cork. A tailored questionnaire (https://storymaps.arcgis.com/stories/bd89e69f3c264dc193579646ce87e776) has been designed to gather climate information from students. At this stage, 49 inputs have been gathered and the current outcome can be visualized in a digital

	map (https://climadapserv.maps.arcgis.com/apps/mapviewer/index.html?webmap=8ba487b09b2140639079f4069188c4fa). The map shows potential vulnerable areas or objects accompanied by pictures. Examples include floodplains, low bridges, clogged water drains and flooded areas.
Guidance	
Triple-A Toolkit	The tool can be used in the following Triple-A phases: • Analysis phase to find vulnerable areas in the city. • Action phase to validate / ground-truth model data or help to prioritize.
Readiness for use	When a license for the tool is available, it is ready for use. If not, the tool will need to be set up first. **With license:** **TRL 8**: Actual system completed and "working." If the tool is fully functional, with a license in place and operational in the intended environment, it would be at TRL 8, meaning it's proven to work under realistic conditions but might still be in the final stages of implementation or optimization. **Without a license:** **TRL 5**: Technology validated in a relevant environment. In this case, it suggests that a functional version of the tool exists, but it requires finding or adapting an open-source alternative, indicating that the tool is still under development or modification to fit the needs of the project
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** • Cost-Effective: Crowdsourcing often reduces the need for expensive data collection processes by relying on the input of volunteers or a large number of contributors. This can be particularly valuable for large-scale or ongoing projects. • Wide Reach: It allows engagement with a diverse, geographically dispersed audience, providing data from various perspectives and contexts. This can be especially useful for urban or climate-related projects where diverse input is crucial. • Community Engagement: Crowdsourcing fosters community involvement, empowering local residents or users to contribute directly to the data and decision-making processes that impact them. This can increase public awareness and support for climate action or urban resilience efforts. • Diverse Data: Crowdsourcing can gather diverse types of data—ranging from text, photos, and videos to geospatial information—which enriches the dataset and enables a more holistic view of the problem. **Weaknesses:** • Data Quality and Reliability: With a large number of contributors, data quality can vary. The input may be inconsistent, incomplete, or inaccurate, especially if there are no mechanisms in place to verify or validate the data. • Lack of Expertise: Depending on the target user group, crowdsourced data might lack the depth and accuracy that could be provided by trained professionals or experts.

	• Bias in Participation: Crowdsourcing typically depends on voluntary participation, meaning the dataset may be biased toward more active or engaged groups, excluding marginalized communities or people who lack access to the technology needed to participate. • Data Overload: If not properly managed, crowdsourced data can quickly become overwhelming, making it difficult to extract useful insights or ensure that the data is processed efficiently. • Privacy and Security Concerns: Collecting data from a large group of ndividuals can raise privacy issues, especially if sensitive information is involved. Ensuring secure data collection and addressing concerns about anonymity and data protection is crucial. • Limited Motivation: Participants may lose interest over time, especially if the tool isn't engaging enough or doesn't provide clear benefits for their contributions. Maintaining user engagement and participation in long-term projects can be challenging. • Technological Barriers: Crowdsourcing tools often rely on internet access and specific devices (like smartphones). This can create a barrier for certain populations, especially in areas with limited digital literacy or infrastructure.
Cost/effort for implementation	If you have an ArcGIS license, the cost and effort to set up this tool are relatively low. Alternatively, open-source solutions like QField are available. However, collecting input from citizens requires an active communication campaign, which involves additional costs and effort that should be carefully considered.
Climate hazards covered	Not hazard specific
Inputs needed	No data is needed for the initial set up of this tool as its function is to collect data. The only input needed is a questionnaire from the city that can be filled with information by citizens. For decision makers to later make use of the tool to define Action it should be populated with spatial data about hazards and vulnerable areas as acquired through the questionnaire. *Difficulty level of inputs needed: Low difficulty*
Methodology	To use the crowdsourcing tool, a city need to follow the next steps: 1. Determine the aim of the crowdsourcing tool. Questions to ask here are: who do you want to reach? What hazard do you want to focus on? What information are you looking for? 2. Make a questionnaire for the information you want to collect from your users. For example, you can ask your user to describe the location, whether the location is flooded, if it is still accessible, and add a picture. 3. Link the results from the questionnaire to a clickable map automatically. As a result, your map will show the different locations of where data is collected. In this step you can consider to first do a quality check on submitted data to ensure that the filled forms are complete and relevant. 4. After setting up the crowdsourcing module, it needs to be tested by a group of users, for example, students. The feedback needs to be collected and adjustments in the questionnaire can be done. 5. The last and probably most important step is the dissemination of the crowdsourcing tool. *Difficulty level of use of approach: medium difficulty*

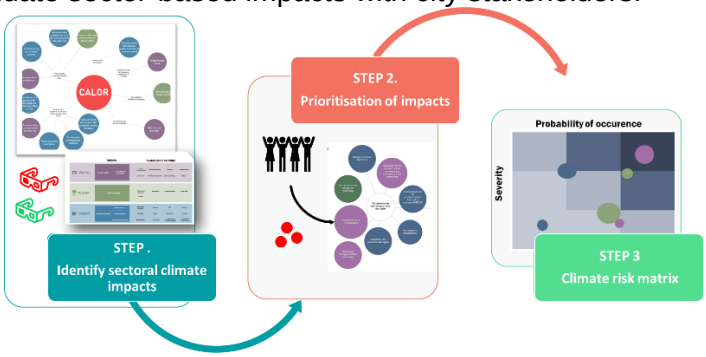
Outputs	The outcomes from the crowdsourcing tool can be presented in a clickable map. For each location described in the questionnaire, a point is created on the maps. Users can click on a point to find out more about that specific location. The data is also available in a spreadsheet. The data is very *easy* to interpret.  *Figure 7: Example of crowdsourcing outcomes, as was implemented in Hanoi, Vietnam (2020).* *Difficulty level of preparing the outputs: Low difficulty (But there would need to be someone quality checking to remove potential spam and irrelevant input.)*
Contacts	Koen Veenenbos Climate Adaptation Services koen@climateadaptationservices.com Sophie van der Horst Climate Adaptation Services sophie@climateadaptationservices.com
Guidance and other documentation	[1] Cork's Climate Change Vulnerability (2022). https://storymaps.arcgis.com/stories/bd89e69f3c264dc193579646ce87e776 [2] Crowdsource Manager (2022). https://solutions.arcgis.com/local-government/help/crowdsource-manager/

3.1.6 Climate Impact diagrams

Overview	
Name of tool	Climate Impact Diagrams
Tool access model Type of tool	This is a workshop tool with free guidance material.
Tool description (overview)	Climate impact diagrams aim to build a shared understanding among all city stakeholders on the opportunities and risks of climate change for the different city sectors. It is a first step to start the conversation about climate change adaptation and work towards a joint approach for taking climate measures, identifying co-benefits and offering ideas for action. Impact diagrams present a simplified, visual summary of current scientific knowledge of climate effects and climate consequences in a city. The diagrams help to gain more insight into opportunities and risks and can kickstart the search for additional knowledge or collaboration partners.
Target user(s)	City stakeholders for the different city sectors.
Sector	The workshop brings together stakeholders from different city sectors.
Geographical scale	Most suitable for stakeholders at city or regional level.
Geographical area	The workshop can be applied to all areas
Urban Adaptation Support Tool (UAST) step(s) of relevance	1. Preparing the ground for adaptation 2. Assessing climate change risks and vulnerabilities
Main graphic	 *Figure 8: Example of an impact diagram* Photo by CAS.
Benefits of using the tool	The impact diagrams are a decision support tool that are appealing for policymakers. They visualise possible outcomes for those making climate investment decisions and enhance dialogue between science and policy.

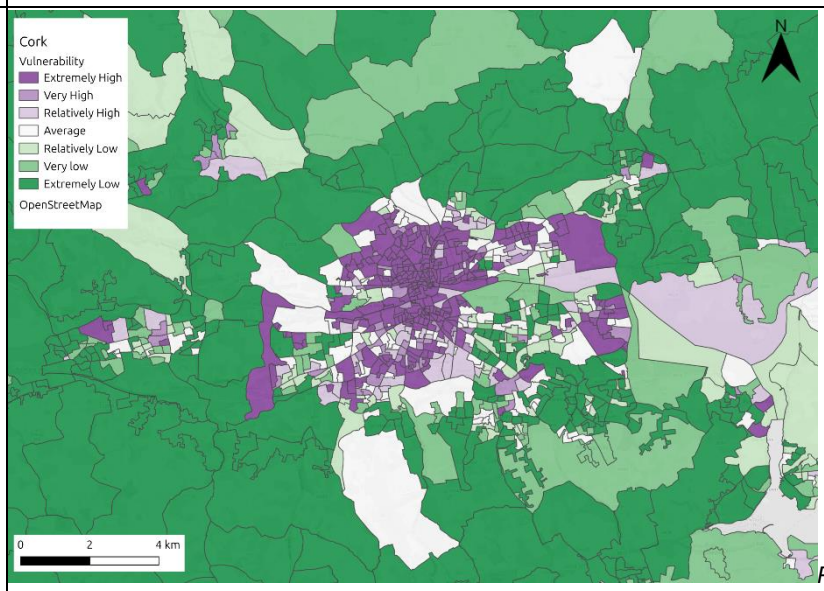
	They offer a visual summary of the climate change impacts by sector (economic, social and natural) in order to contribute to the development of adaptation plans. Impact diagrams can help cities and city staff to gain insight into the opportunities and risks of climate change for their own field of work, and can enable focussed discussion between stakeholders about adaptation options and priorities.
Complementarity	The tool begins with a city specific analysis of climate trends, based on models and observations. All REACHOUT tools that are able to describe such trends work well with the development of climate impact diagrams. These include for example the Thermal Assessment Tool (Tecnalia), Community Flood Resilience Support System (Deltares) and Pluvial flood hazard and risk assessment (CMCC).
Complexity and user requirements	Low – the impact diagrams workshop can be organised by cities on their own, but for a more thorough approach, it is necessary to bring climate science expertise to the workshop (e.g., from the national meteorological service). *Overall level of complexity: Low*
Link to tool webpage	https://reachout-cities.eu/post_type_toolkit/climate-impact-diagrams/
User stories & hub experiences	In REACHOUT Logroño has used this tool to prepare for the Sustainable Energy and Climate Action Plan (SECAP). [Link to the story maps of the city hubs] https://cas-platform.com/REACHOUT/Logrono/
[Examples – case studies]	[Link to the story maps of the city hubs] https://cas-platform.com/REACHOUT/Logrono/ Impact diagrams were first presented in the Dutch National Climate Adaptation Strategy (2016) to complement the IPCCs climate change assessments with national climate scenarios and sector specific impacts.
Guidance	
Triple-A Toolkit	The tool can be used in the following Triple-A phases: • Analysis phase to identify and prioritize climate impacts of a city or region. • Ambition phase to collaboratively create sectoral climate impact chains that provide more information on the opportunities and/or risks of climate change.
Readiness for use	Has been widely used in different context. TRL9.
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** • **Visual and intuitive approach** – Helps stakeholders grasp complex climate impacts, making it accessible for diverse audiences, including policymakers, urban planners, and community groups.

	• **Participatory & interactive** – The workshop format encourages engagement, fostering co-creation and local knowledge integration. • **Flexible & adaptable** – The tool can be tailored to different contexts, scales, and sectors, allowing for application across various climate risk assessments. • **Encourages systems thinking** – The tool helps users understand interconnected impacts and adaptation needs. • **Supports decision-making** – Aids in identifying priority actions, facilitating informed policymaking and project planning. • **Rapid, low-Cost implementation** – Compared to in-depth modeling exercises, the workshops require fewer technical resources and can be implemented relatively quickly. **Weaknesses:** • **Subjectivity in assessment** – The results depend on participant inputs, which may introduce biases or inconsistencies. • **Limited quantification** – Unlike some climate models or risk assessment tools, the CID does not provide numerical risk estimates, making it less useful for detailed cost-benefit analyses. • **Time & facilitation requirements** – Effective use requires facilitators and sufficient time, which may pose challenges in resource-constrained settings.
Cost/effort for implementation	The cost and effort for running this workshop in its basic form are low. Descriptions are available, and it has no technical requirements. The workshop typically takes one morning or afternoon. However, if a supporting literature review is needed, this would require additional time and effort.
Climate hazards covered	All hazards can be used. Often the following themes are included: Heat Drought Floods Sea level rise
Inputs needed	• A city specific analysis of climate trends, based on models and observations, which includes: • Identification of climate hazards most relevant for a city. • Analysis of any observed historical trends in the climate (experts should be involved for correct interpretation of the climate data). • Analysis of future projections for these hazards, where a city needs to select relevant climate scenarios and time horizons (experts should be involved for correct interpretation of the climate data). *Difficulty level of inputs needed: Low difficulty* Gathering information on climate trends can be challenging. Some cities may have access to tailored studies for their city, while others may only have access to national-level or even European-level data and information.

Methodology	This tool is developed on the basis of a workshop, in which draft impact diagrams are validated and prioritized. Using the prioritised impacts, the key climate risks for the city are identified. The workshop will take approximately half a day. Please refer to the Climate impact diagrams & risk workshop guide for a step-by-step explanation on how to carry out an impact diagram workshop where you validate sector-based impacts with city stakeholders.  *Figure 9. The main three steps of the methodology* The guide contains a draft agenda and list of materials needed. *Difficulty level of use of approach: Low difficulty*
Outputs	The workshop will result in sector-based, validated impact diagrams for a city. *Difficulty level of preparing the outputs: Low difficulty*
Contacts	Sophie van der Horst Timo Kelder Climate Adaptation Services (CAS) info@climateadaptationservices.com
Guidance and other documentation	For a practical guide on how to develop impact diagrams and organize a workshop, please refer to the Climate impact diagrams & risk workshop guide, which can be found here. Impact diagrams were first presented in the Dutch National Climate Adaptation Strategy (2016) to complement the IPCCs climate change assessments with national climate scenarios and sector specific impacts. For more information see: https://klimaatadaptatienederland.nl/en/policy-programmes/nas/nas-adaptation-tool/

3.1.7 Social vulnerability tool

Overview	
Name of tool	Social Vulnerability Index (SVI) Tool
Tool access model	The SVI is a free tool. Detailed guidance is provided for users with basic technical knowledge to adapt and implement the tool in their own location. To adjust the indicators used in the SVI or include more localised data, specialised knowledge of socio-economic and environmental indicators and expert technical skills (e.g. coding, statistical knowledge) are necessary. The tools developers offer consultancy services for users who wish to adapt the SVI in this way.
Type of tool	The SVI is a technical tool. Customising and refining the tool is best done in co-creation with its users to ensure that the datasets available are appropriate. This tool is very useful for stakeholder engagement and the facilitation of workshops as the maps created are visually informative and easy to understand.
Tool description (overview)	This tool is designed to help users to assess communities' vulnerability to climate hazards such as flooding and extreme heat. The tool compiles census data for indicators such as housing quality, unemployment rate, and average education levels (amongst others) to analyze the vulnerability of a given community to climate change. The tool also provides an index or score of socio-economic vulnerability for each census-defined small area within a region of interest. These data can be used in tandem with assessments of bio-physical impacts from climate change or can be used as a standalone resource to inform decision-making. The data provided by this tool allows users to better understand climate change risks for a given community, and to compare risks across regions using an easy-to-use map interface. The tool is intended to support decision-makers in municipal government and in industry sectors such as transport, water and agriculture, to assist both effective climate change adaptation and a just transition.
Target user(s)	Researchers and Staff of Local/Regional authorities Local and regional authorities and other decision makers can utilise the tool. Additionally, actors in housing development and management, urban planning, emergency services, and insurance can refer to the tool to complement their usual information systems with additional insights that they can act on. Social science researchers may utilise this tool to better understand vulnerability in different areas.
Sector	Not Sector Specific, although urban planning, infrastructure, health and disaster risk reduction sectors could all benefit from this tool.
Geographical scale	National, Regional, Municipal/Local The information is provided at various scales, dependant on the available datasets from the location of interest. As the datasets used are

	national, comparison of different areas can be done at a national scale. In Ireland the data is provided at the small census area scale for the entire country. This allows specific areas of vulnerability within city regions to be identified.
Geographical area	All Continental, with a focus on urban/populated areas
Urban Adaptation Support Tool (UAST) step(s) of relevance	Step 2. Assessing climate change risks and vulnerabilities The SVI-tool will support UAST step 2 and make minor contributions to UAST steps 1 and 4. The tool identifies spatial areas and populations living there that are particularly vulnerable to different climate hazards, specifically flooding and heat hazards. It utilises factors that determine the sensitivity of a population, along with indicators of their adaptive capacity, and combines this with exposure information to determine average vulnerability over a spatial area. This information on vulnerability to climate hazards is central to understanding what adaptation measures are necessary in an area to protect vulnerable populations and ensure equitable action.
Main graphic	 *Figure 10: Example of social vulnerability mapping for Cork, Ireland, provided by the SVI tool interface*
Benefits of using the tool	• Provides an easy-to-use interface allowing users to quickly examine and visualize zones of relative socio-economic vulnerability. • Can be updated as new census data is collected. The indicators that comprise the index can be tailored to flooding and heat stress. • Complements bio-physical impact assessments to help users to understand the relative sensitivity of any particular location to a given climate hazard. • Provides important socio-economic data for the development of climate change adaptation, disaster risk management, and urban and regional development plans.

Complementarity	This tool can be used effectively in combination with several other REACHOUT tools to better understand climate change, impacts and risks. For instance, the social vulnerability index (SVI) data has been incorporated into damage model layers of the FloodAdapt tool delivered by Deltares. SVI data can also be used in conjunction with the Climate Resilient Development Pathways (CRDP) approach (Deltares), and with the Crowdsourcing Tool (CAS) to inform adaptation planning decisions of local government. Additionally, the social vulnerability maps regarding the heat hazard can also be integrated with the heatmaps developed by Tecnalia to better visualize extreme heat risk.
Complexity and user requirements	Implementation only with support of tool developers/consultants *Overall level of complexity: Medium* Basic/Easy - with a thorough introduction to the tool The tool is an easy-to-use interface which creates maps that can be understood by all users. that have basic coding skills to make use of the free codes on GitHub. However, a higher degree of coding skills in R language will be necessary if users wish to adapt the tool to add additional or higher resolution data that is specific to their area.
Link to tool webpage	The user interface for the SVI Tool is currently under development in Juypter Notebooks.
User stories & hub experiences	**Cork**: is using the SVI Tool in combination with other tools to select areas for urban green space development. The municipality will also use the tool in the updated climate risk assessment for Cork City in 2025, to help integrate social perspectives into climate risk assessment. **Milan**: is using the SVI tool to identify areas of highly vulnerable population density and combine with the outputs of the Thermal Assessment Tool, which will allow them to better target their heat-related work in an equitable way. **Logroño** is using the tool to better define and understand heat and flood hazards in the municipality and be able to identify areas (neighborhoods) of high social vulnerability. Additionally, Logroño is interested in combining the social vulnerability outcome maps with the Thermal Assessment Tool – heatmaps, to better target its heat-related risk. The SVI has been adopted by Logroño municipality within their climate action plans.
[Examples – case studies]	https://www.corkcity.ie/en/climate-action/latest-news/living-with-water-story-map/
Guidance	
Triple-A Toolkit	The tool can be used in the following Triple-A phases:

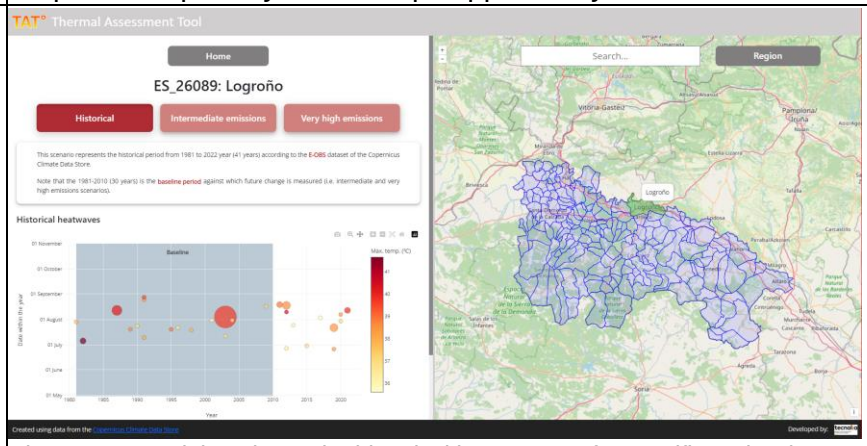
	Analysis phase: • The SVI Tool can be used directly by decision-makers for the purposes of understanding a community's socio-economic vulnerability. Alternatively, it can used in conjunction with other impact and risk analysis methods and tools to assess climate change risks **Ambition phase**: • The SVI Tool can be used to directly inform decision-makers' risk prioritization and identification of objectives **Action phase**: • The SVI Tool can help decision-makers to identify, evaluate and prioritize the most robust and equitable adaptation measures
Readiness for use	TRL 6 – a number of case studies across Europe have been developed
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** • The focus on combining indicators of social vulnerability with specific environmental hazards to allow decision makers to prioritise areas of focus with regards to climate adaptation measures. • The tool is completely opensource, with the codes available in GitHub for anyone to utilise or adapt. • The use of national census data which is widely collected and generally freely accessible to all users, allows for comparison of social vulnerability in different regions within a country. **Weaknesses:** • Some data may be lacking for some indicators through the national census, especially at a high enough resolution. that will allow for comparisons of vulnerability within city areas, and the assumption that knowledge of the general characteristics of an area will constantly yield accurate and precise information about specific individuals within those areas. However, these are unavoidable when using publicly accessible datasets and are considered acceptable in an initial approach to assessing social vulnerability. • The tool also requires some familiarity with the GitHub platform and basic coding skills.

Cost/effort for implementation	Users proficient in the coding language R will be able to update and edit the datasets to implement this tool in their chosen area, with the most current information available. We estimate that this should take no more than 2 days of work. The code to amend this tool is completely open source and available on GitHub, and when completed the user guide will also be freely available.
Climate hazards covered	Flooding (Pluvial, Fluvial, Coastal) Extreme heat The tool is also currently being updated to include wildfires and extreme cold hazards.
Inputs needed	The SVI-tool uses inputs from national census datasets and Copernicus Climate Change Service (C3S) data, both of which are freely accessible and available to users, who can extract the information and include it in the SVI. To add additional indicators and create more detailed outputs, data from regional and local sources may be used. This data is generally held by local authorities and may not be freely available to all users *Difficulty level of inputs needed: High difficulty (needs a lot of data and/or expertise to operate* The SVI uses the coding language R and maps index scores through ESRI-GIS software. The code and guidance for using the tool is freely available as is the Q-GIS platform. The use of this tool requires basic coding/technical ability.
Methodology	The tool involves an application developed using coding language R. The application compiles census data into index scores for each Census small area location and maps those data via Geographic Information Systems software (Arc/Q-GIS) Each small area is colour-coded in relation to its relative vulnerability. Colour-coding uses a 7-point scale from Extremely High to Extremely Low. The choice of indicators and indexing methodology can also be tailored to flooding and heat stress, as needed. *Difficulty level of use of approach:* High *difficulty (needs a lot of expertise to operate / needs support of tool developers)* The use of this tool requires basic coding/technical ability, however, additional inputs of local or regional specific data or another hazard will need a higher level of coding expertise. Once the data is collected and mapped, however, the user interface will be easy to use and to navigate.
Outputs	The SVI Tool provides both datasets and Arc/Q-GIS maps of index scoring, ranging from extremely high to very low vulnerability, across the geographic area(s) of interest, to a chosen environmental hazard. The underlying dataset can also be incorporated into other tools for the purposes of impact and risk assessment. This data is available as

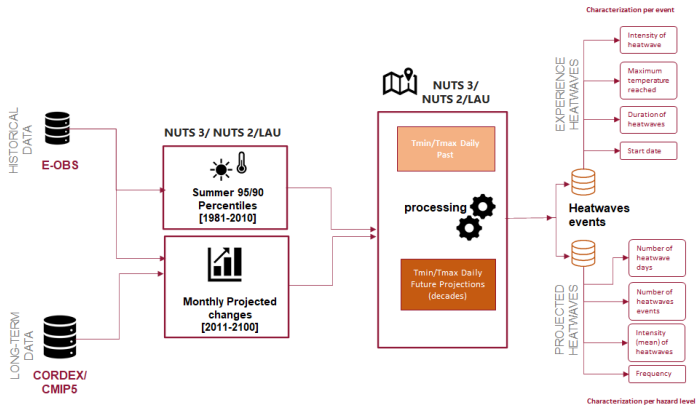
	shapefiles for the highest resolution available from national census data, for example in Ireland this is the small census area The data and maps produced by the SVI Tool will allow decision-makers to understand varying socio-economic vulnerability across their communities. This data can also directly inform the development of climate change planning and policy. *Difficulty level of preparing the outputs: High difficulty (needs a lot of expertise to postprocess)* The development of SVI index scores will need basic coding expertise in the first instance, but once compiled, the tool provides an easy-to-use dataset and maps, accessible for all users.
Contacts	Denise McCullagh (UCC) – denise.mccullagh@ucc.ie
Guidance and other documentation	An overview of the methodology: Fitton, JM, O'Dwyer, B, Maher, B (2021) 'Developing a social vulnerability to environmental hazards index to inform climate action in Ireland'. *Irish Geography,* 54(2), 157-180. McCullagh, D., Cámaro, W., Dunne, D., Nowbakht, P., Philips, C. & Cumiskey, L. (2025) Development of a Social Vulnerability Index: Enhancing approaches to support climate justice. MethodsX (Submitted). Dunne, D., Walther, C., & McCullagh, D. (2024). Characterisation of Social Vulnerability to the environmental hazard of heat in Milan, derived from national census and EU Copernicus datasets (1.0.0) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.13894260 Dunne, D., Camaro, W., & McCullagh, D. (2024). Characterisation of Social Vulnerability to the environmental hazard of heat in Logroño, and the surrounding La Rioja region in Spain, derived from national census and EU Copernicus datasets. (1.0.0) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.13909225 Dunne, D., Camaro, W., & McCullagh, D. (2024). Characterisation of Social Vulnerability to the environmental hazard of flooding in Cork City and County, Ireland, derived from national census and EU Copernicus datasets. (1.0.0) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.13913850 Cámaro García, W., McCullagh, D., Dunne, D., Gannon, C., Phillips, C. & Cumiskey, L. (2025) The Social Vulnerability Index (SVI) Tool Handbook. Jupyter Notebooks. (In Preparation).

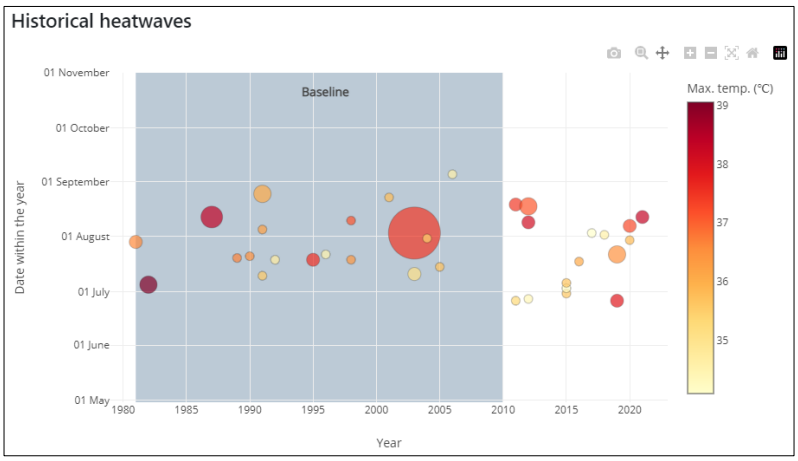
3.1.8 Thermal Assessment Tool (heatwave service)

Overview	
Name of tool	Thermal Assessment Tool
Tool access model	It is a licensed Tool, but it is free of use for the 7 REACHOUT regions and cities. For any other region/city the tool can be adapted using the same methodological approach or by integrating a new heatwave model with different thresholds.
Type of tool	It is a technical tool, that can be used to raise awareness in workshops and support co-creation of services tailored for new cities.
Tool description (overview)	The Thermal Assessment Tool is designed to provide a user-friendly visualization of past, present and future extreme heat episodes (heatwaves) in European regions and cities to raise awareness and better support heat risk assessment. The tool provides customized visualisations to show the magnitude of extreme heatwave events in Europe based on different risk levels “warning”, “alert”, “alarm” that are based on the severity of the potential impacts. The analysis is conducted under current and future climate conditions, considering the intermediate (Representative Concentration Pathway RCP4.5) and very high (RCP8.5) emissions scenarios. The information is provided at various regional scales, including municipality, province, and region levels. This information can be integrated into policy and planning processes and documents (e.g. Sustainable Energy and Climate Action Plans (SECAPs) or Climate Adaptation Plans) or used to assess health impacts or energy consumption patterns.
Target user(s)	National, regional and local authorities or practitioners/stakeholders that are concerned with heat stress assessment and its future impacts. Additionally, it provides easy-to-understand information that can help raise awareness among the general public (citizens).
Sector	Main sector for which has been developed: health. But it coul also be adapted and used in other sectors such as: energy, buildings or agriculture.
Geographical scale	regional, municipal The tool offers a selectable regional map for EU regions for which the heatwave information is available. The user can zoom in and zoom out to select NUTS2, NUTS3 or local administration units.
Geographical area	The tool covers now 7 European regions (Lombardia, La Rioja, Pomorskie, Oslo og Viken, Southern Irland and Attica). It can be activated as service for all other continental regions; see for more details below.
Urban Adaptation Support Tool	1. Preparing the ground for adaptation

(UAST) step(s) of relevance	2. Assessing risk and vulnerabilities Step 2 is the primary RAST step supported by this tool.
Main graphic	 *Figure 11: Panel that shows the historical heatwaves of a specific region (e.g. Logroño)* Source: Tecnalia
Benefits of using the tool	The tool allows end-users and decision-makers to easily visualize how long, intense and frequency will extreme heat events be in the coming decades considering the intermediate (RCP4.5) and very high (RCP8.5) emissions scenarios. This rise awareness on citizens and support governments to prepare and protect the city through effective policy making
Complementarity	The Thermal Assessment Tool works especially well in combination with the **Social Vulnerability** tool to assess and visualize the risk considering heat hazard and heat related social vulnerability.
Complexity and user requirements	*The level of complexity: Low* No additional preparation. The tool has an easy-to-use interface and self-explanatory plots allowing non-expert users to understand its outputs. Additionally, the tool is based on the independent and authoritative Copernicus Climate Change Service (C3S) datasets. The tool showcases how to analyse, process and simplify large volumes of data through different maps and plots that make it easier to understand heatwaves evolution
Link to tool webpage	https://thermal-assessment.urban.tecnalia.dev/
User stories & hub experiences	**Logroño** is using the tool to plan future city interventions and as an input for the SECAP. Logroño has also included the outcomes of the tool in their climate story (link) to raise awareness among citizens about heatwaves impacts which are becoming more frequent and intense in the city. **Milano** is interested in the regional perspective of the tool outcomes and prevision for the future as well as planning for the energy community. Milano has also included some outcomes of the tool in their climate story (link) to better visualize future impacts.

	Athens and Cork are interested on heatwaves evolution in theis city
[Examples – case studies]	Link to the Logroño user story Link to the Milano story map
Guidance – Heatwave service	
Heatwave service overview	This service provides interactive maps and plots to visualize the frequency and severity of heatwaves at different regional scales in Europe for both the historical period 1981-2021, and the projected 30-year periods from 2011-2040 to 2071-2100, in 10-year steps using different future climate change scenarios.
Triple-A Toolkit	The tool can be used in the following Triple-A phase: • Analysis phase to support the heat hazard assessment considering the intermediate (RCP4.5) and very high (RCP8.5) emissions scenarios.
Readiness for use	TRL 7 – system prototype demonstration in operational environment = tested in several regions
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** • Easy-to-use interface and self-explanatory visualizations that allow non-expert users to understand the outputs. • It is based on public, independent and authoritative observational data available for the whole of Europe. • Better understanding of land and space uses during heat episodes in summer. **Weaknesses:** • The definition/threshold for a heatwave in specific countries may differ from the definition used in the tool (based on percentiles). However, this could be easily tailored and implemented for specific region's needs.
Cost/effort for implementation	Tecnalia offers the option to use the tool for other regions with two options: 1. Following the same methodological approach and heatwave model. The estimated effort is 7 person-days (2 days to generate the new datasets at regional/municipality level + 3 days to integrate the data in the tool + 2 days for validation meetings with the region). 2. Implement a new heatwave model with different thresholds, indicators or risk levels. The work effort is estimated in 21 person-days, considering the above-mentioned effort + the update of the implementation module. The tool can be tailored by Tecnalia considering different regional or local requirements.
Climate hazards covered	Extreme heat
Inputs needed	The **Heatwave service** of Thermal Assessment Tool uses public, independent and authoritative Copernicus Climate Change Service (C3S) data as a way to obtain homogeneous data for the whole EU. The input variables are maximum and minimum daily temperature obtained from the next C3S datasets:

	• **e-OBS [1950 to present]**: This dataset provides daily gridded land-only observational data over Europe. 0 • **EURO-CORDEX [2011-2100]**: This dataset provides the future regional climate conditions, according to an ensemble of EURO-CORDEX dataset. **Error! Reference source not found.** The complexity of obtaining and processing the raw data from C3S at different regional levels is **high.** *Difficulty level of inputs needed: High difficulty*
Methodology	A heatwave is a prolonged period of extremely high temperature for a particular region. As there are multiple nation specific definitions at this stage this application makes use of a generic health communtiy definition: a heatwave is defined as a period of two or more days with excessively high temperatures, relative to the usual climate in the area and relative to normal temperatures for the summer season. At first, the **percentiles 95 and 90** of maximum and minimum temperature, respectively, are obtained considering the values of maximum and minimum temperature of the different regional scales (according to NUTS classification) **Error! Reference source not found.** and considering the summer months (**June**, **July, August and September**). The baseline period used to estimate the reference heatwaves goes from **1981 to 2010.** Secondly, maximum and minimum daily temperature historical and projected records are considered. Since the climate models typically provide a biased projection of the future it has been necessary to adjust the bias projections to obtain actual trends of what will happen in the future regarding the studied phenomenon. To do so, a **delta-scaling method** is performed to calculate the biases (perturbation) of each ensemble. Afterwards, this perturbation is added to the observations to get the bias-adjusted projections.  *Figure 12: Heatwave service processing workflow* In a last step, the heatwaves events, which are characterised using the start date, duration, maximum temperature, and intensity, are categorized in **three risk levels**:

	- **Yellow level/Warning Level**: This level is considered when there are 2 consecutives hot days that exceed the corresponding percentiles. Some specific activities might be affected. Generates a situation of **warning**. - **Orange level/Alert Level**: This level is considered when there are 3 or 4 consecutives hot days that exceed the corresponding percentiles. The impact damage might be significant for some sectors. Generates a situation of **alert**. - **Red level/Alarm Level**: This level is considered when there are 5 or more consecutive heatwave days that exceed the corresponding percentiles. The material damage can be very high. It generates an **alarm** situation. *Difficulty level of use of approach: High difficulty*
Outputs	The outcomes of the Thermal Assessment Tool are the following customized panels: **Historical heatwaves panel**: This panel is composed by an interactive plot that shows the historical heatwave events that took place between 1981 to 2021 in a specific region. Each bubble represents a heatwave event. The bubble's colour represents the maximum temperature reached during that event and the size represents the duration of the heatwave. Moving the mouse over each bubble allows to get specific information on the starting date, maximum temperature, severity and duration of the heatwave event. The plot also allows to zoom in or zoom out to better visualize different heatwave events happened in the past.  *Figure 13. Historical heatwaves* **Projected heatwaves panel:** This panel is composed by two interactive plots, visualizing the evolution of the frequency of heatwave events and delivering the number of heatwave days per hazard level in a specific region. • **Frequency of heatwaves per decade:** This plot shows the future evolution of the heatwaves for each hazard level. The yellow, orange and red lines show how frequently the warning, alerts and alarms events will happen in the future. The

frequencies are provided as the average number of events of a specific hazard level per decade. To estimate the average, 30-year periods are considered. The baseline period considered is 1981-2010, while the future ones go from 2011-2040 to 2071-2100, in 10-year steps. Thus, the future decades in the x-axis represent the last decade of the corresponding 30-year window. The uncertainty is given in a best vs. worst case way (i.e. the model that predicts the lowest number of events will be the best case, while the one that predicts the highest will represent the worst case).

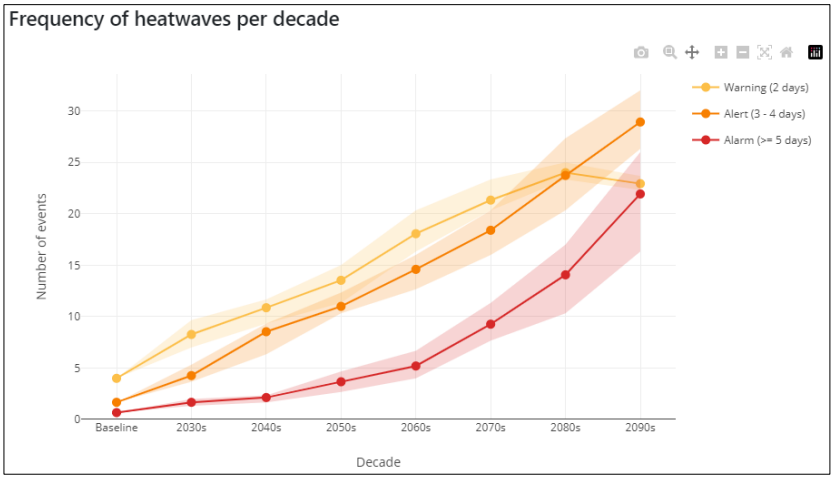


Figure 14. Evolution of the heatwaves's frequency per decade

- **Heatwave days per year:** This plot shows the evolution of the average number of heatwave days per hazard level. The yellow, orange and red bars show the number of warning, alerts and alarms days that will happen in the future. The days are provided on an annual basis. To estimate the average, 30-year periods were considered. The baseline period was 1981-2010, while the future ones went from 2011-2040 to 2071-2100, in 10-year steps. Thus, the future decades in the x-axis represent the last decade of the corresponding 30-year window.

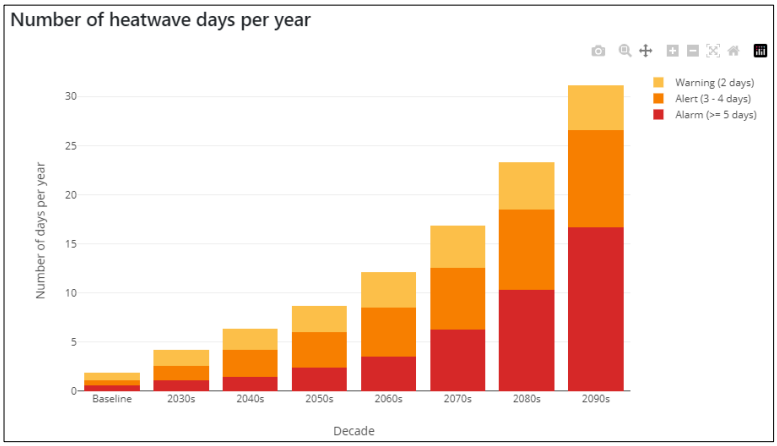


Figure 15. Evolution of the heatwave days per year

- **Heatwave intensity per year:** This plot shows the evolution of the average number of heatwave This plot shows the future evolution of the heatwaves day-time and night-time intensity per risk level. The intensities are provided on an annual basis. The night-time and day-time intensities are defined as the number of degrees over the minimum and maximum temperature thresholds used to detect the heatwaves, respectively.

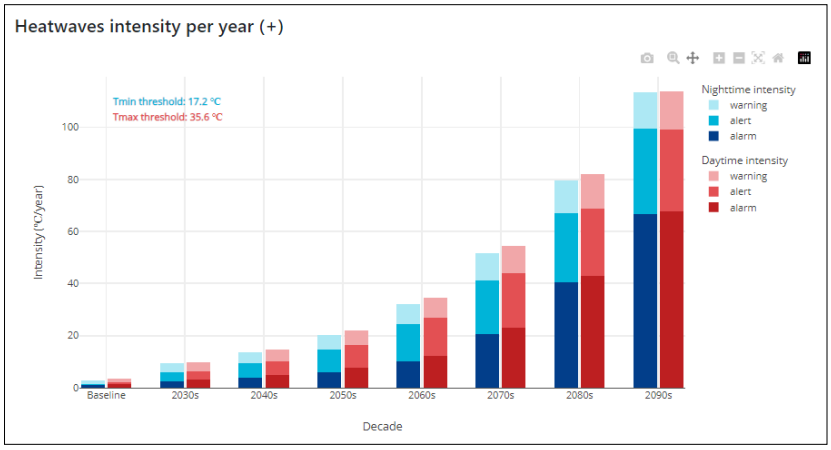


Figure 16. Evolution of daytime and night-time intensity per hazard level

Similar to the previous plots, to estimate the average, 30-year periods are considered. The baseline period was 1981-2010, while the future ones go from 2011-2040 to 2071-2100, in 10-year steps. Thus, the future decades in the x-axis represent the last decade of the corresponding 30-year window.

The user selectable parameters of the heatwave service of the Thermal Assessment Tool are the following:

Selectable regions: This map shows the EU regions for which the heatwave information is available*. The user can zoom in and zoom out to select NUTS2, NUTS3 or Local Administrating Units.*

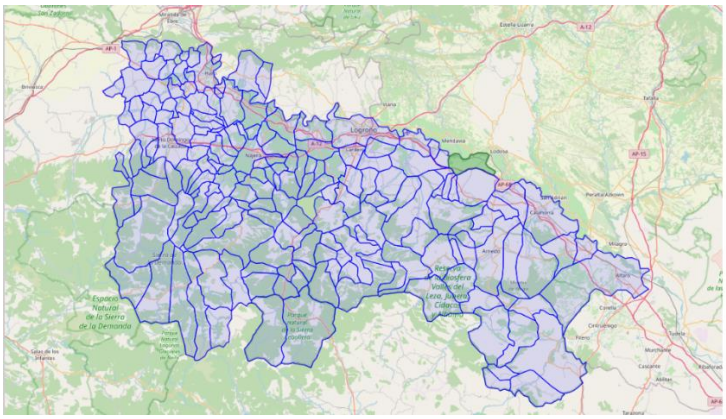
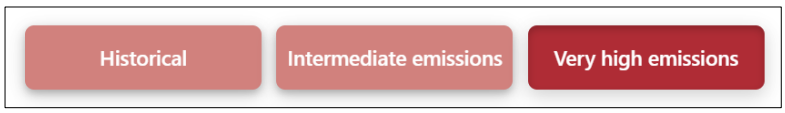


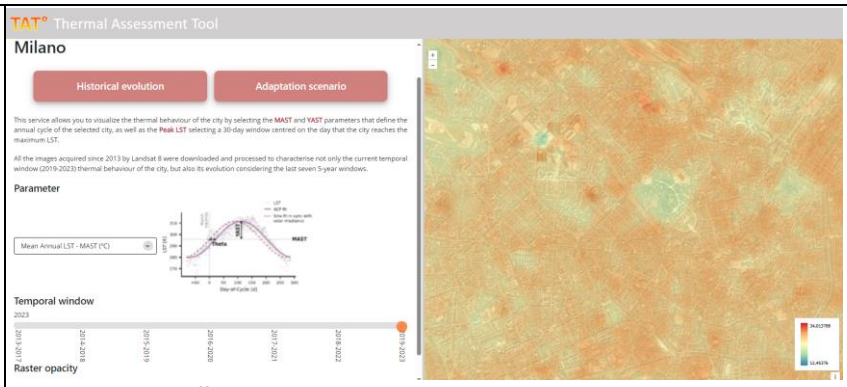
Figure 17. Geographical selectable map to select the region/city

Selectable scenarios: This panel allows to select three possible scenarios: the *historical record* (1981-2021), the *intermediate emissions* scenario (2011-2100) – considering future regional climate conditions, assuming an intermediate greenhouse gases and aerosols emissions scenario (RCP 4.5) - or the *very high emissions scenario* (2011-2100) -

	which represents the future regional climate conditions, assuming a very high greenhouse gases and aerosols emissions scenario (RCP 8.5)  The outputs can be used: • for communication with other stakeholders • to improve the *adaptative capacity* of regions and cities • As input to support different stakeholders in the design of *adaptation plans* and *regional policies* *Difficulty level of preparing the outputs: High difficulty*
Contacts	*TECNALIA* *Nieves Peña Cerezo; nieves.pena@tecnalia.com* tae@tecnalia.com
Guidance and other documentation	Guidance: • https://thermal-assessment.urban.tecnalia.dev/project/data/user_manual.pdf Additional documentation is provided in Zenodo where public datasets have been created for the whole of continental Europe, using Copernicus Climate Change Service (C3S) downloads from the Copernicus Climate Data Store (CDS), providing data regarding the frequency and severity of heatwaves under past, current and future climate (1891-2100) derived from observations and reanalysis for REACHOUT city-hubs as well as for other regions in Europe. *[1]* Heatwaves characterization derived from observations and climate projections to assess thermal behavior of 7 European city-hubs: Milano, Athens, Logroño, Cork, Gdynia, Lillestrøm and Amsterdam (1981-2100) *[2]* Heatwaves characterization derived from reanalysis and climate projections to assess thermal behavior of 7 European city-hubs: Milano, Athens, Logroño, Cork, Gdynia, Lillestrøm and Amsterdam (1981-2100) *[3]* Heatwaves characterization derived from reanalysis and climate projections to assess thermal behavior of regions in Europe (1981-2100) *[4]* Heatwaves characterization derived from observations and climate projections to assess thermal behavior of regions in Europe (1981-2100)

3.1.9 Thermal Assessment Tool (heatmap service)

Overview	
Name of tool	Thermal Assessment Tool
Tool access model Type of tool	Licensed Tool. It is is free of use for 3 REACHOUT cities: Milano, Logroño and Athens. For any other region/city Tecnalia offers a licence tool that can be used following the same methodological approach. Technical Tool, that can be used to raise awareness in workshops and support co-creation of services tailored for new cities.
Tool description (overview)	The Heatmap service of the Thermal Assessment Tool is designed to provide a user-friendly visualization of Land surface temperature (heatmaps) derived from earth observation data to assess thermal behaviour of cities. There is a wide range of methods that can be used to characterise the thermal behaviour of a city, each of them with its advantages and disadvantages. One of these methods uses the land surface temperature that is obtained from remote sensing observations. Although thermal indices are considered more suitable when characterising thermal comfort, still the LST can provide a useful information about the behaviour of a citiy's surfaces and materials. This has implications for several applications such as urban energy efficiency or urban environmental health.
Target user(s)	National, regional and local authorities or practitioners/stakeholders that are concerned with heat stress assessment at city level.
Sector	Main sector for which has been developed: health and urban planning But it coul also be used in other sectors especially for energy or agriculture.
Geographical scale	Municipal/city level The tool offers a selectable regional map for EU cities for which the heatmap (LST) information is available. The user can zoom in and zoom out to better visualize different areas of the city.
Geographical area	The tool covers now 3 European cities (Athens, Milano and Logroño). It can be activated as service for any other city; see for more details below on the methodology section.
Urban Adaptation Support Tool (UAST) step(s) of relevance	3. Preparing the ground for adaptation 4. Assessing risk and vulnerabilities Step 2 is the primary RAST step supported by this tool.

Main graphic	 Source: Tecnalia
Benefits of using the tool	This service allows end-users and decision-makers to easily visualize and characterize heat phenomena at city level by providing an assessment of the land surface temperature.
Complementarity	The Thermal Assessment Tool works especially well in combination with the **Social Vulnerability** tool to assess and visualize the risk considering heat hazard and heat related social vulnerability at city level.
Complexity and user requirements	*The level of complexity: Low* No additional preparation. The tool has an easy-to-use interface and self-explanatory plots allowing non-expert users to understand its outputs. All the images are acquired since 2013 by Landsat 8 were downloaded and processed to characterise not only the current temporal window (2019-2023) thermal behaviour of the city, but also its evolution considering the last seven 5-year windows.
Link to tool webpage	https://thermal-assessment.urban.tecnalia.dev/
User stories & hub experiences	**Logroño, Milano and Athens** are using the tool to plan future city interventions, integrating it with social vulnerability data.
[Examples – case studies]	Link to the Logroño user story Link to the Milano story map
Guidance	
Heatwave service overview	This service provides interactive maps and plots to visualize the frequency and severity of heatwaves at different regional scales in Europe for both the historical period 1981-2021, and the projected 30-year periods from 2011-2040 to 2071-2100, in 10-year steps using different future climate change scenarios.
Triple-A Toolkit	The tool can be used in the following Triple-A phase: • Analysis phase to support the heat stress assessment as well as evolution considering the last years.
Readiness for use	TRL 7 – system prototype demonstration in operational environment = tested in several regions

Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** • Easy-to-use interface and self-explanatory visualizations that allow non-expert users to understand the outputs. • LST can provide a useful information about the behaviour of a citiy's surfaces and materials. **Weaknesses:** • Thermal indices are considered more suitable when characterising thermal comfort.
Cost/effort for implementation	Tecnalia offers the option to use the tool for other cities following the same methodological approach. The estimated effort is 12 person-days.
Climate hazards covered	Extreme heat
Inputs needed	The input data used by the current version of the dataset came from Landsat 8. All the images acquired since 2013 by this satellite for Milan, Logroño and Athens were downloaded and processed to characterise not only the current (2019-2023) thermal behaviour of the city, but also its evolution considering the last seven 5-year windows: - 2013-2017 - 2014-2018 - 2015-2019 - 2016-2020 - 2017-2021 - 2018-2022 The input data used in this dataset come from Landsat 8 downloaded from Earth Explorer (usgs.gov). *Difficulty level of inputs needed: High difficulty*
Methodology	The LST outcomes are based on the concept of annual cycle parameters (ACP) explained in [*Sismanidis, P., Bechtel, B., Keramitsoglou, I., Göttsche, F., & Kiranoudis, C. T. (2021). Satellite-derived quantification of the diurnal and annual dynamics of land surface temperature. Remote Sensing of Environment, 265, 112642. https://doi.org/10.1016/j.rse.2021.112642*] has been considered to deal with anisotropy. All daytime LST acquisitions of the full period were gathered and assigned to the respective day in the annual cycle (relative to the spring equinox), and a sine function was fitted using a least square optimization resulting in the annual cycle parameters (ACP) mean annual surface temperature (MAST) and yearly amplitude of surface temperature (YAST).

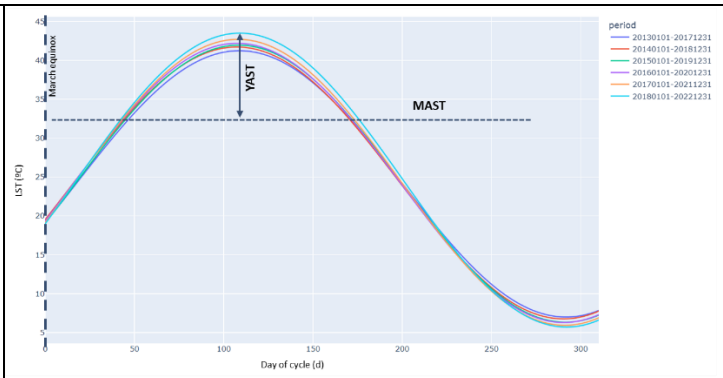


Figure 18. *Example of Annual cycle parameters for Milan city. The plot starts on the spring equinox (day 0 = 20 march)*

Difficulty level of use of approach: High difficulty

Outputs

The outcomes of the Thermal Assessment Tool are the following customized panels:

This service allows end-users and decision-makers to easily visualize the thermal behaviour of the city by selecting the Mean Annual Land Surface Temperature – MAST (ºC), the Yearly Amplitude of LST – YAST (ºC) parameters that define the annual cycle of the selected city, as well as the Peak LST selecting a 30-day window centred on the day that the city reaches the maximum LST.

Mean Annual Land Surface Temperature – MAST: This panel allows to visualize the MAST indicator per the whole city. So, the user can click on any point in the map and visualize the mean annual LST value at that point. The resolution is a 30 meters resolution, so the user can zoom in or zoom out in the map to better visualize the city behaviour.

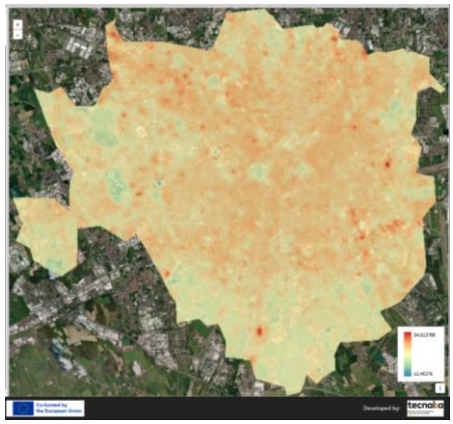


Figure 19. Example of MAST for the city of Milan

Yearly Amplitude of Land Surface Temperature – YAST: This panel allows to visualize the YAST indicator per the whole city. So, the user can click on any point in the map and visualize the yearly amplitude of LST at any cell (30m) of the city. The user can zoom in or zoom out to better visualize these values and better understand city behaviour.

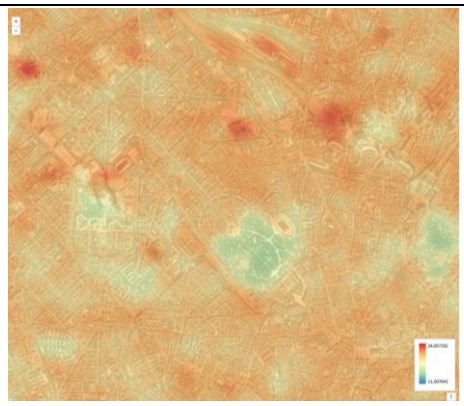


Figure 20. Example of YAST for the city of Milan

Peak Land Surface Temperature (Peak LST): This panel allows to visualize the Peak LST values in the city area. The Peak LST is obtained after getting the Annual Cycle Parameters of each of the periods and selecting a 30-day window centred on the day that the city reaches the maximum LST. This way, the user can observe the city behaviour during those days where maximum LST values are reached.

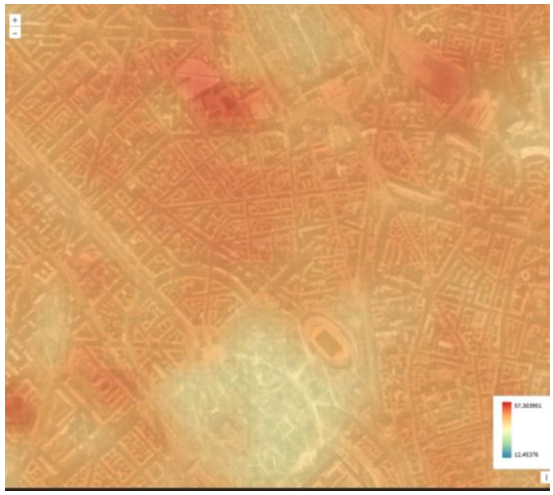


Figure 21.Example of Peak LST for the city of Milan.

Difficulty level of preparing the outputs: High difficulty

Contacts	*TECNALIA* *Nieves Peña Cerezo; nieves.pena@tecnalia.com* tae@tecnalia.com
Guidance and other documentation	Guidance: • https://thermal-assessment.urban.tecnalia.dev/project/data/user_manual.pdf Additional documentation is provided in Zenodo

	[1] Land surface temperature (heatmaps) derived from earth observation data to assess thermal behaviour of 3 European cities: Milano, Logroño and Athens. [2] EarthExplorer (EE) provides online search, browse display, metadata export, and data download for earth science data from the archives of the U.S. Geological Survey (USGS). EE provides a user interface at https://earthexplorer.usgs.gov/ (last accessed in September 2022) [3] The Copernicus Land Monitoring Service (CLMS) provides geographical information on land cover/land use and on variables related to vegetation state, water cycle and earth surface energy variables. More info at https://land.copernicus.eu/

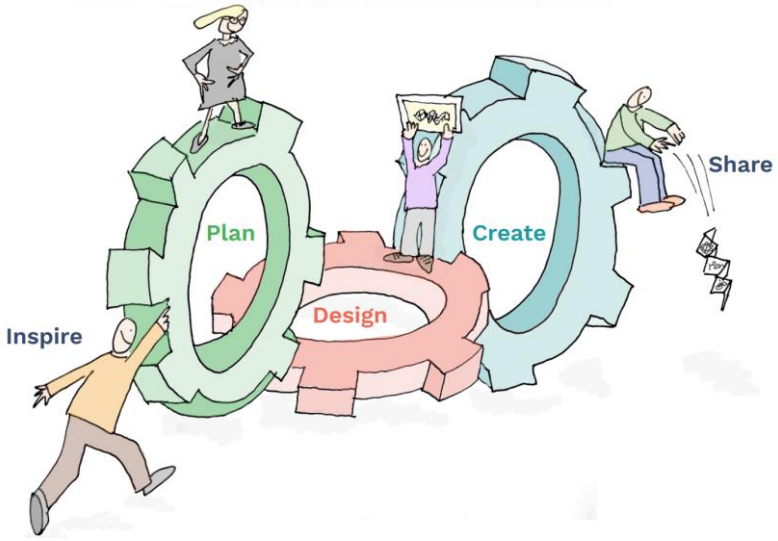
3.1.10 Climate Stories

Overview	
Name of tool	Climate stories
Tool access model Type of tool	Free tool, that offers a method for producing climate stories Soft tool that allows to raise awareness in workshops and allows to build a common understanding between researcher, decision-makers and stakeholders.
Tool description (overview)	Climate stories are a form of structured communication designed to share information, experiences, and targeted messages about climate change/adaptation. Ideally, stories are compelling and entertaining and combine text with supporting media or scientific data. The target audience can be the public or specific group(s). The method (described in the guidebook) enables a stakeholder group (for example municipal employees) to follow co-creation processes and structure story development work to lead to a final climate story product. The story can be practically implemented in various forms or platforms, for example on commercial platforms such as ESRI storymaps, produced as short videos, podcasts, presentations, comics etc. The story can be used to convey all kinds of important public messages about climate change. Defining the audience and the core message are essential components in the development process so that the story appeals to the audience and the core message can be communicated clearly.
Target user(s)	Target users are any groups or organisations with a need to communicate climate related results or information, for example data, action plans, climate projections, public events etc. The stories can target any form of stakeholders, for example citizens, staff of regional authorities,practicioners, politicians etc.
Sector	Relevant for all sectors. Story telling is a communication technique engaging personal and emotional connections. This technique can be applied in any sector or application.
Geographical scale	The tool is applicable at all scales. However, a specific climate story developed using the method will be applicable for a specific target scale, which is dependent on how the story is developed and disseminated.
Geographical area	Relevant for all regions. Similar reasons as for geographical scales.
Urban Adaptation Support Tool (UAST) step(s) of relevance?	Communication of ideas, needs or results are relevant for all steps in the UAST.

Main graphic	 *Figure 22. Example of Climate story - Logroño*
Benefits of using the tool	Story telling creates a personal and emotional connection to target audiences. This has the potential to increase the impact of the climate message, as this connection helps to promote a deeper understanding and connection to the message.. Possible benefits are: • Climate change issues become personal and tangible • Learn about climate change and its impacts. • Learn about how climate hazards affect citizens' lives. • Generate a sense of urgency about what climate resilience entails. • Identify and understand possible climate actions that are being taken/or can be taken.
Complementarity	The climate story is highly versatile and can integrate the results of any climate tool. Climate tools that produce easy-to-understand visuals are easiest to integrate into a climate narrative. Map-based tool outputs are especially impactful. The creative process of developing a climate story helps identify needs for new outputs or products from the tools, for example developing easy to understand infographics expressing some of the more complicated scientific content of the tools.
Complexity and user requirements	The level of complexity is completely dependent on the ambitions of the story. The development of the climate stories requires an iterative approach between the technical developers and the city representatives. A good and engaging narrative takes time to develop. In addition, access to high quality media (images, maps, plots, videos) greatly improves the ability to create a compelling and impactful story. Implementing the story requires a platform as a basis– this can be as simple as a document, or as complex as a specialised story mapping software. *Overall level of complexity: Low*

Link to tool webpage	https://reachout-cities.eu/climate-stories/ https://doi.org/10.5281/zenodo.14500115 (direct link to manual)
User stories & hub experiences	Each City Hub developed a climate story, where each story focused on a core challenge for the city: The cities of Logroño, Milano, and Athens focus on heat impacts in their stories. They target citizens and municipal departments to provide insight into the impacts of heat on specific vulnerable groups (children, outdoor workers, elderly). The Athens story for example describes a day in the life of Grandmother Sophia and her grandchildren during a heatwave. The stories for these cities also describe what is being done by the cities and what action citizens and other stakeholders can take to become more heat resilient. Results from the Thermal Assessment Tool (Tecnalia) and Social Vulnerability to Environmental Hazards Index tool (UCC) are woven into the story. The cities of Lillestrøm, Cork, and Gdynia focus on flooding impacts in their stories. They target citizens, municipal departments, and other relevant stakeholders engaged in city planning. The stories show the impacts of flooding on peoples' daily lives and explain the actions that can be taken by different types of stakeholders. The stories are also used to explain what the city is doing about flooding and why. Results from the Community Flood Resilience Support Tool (Deltares) and the Social Vulnerability to Environmental Hazards Index tool (UCC) will be integrated into the stories where relevant.
[Examples – case studies]	All climate stories are accessible to the public via URL links.
Guidance	
Triple-A Toolkit	It can be relevant for any of the phases of the Triple-A toolkit: **Analysis phase:** Provide insight into the climate change trends, hazards, impacts, risks, and damages, for example, to create awareness or increase support for developing adaptation policy. **Ambition phase**: Show what a climate-resilient city could look like or communicate about adaptation goals and targets. **Action phase**: Show what actions can be taken by whom.
Readiness for use	The tool (a methodology) is ready for use, and a manual describing the method is published and available for free downloading.
Strengths and weaknesses, comparative added value to other similar tools	The tool is a methodology for communicating climate data and climate services that can easily be used by non-specialists and is adaptable for a wide range of purposes. A significant value added is that the co-creation processes in the tool promote teambuilding and collaboration. Requires additional activities such as marketing and promotion to distribute the stories produced.
Cost/effort for implementation	Use of the method is free of charge. The cost of implementation depends on the ambitions for the story complexity and the way it is intended to be implemented (platform). For example, a short narrative story to be produced as a basic podcast may be created in just a couple of days. A complex story intended to be produced as a short video film may require weeks or months of preparations, and the assistance of professional film crews, actors etc. In the REACHOUT project, total

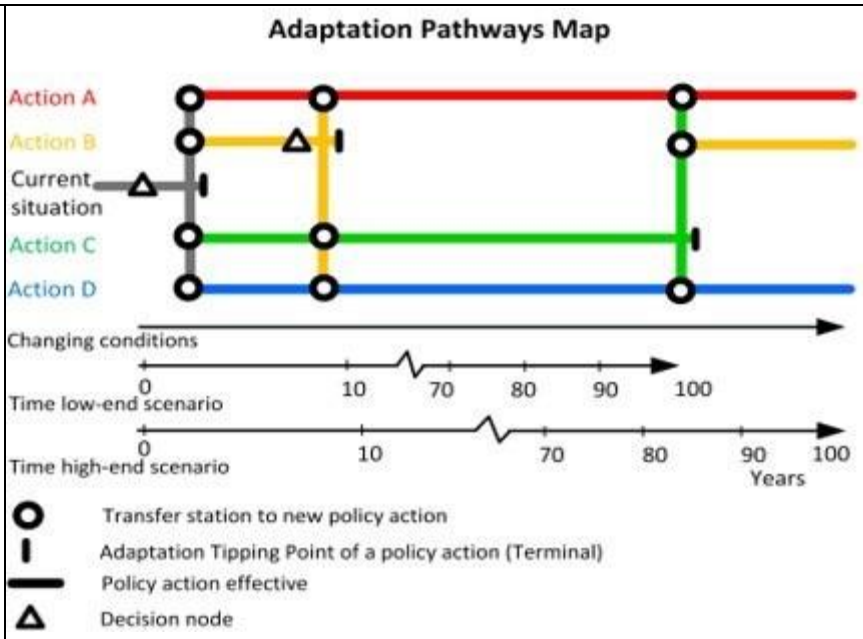
	resources to produce a climate story using the commercial platform *ESRI Storymaps* was probably equivalent to 1-2 man-months in total per story, with the total production time spread over 4-6 months to accommodate the co-creation activities and iterations of story development
Climate hazards covered	REACHOUT focused on water (flooding) and (extreme) heat hazards. Topics such as green space, urban heat and physical measures to combat heat and flooding were also included in the stories.
Inputs needed	The inputs required are entirely dependent on the objectives of the climate story to be developed. In general, the development of the climate stories benefits from high-quality media (photos, images, data plots, videos). GIS/map data is also a powerful source of information. The story also benefits from establishing a subtle emotional/psychological connection to the intended audience, for example using locations and references the target audience is familiar with. These inputs can be gathered from a variety of sources: General media can be collected by photographers or artists, GIS data from the municipality or national mapping authority, media presenting scientific data can be created by climate tools, or from other relevant sources. The development of the story benefits from the involvement of representatives of the target audience, as well as intended owners of the completed story (for example planning officials). Information gathering and story development may be enabled by workshops and direct collaboration between these groups. *Difficulty level of inputs needed: Easy to Medium difficulty, depending on ambition level.*
Methodology	The idea of the climate story is to develop a narrative. This can be achieved using, for example, the classical storytelling structure of a hero, a path, an objective, a trigger, and a resolution. An example of this narrative structure is the story of Little Red Riding Hood (hero), who will visit her grandmother (objective), and while on the way strays from the road into the woods (path), is endangered by the wolf (trigger) and is saved by the huntsman (resolution). Other narrative structures may be more relevant depending on the cultural context of the target group or the city. Developing the cliamte story is a creative collaborative process described through three iterative cycles – Plan, Design and Create:

	 • The planning process establishes the objectives, scope and intended audiences for the story. Stakeholders are identified, including target audiences and appropriate complexitly level of climate data or other information to be communicated. • The second cycle focuses on the development of the story, including deciding the narrative structure to be used (for example 'Hero's journey'), characters and progression in the story, and necessary elements such as supporting data, information, local context or other factors that contribute to creating a local association or personal connections to the story. The intention is to find an emotional connection between the message and the audience, as this connection helps the audience to fully engage in the story and the developing message. • The third cycle is about technical production – developing graphics, implanting the story line in the choen platform, refining characters etc. This cycle can benefit from the involvement of media producers (photographers/videographers), artists, GIS specialists etc. The three development cycles are iterative and interconnected, meaning that decisions or inputs in one cycle can influence the results of the other two cycles. For example, the development of details in the second cycle could trigger a modification to the objectives decided in the first cycle and could also impact the way the story is implemented in the intended platform in the third cycle. *Difficulty level of use of approach: Medium difficulty (first time), Easy difficulty (with some experience)*
Outputs	The output depends on the platform for the implementation required by the stakeholder to develop and maintain the story during and after the project period. Platforms may include story mapping software, text documents, presentations, videography etc.

	Difficulty level of preparing the outputs: Low to High difficulty, depending on the specific platform the story owner selects and the level of competency they possess.
Contacts	• Jan-Willem Anker, CAS • James Strout, NGI
Guidance and other documentation	The method is presented in a downloadable guide book: Climate Adaptation Services, Norwegian Geotechnical Institute, Anker, J.-W., Body, N. S., Boon, E., van der Horst, S., Oen, A., Salazar, S., Strout, J., & van Veldhoven, F. (2024). **How to build a climate story - A practical guide.** Zenodo. https://doi.org/10.5281/zenodo.14500115

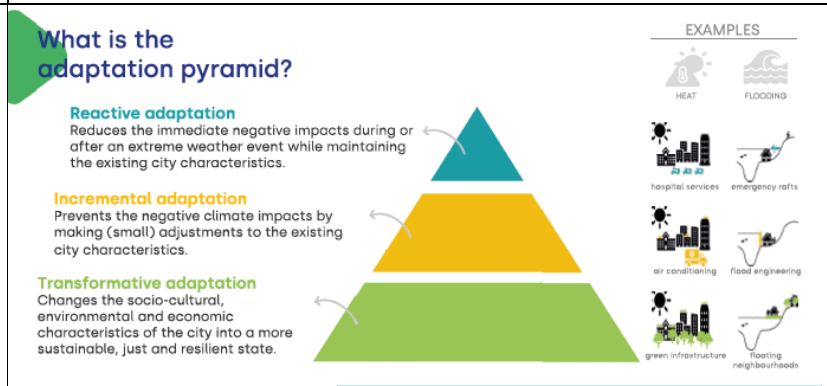
3.1.11 Adaptation pathway generator tool

Overview	
Name of tool	Adaptation pathway generator tool
Tool access model Type of tool	The Pathways Generator Tool (PG) is a free technical tool (software application) enabling users to visualize adaptation pathways. Users are able to consolidate information including measures, sequences, tipping points, path dependencies and evaluation criteria in the tool, using resulting visuals for reports or analysis of solutions options. It is advisable to combine the use of this tool with an associated pathways methodology such as Dynamic Adaptive Policy Pathways (DAPP), guiding users through the process of developing pathways for visualization and analysis in the PG interface. Guidance through a pathways workshop is also available as a soft tool.
Tool description (overview)	The Pathways Generator Tool (PG) develops pathways maps through sequencing adaptation measures and allow comparison of alternative pathways into the future, via evaluations of costs, benefits and co-benefits. Together, DAPP and the PG have been used for flood risk in Miami, water supply in San Francisco and coastal flooding in Aveiro, Portugal, among others.
Target user(s)	PG software users: researcher, staff of regional authority, practioners at regional level Workshop: above and also stakeholders
Sector	Any sectors could be covered. The tool is primarily for visualization and analysis, thus users can bring in any challenge and solutions suitable to their needs. Pathways are especially suitable in applications that involve measures with high potential for regret (e.g. large infrastucture projects) as the core principle is to determine the point in time or level of risk at which additional actions should be taken.
Geographical scale	Any. The tool is primarily for visualization and analysis, thus users can bring in challenge and solutions for whatever spatial scale is suitable to their needs.
Geographical area	Any
Urban Adaptation Support Tool (UAST) step(s) of relevance	Ambition, Action

Main graphic	 *Figure 23. Example of Adaptation Pathway Map*
Benefits of using the tool	It allows decision makers to visualize and analyse pathways, considering longer-term implications and path dependency of near-term decisions to avoid investment regret and lock-in as the uncertain future unfolds. It uses 'tipping points' based on bottom-up vulnerability assessments and defined with stakeholders to ensure that system performance is maintained under a variety of futures. It can be used with different levels of analysis from qualitative expert judgement to quantitative modelling results.
Complementarity	The pathways generator complementary tools are Community Flood Resilience Support System and Climate Resilient Cities Toolbox.
Complexity and user requirements	*Overall level of complexity: Low-Medium*
Link to tool webpage	Download the executable onto your computer to start using it.
User stories & hub experiences	Cork is working with this tool for adaptation to floods (in connection with developing Climate Resilient Development Pathways).
[Examples – case studies]	A wide range of examples and case studies exist, from cities to deltas. There is an overview paper with an overview of adaptation pathways case studies: https://doi.org/10.1016/j.gloenvcha.2024.102907
Guidance	
Triple-A Toolkit	The tool can be used in the following Triple-A phases: Ambition phase: • The PG Tool supports the mapping and visualisation of the solution space Action phase: • The PG Tool can help decision-makers to identify, evaluate and prioritize the best pathway alternative
Readiness for use	High TRL. Existing PG version is live and operational. Coming updated version in final stages of development.

Strengths and weaknesses, comparative added value to other similar tools	Quick visualisation of pathways. Easy to use. Not many similar tools are around.
Cost/effort for implementation	Tool use is free. Guidance on the pathways process and additional tool feature development available on a consultancy or case-by-case basis.
Climate hazards covered	Any. The tool is primarily for visualization and analysis, thus users can bring in challenges and solutions for whatever hazard is suitable to their needs.
Inputs needed	Brief manual to help navigate the Pathways Generator (link to the Pathways Generator Flyer.pdf) Difficulty level of inputs needed: Medium difficulty
Methodology	The Pathways Generator enables users to visualize adaptation pathways via visualization styles such as metro maps and bar charts. Users may also analyze and compare pathways options, foreseeing future implications of choices over time including maladaptation and lock-ins, enabling decision-making about shorter-term actions. Inputs include the following: Adaptation measures & sequences Tipping points – how long the measures are sufficient Scenarios – how the issue of concern (e.g. sea level rise) is changing Evaluation criteria – cost, efficacy and other priorities with which the measures may have synergies, co-benefits or conflicts Difficulty level of use of approach: Low difficulty
Outputs	The primary outputs of the pathways generator are different visualizations allowing users to assess and communicate pathways, for example via reports or community events. This tool is designed to be utilized in combination with the Dynamic Adaptive Policy Pathways methodology or other methodology of user choice, resulting in a robust and flexible adaptive plan. Difficulty level of preparing the outputs: Medium difficulty
Contacts	Deltares Sarah Wright, sarah.wright@deltares.nl Gaby Langendijk, Gaby.Langendijk@deltares.nl
Guidance and other documentation	To learn more about adaptation pathways: https://pathways.deltares.nl

3.1.12 The Adaptation Pyramid

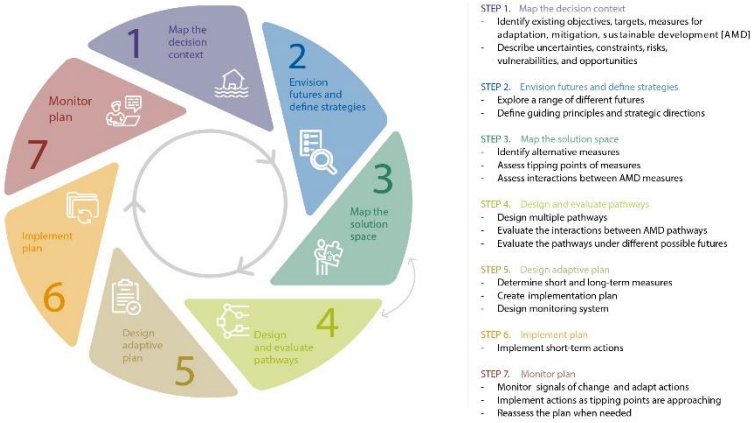
Overview	Information will be directly included on REACHOUT webpage
Name of tool	The Adaptation Pyramid
Tool access model Type of tool	The Adaptation Pyramid is free tool. It offers a workshop method and visual instrument for policymakers to identify a coherent set of goals, targets, and actions, and set the course for adaptation. It offers workshop materials and guidelines are available for free.
Tool description (overview)	The Adaptation Pyramid aims to help cities in setting ambitions on a balanced set of adaptation measures. The pyramid is a metaphor of a climate-proof system which consists of reactive, incremental and transformative types of measures. It is a workshop approach where city representatives together discuss how to set a balanced ambition for the adaptation strategy for the city. The Pyramid supports ambition setting through both thinking about the broader picture (a balanced set of transformative, incremental and reactive adaptation) – and identifying and defining concrete goals, targets and actions, and linking the two in a comprehensive manner. In stakeholder-driven workshops the metaphor of a pyramid proved helpful to start the conservation on the current and desired situation between practitioners working on different sectors and domains. Mapping the current and desired goals and action will require multiple iterations of elaboration, including deliberation and finding support. This will include exploring suitable and effective solutions as well as further understanding the causes underlying the main risks.
Target user(s)	City planners, adaptation experts
Sector	Urban planning, water management
Geographical scale	Regional to urban level
Geographical area	Not applicable
Urban Adaptation Support Tool (UAST) step(s) of relevance	The aim is primarily to support the identification of adaptation options (UAST step 3).
Main graphic	 *Figure 24: The Adaptation Pyramid*
Benefits of using the tool	The participants that have worked with the approach generally find the approach appealing and engaging. It stimulates discussing the long-term (>50 to 100 years), going beyond ad hoc measures and incremental solutions. The Pyramid approach has been adopted by the national Delta Program as a key concept to further refine

	and specify local adaptation goals and targets (Deltaprogramma, 2024).
Complementarity	The climate resilient development pathways and the pyramid can be used in a complementary way.
Complexity and user requirements	*Ranking: low* It can be implemented by cities on their own with some knowledge of climate risks.
Link to tool webpage	https://climateadaptationservices.com/en/projecten/the-adaptation-pyramid/
User stories & hub experiences	The first version of the Adaptation Pyramid concept was developed together with the water authorities of Delfland and Vallei & Veluwe in The Netherlands. The need to transition was being felt by the water authorities. The traditional (incremental) way of managing the water system would no longer hold against a background of climate change and rapid urbanization and development. Three cities have piloted the approach and it is being further implemented across three regions in the Netherlands.
[Examples – case studies]	https://climateadaptationservices.com/en/projecten/the-adaptation-pyramid/
Guidance	
Triple-A Toolkit	Ambition: (risk prioritization, identification of objectives)
Readiness for use	The approach is ready to be used. Workshop materials and guidelines are available. The Pyramid approach has been adopted by the national Delta Program as a key concept to further refine and specify local adaptation goals and targets (Deltaprogramma, 2024).
Strengths and weaknesses, comparative added value to other similar tools	The approach requires active participation from city planners, decision makers and experts. It is very easy to apply the approach, however a weakness is that the results will have to be digitized manually after each workshop. A digital tool will become available soon.
Cost/effort for implementation	Workshop is 0.5 day. Some preparation, some work after. You can download all the materials here (materials developed start 2025).
Climate hazards covered	
Inputs needed	*Low difficulty = few inputs, non-expert can input*
Operation/Methodology	How does the tool work? Which method / approach is used? In three workshops (half day), concrete goals, targets and actions are being identified within the contexts of coping with heat, floods and droughts. This is being done for the three layers of the adaptation pyramid. Municipalities are asked to indicate the current as well as the preferred shape of the adaptation pyramid. The workshops trigger discussions about transformative change. In most cases cities indicate that incremental solutions have dominated over the past years. Only little effort has gone into transformative adaptation. Also reactive adaptation has not really developed. It is a qualitative workshop method that requires no to little preparation nor data inputs.

Outputs	The output is presented in tables that give a structured overview of identified goals, targets and actions for the three layers of the pyramid.
Contacts	Who are the contact persons for questions? hasse@climateadaptationservices.com eva@climateadaptationservices.com
Guidance and other documentation	https://climateadaptationservices.com/en/projecten/the-adaptation-pyramid/

3.1.13 Climate Resilient Development Pathways (CRDP)

Overview	
Name of tool	Climate Resilient Development Pathways (CRDP)
Tool access model Type of tool	CRDP is a systematic approach to integrate adaptation, mitigation and sustainable development over time and under uncertainty. The approach can be used freely, nevertheless, consultancy service would be advisable to ensure adequate and full application of the tool. CRDP can integrate other tool outcomes of the Triple-A Toolkit (and beyond), such as the TAT, SVI-tool, FloodAdapt, and Pluvial Hazard Tool. The CRD pathways are commonly co-created, and workshops or other participatory formats would be beneficial.
Tool description (overview)	Climate Resilient Development Pathways (CRDP) aim to integrate adaptation, mitigation and sustainable development objectives into flexible pathways over time, while considering deep uncertainties regarding climate change, as well as other sources of uncertainty. CRDP support integrated urban planning and implementation of climate action. CRDP closely consider mitigation targets, and can be used for flood and heat impacts, as well as for a wide variety of development issues. The main target groups of the approach are decision makers and/or urban planners, although a wider engagement is recommended for different steps during the co-creation process of pathways. The climate resilient development pathways design process starts by envisioning multiple desirable futures and understanding the decision context and current policy objectives and actions, for adaptation, mitigation and development. Thereafter the synergies and trade-offs are assessed between the different climate actions, as well as tipping points are identified – meaning points in time when new action setting will be required. Consequently, alternative actions are co-developed for the future to stay on desirable pathways. The final outcome is a pathways map, as well as an implementation and monitoring plan.
Target user(s)	National, regional and local authorities that are concerned with strategic planning and have a wish for a more integrated approach covering climate adaptation, mitigation and sustainable development. Furthermore, the CRDP approach embeds a wider set of stakeholders, incl. policy makers, civil society representatives and citizens.
Sector	Non-sector specific.
Geographical scale	The CRDP approach can be applied at different geographical scales.
Geographical area	Not area specific.

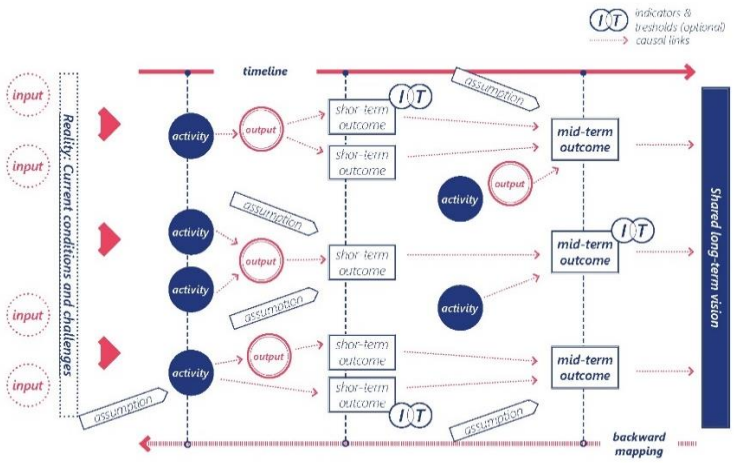
Urban Adaptation Support Tool (UAST) step(s) of relevance	The ambition step, and partly the action step.
Main graphic	 Source: Langendijk et al. (preprint)
Benefits of using the tool	• Integrated climate action planning, using a combined approach between adaptation, mitigation and sustainable development. • Designing pathways over time that can provide insights into the range of options to achieve resilient urban future(s). Assessing synergies and trade-offs between adaptation, mitigation and sustainable development objectives and measures. • Longer-term urban resilience planning under climate change and uncertainty (while also identifying near-term “no regret” actions). • Implementing integrated climate action. • It may support breaking silos within planning processes and municipalities.
Complementarity	• CRCTool may support defining adaptation actions, if CRDPs are developed at the sub-neighborhood scale. • FloodAdapt may support identifying flood risk areas and adaptation tipping points, and the tool can support testing different adaptation options under projected climate change. • SVI-Tool can help to identify areas with vulnerable groups to underpin the development of just pathways. • Other REACHOUT tools can provide data and information to support CRDP development (e.g. Heat Assessment Tool, Pluvial Flood Tool).

Complexity and user requirements	This tool can operate on different levels of complexity: Low: Illustrative, qualitative pathways. Medium-to-high: Model/data-informed, quantitative pathways.
Link to tool webpage	No website, please contact: gaby.langendijk@deltares.nl
User stories & hub experiences	• Cork, urban planning and implementation. • Logrono, urban planning and implementation.
[Examples – case studies]	See above, no concrete outcomes yet.
Guidance	
Triple-A Toolkit	Ambition, possibly action.
Readiness for use	TRL 6/7
Strengths and weaknesses, comparative added value to other similar tools	Added value: • Assess interactions between adaptation, mitigation and sustainable development objectives and measures, and constructing integrated pathways optimizing synergies between the measures. Weaknesses: • The approach is relatively complex due to its integrative nature.
Cost/effort for implementation	Qualitative/illustrative pathways: in the order of several weeks up to 1-2 months in person-days. Quantitative, model-based pathways: in the order of a couple of months in person-days (depending on complexity and models used etc.).
Climate hazards covered	Not hazard specific
Inputs needed	Existing policy plans and documents related to adaptation, mitigation, development, etc. Existing data on risks and vulnerabilities (if any). Information on governance structures and key players/stakeholders.
Methodology	The CRDP approach is based on the established Adaptive Policy Pathways Planning (DAPP) approach. The CRDP approach is going beyond adaptation, by incorporating also mitigation and sustainable development.
Outputs	Pathways map showing a diverse set of pathways integrating adaptation, mitigation and sustainable development. Implementation and monitoring plans.
Contacts	Deltares. Gaby Langendijk, gaby.langendijk@deltares.nl
Guidance and other documentation	Langendijk, Gaby S. and McEvoy, Sadie and McCullagh, Denise and Haasnoot, Marjolijn, A Stepwise Approach to Operationalise Climate Resilient Development Pathways Planning – with an Illustrative Application for Cork City in Ireland. Available at SSRN:

	https://ssrn.com/abstract=4998837 or http://dx.doi.org/10.2139/ssrn.4998837

3.1.14 Theory of Change (ToC): Navigating transformation towards a desired vision

Overview	
Name of tool	Theory of Change (ToC): Navigating transformation towards a desired vision
Tool access model Type of tool	Theory of Change (ToC) is available for free, and it is especially useful to support workshop facilitation and for building shared vision considering the views from different stakeholders. It offers free guidelines and visual instruments (templates)
Tool description (overview)	The aim of a tool is to guide and support on the development of a Theory of Change (ToC) participatory workshop. ToC is essentially a comprehensive description and illustration of how and why a desired change is expected to happen in a particular context. In other words, ToC is a conceptual framework that outlines the causal pathways through which interventions are expected to bring about desired outcomes. The tool provides materials and guidelines for a collaborative work that constructs a ToC based on a shared vision considering the views from different stakeholders It guides participants in understanding current conditions, strategically planning activities, and identifying outputs and outcomes. The tool promotes inclusivity, ownership, and commitment among stakeholders, ensuring a logical and measurable framework that accommodates flexibility and iteration. It ultimately supports the documentation and communication of the developed theory of change.
Target user(s)	This soft tool is designed to assist consultants or practitioners in developing a narrarive of change. It provides guidance on conducting workshops that build a diagram representing the causal link analysis, bringing together key stakeholders essential for driving meaningful change.
Sector	This tool can address any sector of interest, but it is not sector specific
Geographical scale	The scale of application depends on the scope of the transformational adaptation, that is on the scope of the ambition.
Geographical area	This field does not apply
Urban Adaptation Support Tool (UAST) step(s) of relevance	Step 1 Preparing the ground for adaptation

Main graphic	 *Figure 25: Theory of change diagram*
Benefits of using the tool	A theory of change helps to identify solutions to effectively address the causes of problems that hinder progress (e.g. in climate adaptation) and guide decisions on which approach should be taken. Furthermore, creating a shared vision within a ToC fosters alignment and collaboration among stakeholders, enhancing the effectiveness of adaptation planning by ensuring collective understanding and commitment to common goals.
Complementarity	Are there any other REACHOUT tools (or other tools outside of REACHOUT) that this tool works well with? Analysis tools (e.g. climate impact diagrams, thermal assessment tool) may help to understand the problems and challenges that a city faces. Action tools, such as adaptation libraries *e.g.* RESIN AOL, that target to identify activities or adaptation solutions may be used to identify the activities to reach the change. ToC can also serve Adaptation or resilience pathways as an entry point. Pathways can help to prioritize and sequence the activities.
Complexity and user requirements	*Ranking: Medium* ***Medium** = can be implemented by cities on their own with local knowledge and some knowledge of climate risks. However, developing a ToC for complex systems can be challenging, especially when stakeholders have limited experience or knowledge on the context.*
Link to tool webpage	https://reachout-cities.eu/wp-content/uploads/2024/05/P2R_ToC-2.pdf
User stories & hub experiences	Not applied in REACHOUT
[Examples – case studies]	[Link to the story maps of the city hubs]
Guidance	
Triple-A Toolkit	It is closely aligned with ambition setting, which involves defining ambitious and aspirational vision and goals for the future:

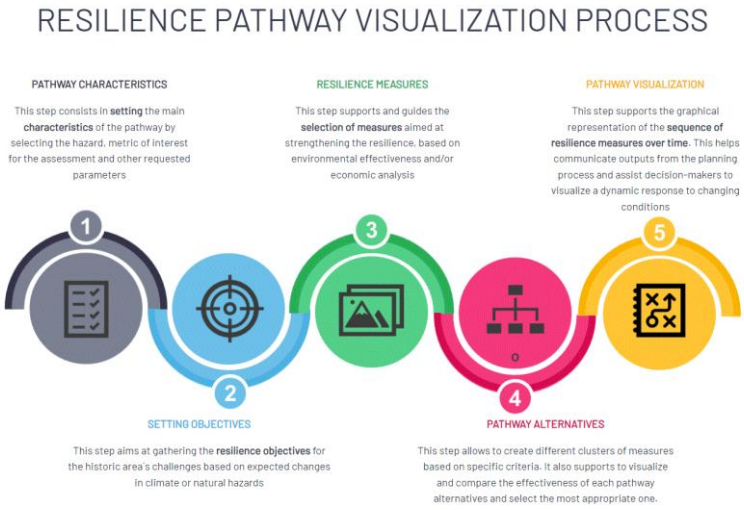
	• Developing a vision for a city often involves creating a clear narrative about the desired future state. The theory of change provides a structured framework to articulate this narrative, breaking down the vision into actionable steps.
Readiness for use	TRL 7
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** 1. Clarity and Focus: a. Helps articulate clear goals and the necessary steps to achieve them. b. Makes assumptions about change explicit, facilitating better communication among stakeholders. 2. Stakeholder Engagement: a. Encourages collaboration by involving diverse stakeholders in mapping causal links and shared outcomes. b. Fosters ownership and commitment to the process and its outcomes. 3. Flexibility: a. Adaptable to various sectors and scales, from community-level projects to large-scale programs. b. Can be revised as conditions or assumptions change. 4. Monitoring and Evaluation (M&E): a. Serves as a foundation for designing robust M&E frameworks by linking activities to outcomes and impacts. b. Can highlight key indicators to track progress and assess effectiveness. 5. Strategic Thinking: a. Encourages systemic analysis of the context, including barriers, enablers, and risks. b. Identifies leverage points to maximize impact. **Weaknesses:** 1. Complexity and Time-Intensity: a. Developing a comprehensive ToC can be resource-intensive and require significant time and expertise. 2. Assumption-Driven: a. Relies heavily on the accuracy of assumptions, which may not always hold true in dynamic or uncertain contexts. b. Potential for confirmation bias if assumptions are not rigorously tested or questioned. 3. Limited Predictive Power: a. While it maps pathways to change, it does not guarantee outcomes due to unforeseen variables or contextual shifts. b. Less suitable for highly complex systems where change is nonlinear and emergent. 4. Participation Challenges:

	a. Engaging diverse stakeholders effectively can be difficult, especially in contexts of power imbalances or conflicting interests. **Comparative Added Value to Similar Methods:** 1. Compared to Logic Models: ToC provides a deeper exploration of causal relationships and the "why" behind the pathway to change, while logic models focus more on linear inputs, outputs, and outcomes. 2. Compared to Scenario Planning: While scenario planning explores multiple possible futures, ToC is grounded in a singular, desired future and outlines the steps to achieve it, making it more action-oriented. 3. Compared to Strategic Planning Tools: ToC explicitly connects activities to long-term outcomes and impacts, emphasizing the systemic and interconnected nature of change, which some strategic planning tools might overlook.
Cost/effort for implementation	The workshop runs over one or two days. However, the material preparation and post-processing of the workshop material may depend on the complexity of the system as well as the stakeholder engagement efforts. This may require between extra 3 working days (In-house/external facilitation, limited data collection, and fewer stakeholders, simple output representation) to weeks (external facilitation, extensive stakeholder engagement, large number of information to be revised, more sophisticated output representation. The effort does not account for key performance indicator identification in case there is a need to design robust M&E frameworks of outputs, outcomes and impacts.
Climate hazards covered	Not hazard specific
Inputs needed	Developing a ToC typically requires the following inputs: 1. Contextual system understanding: • In-depth knowledge of the social, economic, and environmental context in which the initiative or plan operates. 2. Stakeholder engagement: • Involvement and participation of diverse stakeholders to capture various perspectives, sectoral knowledge and ensure inclusivity. 3. Evidence and research on the issue being addressed: • In climate change adaptation this can be vulnerability and risk assessment of the system, knowledge on the impacts of climate change etc. Medium, since there is a need for appropriate stakeholder engagement who have good knowledge on the system and evidence about the issue. *Medium = some data, some expertise*
Operation/Methodology	The method to develop a ToC involves several key tasks:

	Task 1: Identify long-term goal or vision and a reality of the current system Begin by clearly defining a specific, unambiguous long-term vision and current reality related to the socio-techno-ecological system. Analyze the current state thoroughly, considering existing conditions and challenges. This analysis serves as the starting point for establishing causal relationships, connecting the vision to outcomes, outputs, and activities systematically. Task 2: Develop a causal roadmap through outcomes and causal links Create a causal roadmap by identifying preconditions and outcomes that align chronologically toward the long-term goal. Use backward mapping to articulate causal links, ensuring the roadmap reflects a linear progression. This approach helps define realizable outcomes and maintains consistency throughout the pathway. Task 3: Operationalize outcomes through activities and outputs Translate established outcomes into clear activities and resulting outputs that contribute to achieving the expected outcomes. Activities represent actions that drive the intervention (or adaptation measures), while outputs are the tangible results or products. This step helps identify change catalyzers and ensures alignment with the ToC. Task 4: Articulate assumptions Recognize and articulate key assumptions made by stakeholders regarding enabling conditions and contextual details. These assumptions represent trends or changes crucial for operationalizing outcomes. Grounded in evidence and research, assumptions serve as indicators to gauge the ToC's effectiveness and may prompt revisiting or modification if they prove inaccurate. An added value of the ToC lies in its ability to define indicators and thresholds for monitoring progress and adjusting strategies as needed.
Outputs	The outputs of a ToC typically include: 1. Causal roadmap canvas (Figure 1): A visual representation illustrating the logical connections between the long-term vision, outcomes, outputs, activities, and assumptions. This diagram serves as a comprehensive and structured overview of the planned roadmap for achieving the desired change. 2. Shared Narrative (post-processing of ToC diagram): A shared understanding and narrative that articulates how the identified outcomes and activities contribute to the achievement of the long-term goal. This narrative is crucial for effective communication, collaboration among stakeholders and thus implementation of the ToC.

	Medium = some expertise to postprocess and participation in the ToC
Contacts	Who are the contact persons for questions? Saioa Zorita, TECNALIA, saioa.zorita@tecnalia.com Adriana Aguirre Such, TECNALIA, Adriana.aguirre@tecnalia.com Nieves Peña, TECNALIA, nieves.pena@tecnalia.com
Guidance and other documentation	

3.1.15 ARCH RPVT: Resilience Pathway Visualisation Tool

Overview	
Name of tool	ARCH RPVT: Resilience Pathway Visualisation Tool
Tool access model Type of tool	It is a free tool that can be used to facilitate and support the resilience pathway development. It is an easy-to-use web-based tool (technical) supported by a guidance to support and its use to policy makers.
Tool description (overview)	The ARCH Resilience Pathway Visualization Tool (ARCH RPVT) is designed to create and visualize resilience pathways (*). It provides a user-friendly graphical interface through which users interact to select, prioritize and sequence potential resilience measures over time that can be deployed as circumstances evolve. Measures can be selected and prioritized according to various performance metrics addressing mainly floods and heatwaves, but also earthquake and drought/water scarcity. The aim of the RPVT is to support the resilience pathway development to city administrators, heritage managers and/or decision makers in the context of historic, urban or agriculture areas. * A Resilience Pathway is a decision-making support approach, closely related to planning, that addresses both slow-onset climate change and natural disasters management. It is a roadmap - sequences of potential actions that can be implemented progressively as conditions evolve.
Target user(s)	Researchers, consultants
Sector	Agriculture, urban, heritage (agriculture and urban)
Geographical scale	It may be applied at different geographical scales, building, neighbourhood, municipal or agriultural landscape
Geographical area	This field does not apply
Urban Adaptation Support Tool (UAST) step(s) of relevance	Step 3 Identifying adaptation options Step 4 Assessing and selecting adaptation options
Main graphic	 *Figure 26 Steps followed to design a resilience pathway within the ARCH RPVT* Source: http://arch.tecnalia.com/index

Benefits of using the tool	Resilience Pathways, and thus ARCH RPVT, offers distinct advantages over conventional planning tools. Key benefits include: • The ability to accommodate various future scenarios, enhancing adaptability to climate change. • These pathways can rely on evidence ensuring robust planning and they facilitate the consideration of diverse actions and their optimal sequence to address challenges or risks. • Significantly, they minimize uncertainty by linking decision points to observed climate-related events rather than fixed timeframes. This approach provides flexibility and time for strategic planning, alleviating the immediate pressure of decision-making.
Complementarity	ARCH Resilience Assessment Dashboard (ARCH RAD) ARCH Resilience Measure Inventory (ARCH RMI) Climate resilience sustainable pathway Analysis tools
Complexity and user requirements	*Ranking: medium-high* ***Medium** = can be implemented by cities on their own, if some basic knowledge of adaptation pathways* ***High** = Implementation only with support of tool developers/consultants*
Link to tool webpage	http://arch.tecnalia.com/index
User stories & hub experiences	Logroño has used it in opreparation for the 3rd workshop on resilience pathways together with the Adaptation Pathway generator.
[Examples – case studies]	[Link to the story maps of the city hubs]
Guidance	
Triple-A Toolkit	Action: Identification, evaluation, prioritization and sequence of adaptation and disaster risk management measures considering climate change uncertainty for urban and agriculture areas with special focus on heritage.
Readiness for use	TRL 5
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** 1. User-Friendly Interface a. Provides a clear, graphical interface with pre-configured drop-down menus that simplify navigation and decision-making. 2. Customizable Resilience Pathways a. Supports both adaptation pathways (pre-disaster planning) and resilience pathways (pre-, during, and post-disaster planning). 3. Integration of Quantitative and Qualitative Approaches a. Enables the selection of physical, environmental, and economic performance indicators (e.g., benefit-cost ratio). b. Offers flexibility to adopt qualitative measures when quantitative metrics are unavailable or insufficient. 4. Data-Driven Decision-Making

	a. Incorporates a relational database to provide effectiveness and economic performance data for resilience measures. b. Supports evidence-based prioritization and sequencing of measures. **Weaknesses:** 1. Limited Hazard Scope: Currently supports a restricted set of hazards (e.g., flood, heat extremes, earthquakes), which might not cover all risks faced by historic areas. 2. Dependency on Preloaded Data: Performance assessments rely on preloaded data, which may not fully reflect local contexts or new research. 3. Focus on Historic Areas: Tailored to historic urban and agricultural heritage, limiting broader applicability to other sectors. 4. Learning Curve for New Users: Despite a user-friendly design, the tool may require training or guidance for users unfamiliar with domain terms and the approach. **Comparative Added Value of RPVT** 1. Specialized Focus on Heritage Resilience a. Unlike other tools, the RPVT addresses the unique challenges of historic areas, balancing preservation and resilience. b. Offers tailored measures for urban and agricultural heritage, filling a niche in climate adaptation tools. 2. Integration with Economic and Environmental Metrics a. Combines cost-benefit analysis with environmental performance, making it particularly suitable for decision-makers seeking balanced, evidence-based solutions. b. Goes beyond qualitative-only tools by providing quantitative insights where available. 3. Multi-Strategy Pathway Development a. Supports both adaptation and resilience strategies, which is a unique feature compared to tools that focus solely on pre-disaster planning.
Cost/effort for implementation.	It may vary on initial knowledge around adaptation/resilience pathways, but it may range from a week to several weeks.
Climate hazards covered	Extreme heat, Pluvial flooding, other: earthquakes (Quantitative analysis) Extreme heat, flooding, earthquakes, drought and water scarcity,, landslides, soil erosion, biological activity (Qualitative)
Inputs needed	As part of the resilience pathway development, the user needs to understand the systems' context to set objectives or tipping points and vulnerability and risk. This needs to be done prior to the actual resilience pathway development. The ARCH Resilience Pathway Handbook can provides step by step guidance and provides some qualitative resources to understand the system and set the ground for a resilience pathway. On the other hand, The ARCH RPVT provides a list of 261 resilience measures with their environmental or economic

	performance, when available, that can be used for the pathway development. However, the ARCH Resilience Measure Inventory (ARCH RMI) gathers all the measures in an interactive tool that provides a more comprehensive overview of the resilience measures. *Medium = some data, some expertise*
Operation/Methodology	The ARCH RPVT guides users through a multi-step process (Figure 1) for designing pathways addressing climate change adaptation and disaster risk management. In Step 1, users set characteristics such as pathway name, description, and type of inventory (urban or agricultural heritage). Based on this, the ARCH RPVT pre-configures drop-down menus for hazard selection (e.g., flood, heat extremes, earthquake). Users then choose between adaptation or resilience strategies. In Step 2, users describe objectives (or tipping points) for adaptation or resilience in the historic area. Step 3 involves selecting resilience/adaptation measures, with the ARCH RPVT providing a list of measures tailored to the pathway characteristics. Users can filter measures based on environmental or economic performance, selecting those relevant to their pathway. Step 4 involves creating pathway alternatives. Users can manually select measures or use criteria for comparison, visualizing their performance through bar charts. The ARCH RPVT allows users to explore various pathways, benchmarking them against resilience goals. In Step 5, users sequence resilience measures over time and allocates measures to different scenarios, which can be linked to tipping points. The tool offers qualitative and quantitative representations based on environmental effectiveness or economic efficiency (BCR analysis). These visualizations assist in prioritizing measures and understanding what each pathway entails for implementation and it emphasizes that the implementation of the measures has a degree of uncertainty, depending on the evolution of climate change. For further information, please visit the user guide. *Medium = some expertise needed*
Outputs	The ARCH RPVT is conceived for both climate change adaptation and disaster risk management with focus on (1) heritage building & urban settings as well as (2) cultural heritage landscapes with focus on agricultural heritage. It is conceptualised to support and guide practitioners: • to gather evidence-based information about resilience measures identified in the ARCH RMI or RPVT (Figure 27); • to select and compare measures based on environmental effectiveness and/or economic analysis (Figure 27);

- to create and benchmark different alternatives (cluster of measures) based on different performance metrics;
- to build resilience pathways (roadmaps) by sequencing the potential measures over time considering different scenarios or changing circumstances (Figure 28 & Figure 29);
- to communicate and assist decision-makers to visualize a dynamic response to changing conditions (Figure 28 & Figure 29).

These outcomes may be used:

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

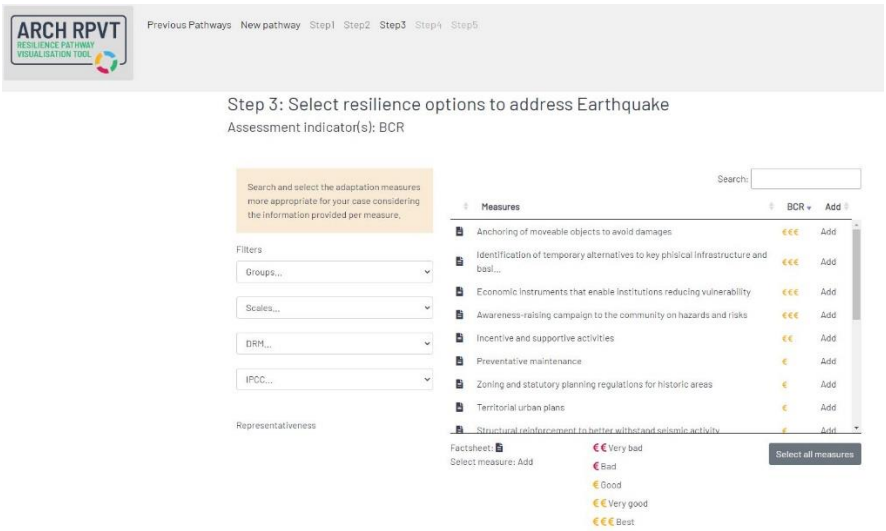


Figure 27 The ARCH RPVT includes semi-quantitative performance information, in this case the Benefit-Cost Ration (BCR) of resilience measures.

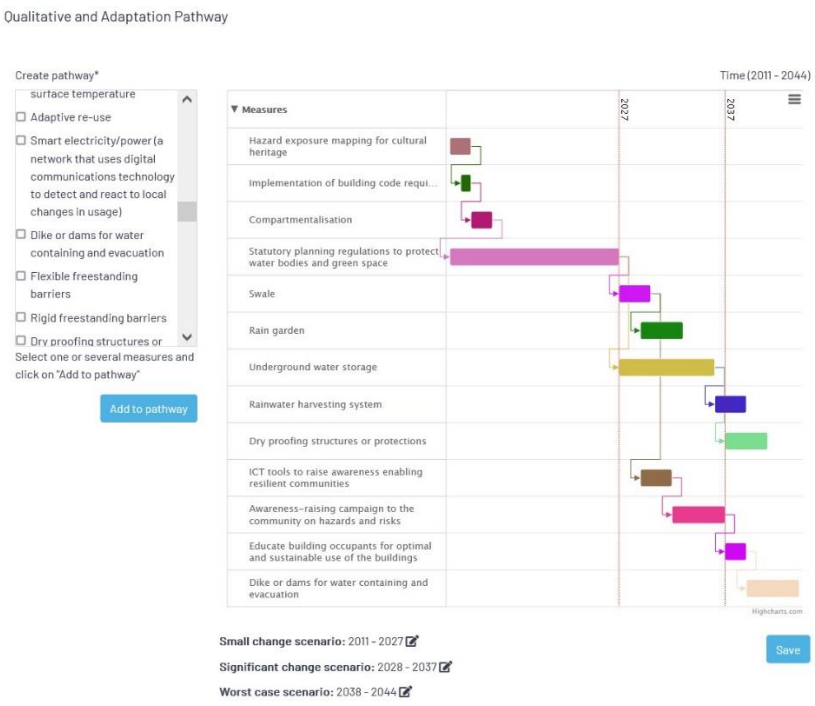


Figure 28 Qualitative adaptation pathway visualization example for pluvial flooding hazard

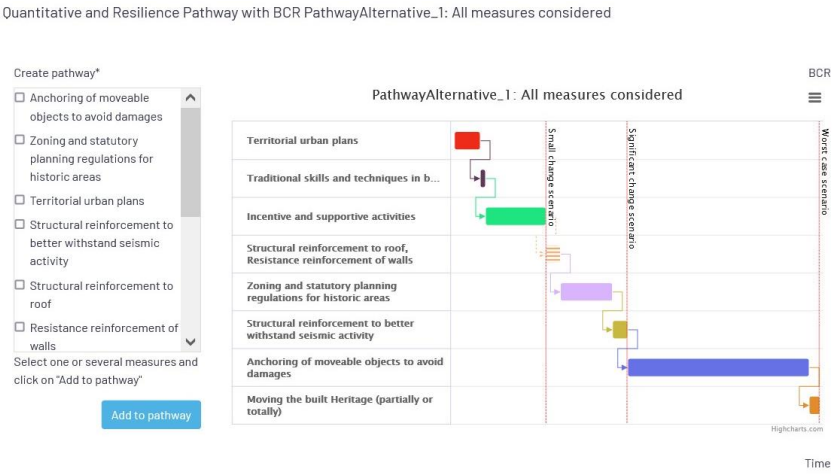


Figure 29 Quantitative resilience pathway (pre-disaster phase) visualization example based on economic performance of measures

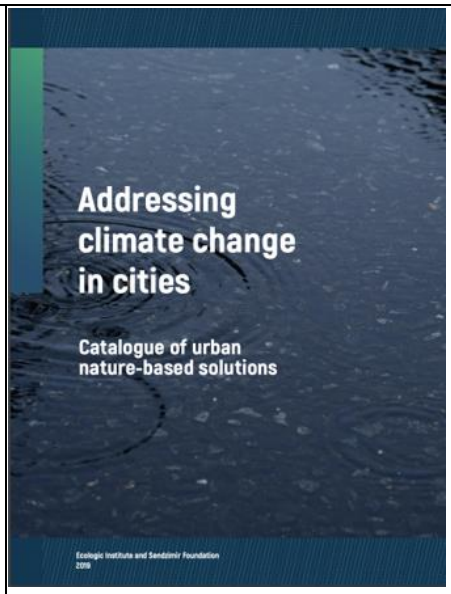
Low = may not need postprocessing, but some adjustments to policy process

Contacts	Saioa Zorita, TECNALIA, saioa.zorita@tecnalia.com Nieves Peña, TECNALIA, nieves.pena@tecnalia.com
Guidance and other documentation	ARCH RPVT user guide: http://arch.tecnalia.com/static/file/D6.4_Annex_RPVT_User%20guide_21_07_2022.pdf The ARCH RPVT can be used in conjunction with the ARCH Resilience Pathway Handbook. (step-by-step methodology):

	https://savingculturalheritage.eu/fileadmin/user_upload/Deliverables/arch-handbook-update-23-v02.pdf

3.1.16 Catalogue of NBS measures

Overview	
Name of tool	Catalogue of NBS measures
Tool access model Type of tool	This is a free tool that can be used to support workshops and consultancy services. It offers a self-explanatory catalogue of NBS measures (soft tool) Customizing and using the solutions from the tool is best done in co-creation with users of the space where solutions are planned to be implemented.
Tool description (overview)	The catalog compiles Nature-Based Solutions (NBS) for cities. Case studies focus on NBS which have been deployed in Germany. However, these exemplify high climate mitigation potential and applicability across a range of urban contexts. Information on cost-effectiveness and NBS' potential to mitigate climate change are presented alongside implementation guidelines. The selected case studies show how NBS can be used in combi-nation with one another in order to create systemic solutions that address multiple urban challenges in parallel – at sites as small as a playground or as large as an entire city.
Target user(s)	Researcher, staff of regional authority, practitioners at the regional level, stakeholder, citizen Mainly: NBS designers, architects, planners, staff of city authority
Sector	biodiversity, buildings, disaster risk reduction, urban, water management
Geographical scale	regional, municipal, and/or building
Geographical area	All
Urban Adaptation Support Tool (UAST) step(s) of relevance	Step 3 Identifying adaptation options Step 4, Assesing and selecting adpatation options Primary is Step 3

Main graphic	
Benefits of using the tool	The benefits of using the NBS catalog include: • Comprehensive Resource: A centralized collection of Nature-Based Solutions tailored for urban environments. • Inspiration and Guidance: Provides practical examples and ideas for cities to implement sustainable and eco-friendly initiatives. • Improved Decision-Making: Supports authorities and planners in selecting the most suitable solutions for specific local challenges. • Enhanced Resilience: Encourages the integration of natural processes to mitigate climate risks and improve urban sustainability. • Knowledge Sharing: Facilitates the exchange of best practices and successful implementations across cities.
Complementarity	The too can be used within the CRC Tool or ARCH Adaptation Pathway Visualization Tool to better understand the solutions available, also with NBS Adaptation Tool and NBS Workshop in designing phase.
Complexity and user requirements	Low - The catalog contains a comprehensive explanation of solutions, along with graphical material, describing how to design and build each solution. No additional preparation. Users should have a basic understanding of urban planning concepts or environmental sustainability. Users must have access to the catalog through an internet-enabled device.
User stories & hub experiences	The catalog (digital version and paper one) was used during the presentation of various NBS solutions, including the systemic implementation of these solutions, during the workshops held in Gdynia.
[Examples – case studies]	The catalogue can be used during workshops, decision-participatory process, designing solutions. This catalog provides practical guidance on implementing urban nature-based solutions, offering clear descriptions, case studies, and visual materials to inspire and support decision-making. It is designed to help urban planners, local

	authorities, and community leaders integrate sustainable and climate-adaptive strategies into their projects.
Guidance	
Triple-A Toolkit	The tool can be used in the following Triple-A phases: Ambition - to design and implement NBS in bult environment
Readiness for use	TRL 8
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** • User-Friendly: The catalog is easy to navigate with clearly categorized solutions. • Practical Guidance: Provides detailed examples, case studies, and visuals for implementation. • Adaptability: Can be tailored to various urban contexts and challenges. **Weaknesses:** • Data Dependence: Requires local data for effective use, which may not always be available. **Added Value:** This tool offers a comprehensive and visual approach to nature-based solutions, making it more accessible and actionable compared to other tools. Its focus on participatory methods and localized adaptation sets it apart from tools that may be more theoretical or generalized.
Cost/effort for implementation	Open source, no cost to use.
Climate hazards covered	Mean air temperature, Extreme heat, Mean precipitation, Extreme precipitation, Aridity Other: flooding, drought and water scarcity, soil erosion
Inputs needed	To effectively use the catalog, users need a basic understanding of urban planning and climate adaptation, as well as knowledge of the specific challenges in their area, such as flooding or biodiversity loss. Local data, including environmental and demographic information, is essential for tailoring solutions to the context. Resources like budget estimates and materials for implementation, as well as technology for viewing and planning projects, are also necessary. Engaging stakeholders, including local authorities and community members, helps ensure solutions align with local needs. Finally, users should have clear project goals and timeframes to identify the most suitable nature-based strategies from the catalog.
Methodology	**Identify the Urban Challenge** • Begin by assessing the specific challenges or risks in the area, such as flooding, heatwaves, or biodiversity loss. • Use local data and community feedback to prioritize issues that require solutions. **Explore the Catalog**

	• Navigate the categorized solutions to find relevant options for addressing the identified challenge. • Review descriptions, case studies, and visual materials to understand the feasibility and impact of each solution. **Assess Local Context** • Evaluate the selected solutions against local conditions, including environmental, social, and economic factors. • Ensure the proposed solutions align with existing urban plans, policies, and stakeholder needs. **Engage Stakeholders** • Share findings and ideas from the catalog with local authorities, experts, and community members through workshops or consultations. • Use participatory approaches to refine and adapt the solutions for the local context. **Develop an Implementation Plan** • Create an action plan based on the selected solutions, including short- and long-term measures. • Identify resources, responsibilities, and timeframes needed to execute the project. **Monitor and Evaluate** • After implementing the solutions, monitor their effectiveness and collect feedback. • Use the insights gained to refine strategies for future projects.
Outputs	The catalog provides tailored nature-based solutions to address specific urban challenges such as heatwaves, flooding, or biodiversity loss. Users will gain practical guidance and inspiration for implementing sustainable strategies in their local context. Outputs include categorized solutions, detailed descriptions, case studies, and visual materials to support project planning and decision-making. It facilitates informed discussions and collaboration among stakeholders, such as local authorities and community members. Additionally, the catalog helps create actionable plans and projects that contribute to climate adaptation, environmental sustainability, and improved urban living conditions.
Contacts	The Sendzimir Foundation https://sendzimir.org.pl/en/ kontakt@sendzimir.org.pl
Guidance and other documentation	https://sendzimir.org.pl/en/publications/catalogue-of-urban-nature-based-solutions/

3.1.17 NBS workshop with the use of the Adaptation Form

Overview	
Name of tool	NBS workshops with the use of the Adaptation Form
Tool access model Type of tool	NBS workshops with the use of the Adaptation Form is a free tool. Consultancy services can be beneficial to have a basic understanding of urban planning and climate adaptation, along with knowledge of NBS solutions. NBS workshops using the Adaptation Form serve as a flexible (soft) tool that facilitates co-creation with space users, ensuring that planned solutions are tailored to their needs and the local context.
Tool description (overview)	This guide has been developed to help organise workshops that will support local governments and social organisations in participatory design and development of action plans related to the implementation of blue-green infrastructure (BGI) solutions. It also aims to increase participants' knowledge of projects that will make cities greener and more resilient to climate change. Among the core aims of these workshops are adapting the curriculum on blue-green infrastructure to local needs, specifying previously defined goals and including an overview of best practices. The guide includes a model of the recommended workshop structure, presentation topics, and, for use in the practical part, the Adaptation Form. The form serves as a tool for analysing spaces for adapting to climate change, intended to help the diagnosis and search for solutions for the selected space. It helps examine the potential of adapting a given space to climate change, determine which parts of the space are most exposed to risks associated with the climate crisis and what short and long-term solutions can be implemented. It allows an assessment of a selected space – e.g. a square, a street, a block or a district, or even a larger built-up area, by the local community or by experts. Observations can be conducted individually or in groups. The Form contains four areas of analysis related to challenges of the climate crisis experienced by built-up areas: heat waves, heavy rain, storms, and loss of biodiversity. The workshop scenario can be used in its entirety, in part or as an inspiration in assessing local contexts. For example - a participatory workshop can be built around the Adaptation Form or it can be used as one of many tools or methods used in the process of co-creating space. The workshops are designed for urban professionals and local decision-makers responsible for public places, maintenance of green areas and sustainable development of the city.
Target user(s)	Researchers, staff of regional authority, practitioners at the regional level, stakeholderw, citizenw Mainly: NBS designers, architects, planners, staff of city authority, facilitators of the workshops
Sector	biodiversity, buildings, disaster risk reduction, energy, transport, urban, water management

Geographical scale	municipal, and/or building
Geographical area	All
Urban Adaptation Support Tool (UAST) step(s) of relevance	Step 1 Prearing the ground... Step 2 Assesing... Step 3 Identifying adaptation options Step 4, Assesing and selecting adpatation options Primary is Step 1
Main graphic	 
Benefits of using the tool	Training outcomes: • Learning about solutions, tools and methods supporting the city in its adaptation to climate change. • Acquiring skills in applying BGI solutions in a selected part of the city. Objectives of the workshops: • Familiarising participants with the basics of climate change adaptation principles. • Building knowledge on the technical aspects of implementing BGI solutions in urban areas. • Presenting legal aspects of implementing BGI projects. • Presenting best practices as sources of new ideas and projects. • Developing multi-level management skills – better coordination of activities conducted by various departments and city entities for the development of BGI. • Creating conditions for learning by doing, through practical work on a selected part of the city. Benefits of using the Adaptation Form:

	• Comprehensive Climate Adaptation Analysis: It provides a structured approach to assess public spaces in terms of their resilience to climate change, helping to identify specific areas at risk and potential adaptation measures. • Holistic Evaluation: The tool covers key challenges of the climate crisis, including heat waves, heavy rain, storms, and biodiversity loss, offering a thorough analysis of how these factors affect the built environment. • Flexible Use: The tool can be applied to various scales of public spaces, such as squares, streets, blocks, districts, or even larger areas, allowing for adaptable assessments across different contexts. • Inclusive and Participatory: The Form enables both experts and local communities to conduct evaluations, fostering greater engagement and involvement of stakeholders in the adaptation process. • Supports Decision-Making: By identifying areas most at risk and suggesting short- and long-term solutions, the tool assists in prioritizing interventions for climate resilience in urban planning. • Versatile for Various Workshops: It can be used in public consultations, expert workshops, or participatory sessions, contributing to the co-creation of space and enhancing the collaborative nature of planning. • Practical and Actionable Insights: With its practical format, the tool guides users in identifying immediate and long-term solutions, making it a valuable resource for both planning and implementing climate adaptation measures.
Complementarity	The tool begins with a city specific analysis of climate trends, based on models and observations. All REACHOUT tools that are able to describe such trends work well with the development of climate impact diagrams. These include for example the Thermal Assessment Tool (Tecnalia), Community Flood Resilience Support System (Deltares) and Pluvial flood hazard and risk assessment (CMCC).
Complexity and user requirements	Low - The NBS workshop can be organised by cities on their own, but for a more thorough approach, it is necessary to bring NBS expertise and facilitator to the workshop. To effectively use this tool, users should have a basic understanding of urban planning and climate adaptation concepts. Knowledge of environmental issues, such as climate risks (e.g., heatwaves, flooding, and biodiversity loss), is also important. Familiarity with participatory approaches and community engagement methods will help in involving stakeholders effectively. Additionally, users should have experience with site analysis techniques, including environmental and social assessments. Having some background in sustainability or climate change adaptation strategies would be beneficial for understanding and applying the tool's recommendations. The workshops using only the Adaptation Form can be organised by cities or NGOs or other institutions on their own, but for a more thorough approach, it is necessary to bring NBS expertise and facilitator to the workshop. Before workshop is good to prepare maps of the area which will be assessed.

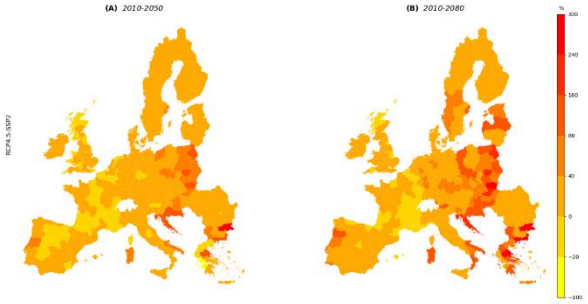
	Users must have access to the printed form (A4 format, possible to print only in black-white format) of Adaptation Form and maps of the area which will be assessed. It's worth having hard pads and something to write on.
User stories & hub experiences	The guide is based on the experience of the Sendzimir Foundation from workshops on planning and designing nature-based solutions which were organised in many cities in Poland. Particularly, in Gdynia it was used with city representatives wishing to plan adaptation actions in the city for its planning strategy. It helped them to: • Identify areas vulnerable to a climate hazard of interest for the city e.g. heatwaves, flooding. • Make a conceptual design of implementing blue and green solutions in the part of the city • Provide the opportunity to use intangible knowledge of city representatives from different departments to complement scientific knowledge. During the workshops in Gdynia, the Adaptation Form was used to map the most vulnerable areas of a selected part of the city. Participants identified key climate risks and proposed both short-term and long-term solutions to enhance the area's resilience.
[Examples – case studies]	Partly, the scenario of workshop and Adaptation Form was also used during educational workshops on nature-based solutions, in classes with architecture students at the Faculty of Architecture, and with residents during the collaborative process of creating a site development concept.
Guidance	
Triple-A Toolkit	The tool can be used in the following Triple-A phases: -Analysis phase to find vulnerable areas in the city -Action phase to plan solutions
Readiness for use	TRL 8
Strengths and weaknesses, comparative added value to other similar tools	**Strengths:** • **Participatory Approach**: Encourages collaboration with local communities and stakeholders, ensuring solutions are tailored to real needs. • **Practical and Visual**: Provides clear guidance, case studies, and visuals, making it easy to understand and implement. • **Holistic Analysis**: Covers a wide range of climate risks, such as heatwaves, flooding, and biodiversity loss, offering comprehensive solutions. **Weaknesses:** • **Data Requirements**: Relies on accurate, localized data for effective implementation, which may not always be available. • **Stakeholder Engagement**: Success depends on active involvement from local communities and experts, which can be challenging to achieve. **Added Value:**

	Compared to other tools, this one is unique in its combination of participatory processes, practical guidance, and focus on specific climate risks. Its adaptability to different urban contexts and its ability to engage a broad range of stakeholders make it more actionable and inclusive. Can be used as an educational tool.
Cost/effort for implementation	The form is available under the Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) license
Climate hazards covered	Mean air temperature, Extreme heat, Cold spells and frost, Mean precipitation, Extreme precipitation, River flooding, Aridity, Snow and land ice, Relative sea level, Coastal flooding,
Inputs needed	The inputs needed to use this tool include: • **Local Data**: Information on the specific climate risks affecting the area, such as heatwaves, flooding, and biodiversity loss - optional. • **Site Analysis**: Data on the environmental, physical, and social conditions of the selected space, including existing infrastructure and vulnerabilities - optional. • **Stakeholder Insights**: Feedback from local communities, experts, or authorities to understand local needs and priorities - optional.. • **Adaptation Form**: The tool itself, which provides a structured framework for conducting the analysis. • **Facilitators/Participants**: A team of trained facilitators and stakeholders (e.g., residents, students, or professionals) to help carry out the process collaboratively.
Methodology	The methodology is described on page 3 and 4 of the Guide. The methodology for using the Adaptation Form involves a systematic and participatory approach. Conduct a thorough site analysis, collecting data on environmental, physical, and social conditions during workshops. Engage stakeholders, including local communities and experts, to gather insights and ensure the solutions reflect local needs and priorities. Use the tool's Adaptation Form to guide the analysis, evaluating the space's vulnerability to climate impacts during the site visit. Finally, collaborate with participants to develop an actionable plan for implementing the identified solutions.
Outputs	• **Climate Risk Assessment**: A detailed evaluation of the selected space's vulnerability to various climate risks, such as heatwaves, flooding, and biodiversity loss. • **Adaptation Measures**: A list of short-term and long-term adaptation strategies tailored to the specific needs of the area. • **Stakeholder Recommendations**: Insights and suggestions gathered from stakeholders, ensuring that solutions address local concerns and priorities. • **Actionable Plan**: A clear and structured plan for implementing the identified adaptation solutions, providing steps for improving the space's resilience. • **Collaborative Solutions**: A set of proposed actions created through participatory processes, fostering community ownership and engagement in climate adaptation efforts.

	Additionally, using the tool helps raise awareness and knowledge about nature-based solutions (NBS) among participants. It contributes to increasing understanding of available climate solutions and their impact on improving urban spaces, which can lead to better city planning and management in the context of climate change. Additionally the outputs of using the Adaptation Form include a detailed assessment of the selected space's vulnerability to climate risks, such as flooding or heatwaves. It generates a list of tailored short- and long-term adaptation measures. The tool also provides insights and recommendations for improving the space's resilience to climate change. Additionally, it facilitates collaborative discussions among stakeholders, ensuring solutions align with local needs. Finally, the tool helps create an actionable plan for implementing the proposed solutions.
Contacts	The Sendzimir Foundation https://sendzimir.org.pl/en/ kontakt@sendzimir.org.pl
Guidance and other documentation	Guide: https://sendzimir.org.pl/en/guide-for-urban-professionals-climate-adaptation-workshop-scenario/ Adaptation Form: https://sendzimir.org.pl/en/participatory-spatial-planning-tool-for-climate-adaptation/

Global and EU level climate service tools for the financial sector

3.1.18 Dynamic Integrated Flood Insurance (DIFI) model

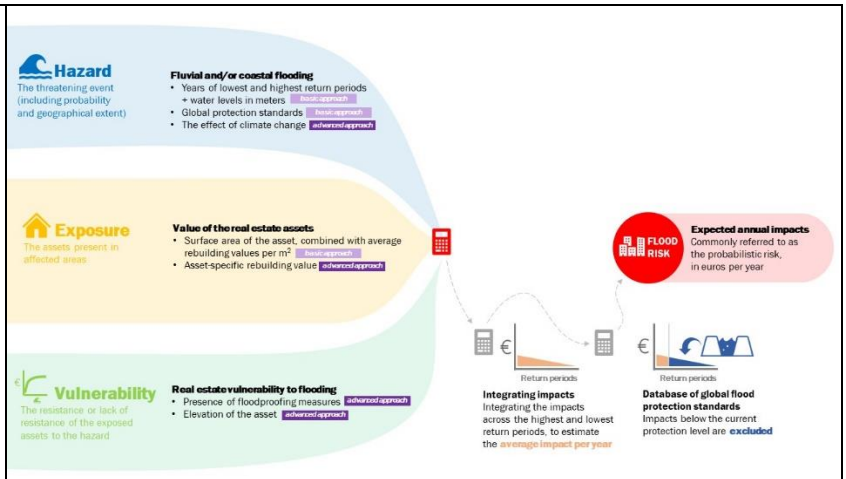
Overview	
Name of tool	Dynamic Integrated Flood Insurance (DIFI) model
Tool access model Type of tool	This is a free tool. It requires some technical expertise to be applied.
Tool description (overview)	The DIFI model offers insight into the development of flood insurance premiums, unaffordability and demand for coverage under different flood insurance systems. The model uses climatic and socioeconomic input data from the flood model GLOFRIS. Results show the development of the insurability of flood damage across Europe and what action could be taken to enhance the sustainability of flood insurance markets to climate change. The target group of this tool consists of policy makers, insurance companies and real estate investors.
Target user(s)	Researcher staff, policymakers, pension funds, banks find use in the tool, as it gives insight into how flood insurance premiums and affordability will develop with climate change
Sector	Buildings, disaster risk reduction, financial sector, coastal areas
Geographical scale	European scale
Geographical area	Countries in the European Union and the United Kingdom
Urban Adaptation Support Tool (UAST) step(s) of relevance	The primary ste of the UAST to which the tool is associated is assessing climate change risks and vulnerabilities, although it is also useful in assessing and selecting adaptation options.
Main graphic	 *Figure 30: Development of unaffordability of insurance between 2010-2050 and 2010-2080.* Source: [1]
Benefits of using the tool	The tool offers insight into the insurability of flood risk in Europe. Moreover, the model can be extended to assess the reasons for a potential flood insurance gap: the level of uninsured flood risk. For example, more certainty of government aid after a flood event will reduce flood insurance demand. Outcomes may help policy makers in the stimulation of flood insurance uptake or the implementation of individual flood damage mitigation measures.

Complementarity	Complementary to the GLOFRIS/REACT tool from VU-IVM
Complexity and user requirements	There is some expertise on climate assessments required. *Overall level of complexity: Medium (customized approach)*
Link to tool webpage	N/A
User stories & hub experiences	The Amsterdam city hub (APG) may benefit from the use of the DIFI tool to distinguish different possibilities for flood insurance based on their real estate investment portfolio and this may guide their investment decisions.
[Examples – case studies]	
Guidance	
Triple-A Toolkit	The tool can be used in the following Triple-A phase: **Analysis phase**: (risk & vulnerability, impact assessments) • identification of socio-economic tipping points for insurance uptake under climate change; • insight in the role of the government in crowding out insurance uptake; • evaluation of insurance market reforms that can improve the capacity of insurance to deal with climate change. **Action phase**: Outcomes may help policy makers: • for stimulation of flood insurance uptake; • to implement flood damage mitigation measures.
Readiness for use	The tool is developed and currently in use by VU-IVM for scientific output. VU-IVM needs to be contacted in order to use the tool as city hub
Strengths and weaknesses, comparative added value to other similar tools	**Strength**: able to simulate behavior with climate change and include the dynamics of adaptation and insurance premiums **Weakness**: it is not a full agent-based model, so decision-making methods are simplified
Cost/effort for implementation	The costs are mainly working hours, as new input data needs to be inserted into the model and the model needs to be tailored to insurance markets in other regions
Climate hazards covered	Coastal and riverine flooding
Inputs needed	• Input from the GLOFRIS/REACT model (also in the REACHOUT tool package) (medium difficulty) • Climate and socio-economic scenarios (RCP-SSP) up to 2080. (low difficulty) • Insurance structures in Europe (low difficulty) *Difficulty level of inputs needed: Low – Medium difficulty*
Methodology	The DIFI model matches three different modules and two types of additional input data. The first module is the flood risk module, which uses input data from GLOFRIS (REACHOUT tool), which gives expected annual damages for high-risk areas. Various climate (RCP) and socio-economic scenarios (SSP) are used for future projections up to 2080. The second module is the insurance sector module, where insurance premiums are calculated for

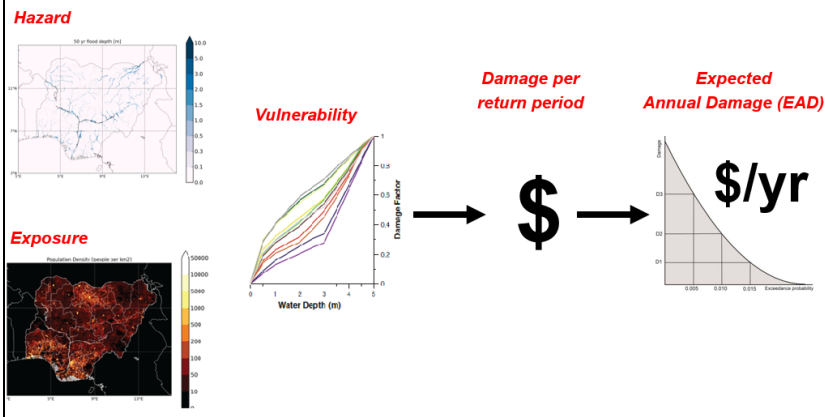
	different insurance systems. The final module is the consumer behavior module, where the affordability of insurance premiums depends on income. [2] *Difficulty level of use of approach: High difficulty*
Outputs	The output of the model consists of calculated flood insurance premiums, projections of the unaffordability of flood insurance premiums. An individual within the model chooses whether they want to insurance and to what extent individual risk reduction measures are incentivized. The individual attempts to maximize their utility within the model, given financial constraints and expected insurance outcomes. This way, the uptake of insurance per region can also be calculated. Finally, the degree of incentivized flood risk reduction on the household level can be calculated. This may help stimulating individual behavior for flood damage reduction. The format of the outputs is in maps per NUTS2 region that show the insurance uptake within these regions. *Difficulty level of preparing the outputs: Medium difficulty*
Contacts	VU-IVM Thijs Endendijk; t.endendijk@vu.nl
Guidance and other documentation	[1] Tesselaar, M., Botzen, W. W., Haer, T., Hudson, P., Tiggeloven, T., & Aerts, J. C. (2020). Regional inequalities in flood insurance affordability and uptake under climate change. *Sustainability*, *12*(20), 8734. [2] Tesselaar, M., Botzen, W. W., Robinson, P. J., Aerts, J. C., Zhou, F., (2022). Charity hazard and the flood insurance protection gap: An EU scale assessment under climate change, Ecological Economics, Volume 193, 2022, 107289, ISSN 0921-8009, https://doi.org/10.1016/j.ecolecon.2021.107289.

3.1.19 Real Estate Asset Climate Testing (REACT) tool

Overview	
Name of tool	Real Estate Asset Climate Testing (REACT) Tool
Tool access model Type of tool	It is a freely available open-access tool. It is a technical tool that require some expertise to read the technical documentation and collect input data needed to run the tool.
Tool description (overview)	Climate change and its associated risks, such as flooding, require assessing potential impacts on real estate assets to avoid depreciation in value. Following the implementation of the EU Taxonomy, EU regulations will mandate reporting on physical climate risks, emphasizing the need for transparency, openness, and standardization in physical climate risk assessments. The Real Estate Asset Climate Testing (REACT) Tool calculates Expected Annual Damage (EAD) (i.e., flood risk) for individual assets and portfolios, using EU-level open data in a simplified way. This tool serves as a screening process for real estate practitioners to assess flood risk in their EU-level portfolios, enabling informed decisions to tackle climate change-induced risks. Serving as an initial step for assessing the physical flood risk of assets, it does not constitute a comprehensive risk analysis. This typically necessitates more tailored flood risk models and input data (e.g., de Moel et al., 2014; Al Assi et al., 2023).
Target user(s)	Real estate investors, municipal policymakers, data analysts at financial institutions, banks, insurance companies
Sector	Buildings, disaster risk reduction, financial, real estate
Geographical scale	The REACT tool uses flexible input data and can the geographical scale can be adjusted based on the input data chosen, depending on the preference of the user. The tool can be national, continental, or even global.
Geographical area	Depends on the input data
Urban Adaptation Support Tool (UAST) step(s) of relevance	Assessing climate change risks and vulnerabilities and assessing and selecting adaptation options

Main graphic	 *Figure 31: How the REACT tool calculates flood risk* Source: https://zenodo.org/doi/10.5281/zenodo.8333491
Benefits of using the tool	The aim of this freely available open-access tool is to enable data analysts supporting real estate owners, managers, and investors to conduct simplified risk assessments for individual assets and portfolios. Utilizing publicly accessible EU-level climate data and maintaining full transparency regarding the underlying methodologies, the goal is to enhance the comparability and reproducibility of the resulting risk assessments. The tool operates on an open approach, allowing asset owners to refine, compare, and integrate results as needed.
Complementarity	The tool is complementary with the FLOPROS database, which is an evolving global database of flood protection standards. Including flood protection standards gives a more accurate representation of flood risk.
Complexity and user requirements	The objective of the tool is to offer simple, open, and transparent insights for real estate managers and policymakers to evaluate various types of flood risks (including coastal, riverine, and pluvial) for their assets. The tool is designed for use by data analysts with some Geographic Information System (GIS) knowledge, although extensive GIS or flood expertise is not necessary. *Overall level of complexity: Low (simplified version)-Medium (advance version)*
Link to tool webpage	A link to the REACT tool can be found here.
User stories & hub experiences	A simplified version named REACT tool has been applied for the Amsterdam city hub (APG) and real estate investor AEW. The tool functions well as an early scan/overview of pluvial and riverine flood risk, although some background GIS knowledge is required.
[Examples – case studies]	• In a recent application of the REACT tool, APG conducted a flood risk assessment for a random sample of European real estate assets. The analysis utilized open-source flood and regional protection data as recommended in the REACT tool technical documentation.

	• The analysis revealed intriguing nuances, highlighting significant shifts in vulnerability across specific regions and notable divergences among future time periods and scenarios. • The findings indicate a positive correlation between higher flood protection standards and a decrease in flood risk. Countries with robust protection standards exhibit greater resilience to flood hazards. • These results emphasize the importance of ongoing monitoring and adaptation to navigate the evolving landscape of climate-related risks. The REACT tool contributes valuable insights to the broader effort of enhancing climate risk assessments within the real estate sector.
Guidance	
Triple-A Toolkit	The tool can be used in the following Triple-A phases: • **Analysis phase** to identify areas with higher flood risk where action is required. • **Action phase** to assess the impact of several adaptation strategies, assisting the decision-making process.
Readiness for use	TRL9 - The tool is ready to use
Strengths and weaknesses, comparative added value to other similar tools	The tool is mainly aimed at empowering real estate investors to no longer rely on a single data provider for the assessment of flood risks in their real estate investment portfolios. The flexible input data and the open structure in Excel aim to build capacity within financial institutions to understand climate risk assessments.
Cost/effort for implementation	Low costs, only needs some time to read the technical documentation and collect input data. To gain understanding, it is also possible to use the tool manually and play around to see how several inputs affect flood risk
Climate hazards covered	Coastal and riverine flood risk
Inputs needed	• Hazard: inundation maps (e.g. Dottori et al., 2022)), preferably on a high resolution. The tool itself gives some recommendations for open-source hazard maps (Difficulty: medium) • Exposure: value at risk of flooding. This can be the rebuilding value of specific building types within the flood prone area. It is possible to input either the surface area of the building or an absolute rebuilding value (Difficulty: low) • Vulnerability: the relationship between inundation depth and flood impacts, already included. Another option in the advance version is to account for the impact of specific adaptation strategies. For example, the damage-reducing potential of building level strategies or the protection standards for large-scale protection. (Difficulty: low)

	Difficulty level of inputs needed: Medium difficulty
Methodology	The REACT tool combines flood hazard, exposure and vulnerability to determine flood risk. First, hazard is the probability of flooding and the impacts that come with certain probabilities. Exposure refers to the value at risk of flooding, typically determined as the value of buildings per m2 in an area or the average value of a specific land use category. Finally, vulnerability means the sensitivity of buildings or land use types to flooding. The tool scans for each grid cell the inundation depth, and calculates the percentage of damage caused by this water level, to match that with the asset's actual value. Summing up all these grid cells will give the expected direct damage per return period. Adding all return periods will give the expected annual damage (EAD) of flooding. This is denoted in € per year.  The first step is to load in all the input data as described before (difficulty: medium). The next step is to run the model to determine flood risk under current adaptation strategies. The inclusion of different potential adaptation strategies will require the adjustment of input data (difficulty: medium). *Difficulty level of use of approach: medium difficulty*
Outputs	The REACT tool estimates expected annual damage (EAD) for flooding (in euro/year) for individual assets making use of a simplified risk calculation. It offers advanced options to incorporate asset-specific values, adaptation measures, and the influence of climate change on risk. Users are encouraged to customize the tool to their unique use cases, facilitated by its simple and open setup in Excel. Being primarily designed for screening purposes, the tool provides a preliminary estimate of flood risk for assets or locations within a portfolio. However, for asset-specific decisions, a more detailed and comprehensive risk analysis using tailored local input would be essential. *Difficulty level of preparing the outputs: Low difficulty*
Contacts	Thijs Endendijk – VU-IVM – t.endendijk@vu.nl
Guidance and other documentation	[1] https://zenodo.org/doi/10.5281/zenodo.8333491

	[2] Ward, P., Jongman, B., Aerts, J. et al. A global framework for future costs and benefits of river-flood protection in urban areas. Nature Clim Change 7, 642–646 (2017). https://doi.org/10.1038/nclimate3350

Consultancy services

The aim of the REACHOUT project has been focused in fostering appropriate engagement and implementing robust co-creation processes to collaboratively develop user-driven climate services and tools, helping bridge the gap between the supply and demand for climate services.

In addition to providing the above range of "soft" and "technical" tools, REACHOUT offers three pivotal services that stand out for their capacity to support the process of developing and implementing user-driven climate services. These services are designed to facilitate collaboration, enhance understanding of climate risks and opportunities, and ensure that the tools are used for climate action are both practical and effective. The following three services are at the heart of the REACHOUT offer:

1. **Triple-A decision support for climate adaptation**
   This premium decision support service offers a flexible and tailored approach to help urban planners and climate adaptation practitioners to start their climate adaptation journey. It integrates three key components: “Analysis,” “Ambition,” and “Action.” through a process of continuous learning, cities assess climate impacts and risks, establish clear objectives and goals, and develop and implement effective adaptation strategies. By fostering stakeholder collaboration and leveraging robust tools and expert guidance, the Triple-A decision support serves as a dynamic and adaptable guide for cities as they navigate the complexities of urban adaptation

2. **Co-creation of tailored climate services**
   Every region and community face unique climate challenges, which is why the Tailored Climate Services offered by REACHOUT are customized to meet specific needs. These personalized services ensure that the tools and solutions developed are not only relevant but also practical for the specific contexts in which they will be implemented. By aligning the climate services to local needs, REACHOUT empowers users to take decisive action and build long-term resilience against the changing climate.

3. **Transformative co-Lab workshops**
   At the intersection of expertise and stakeholder input, the transformative co-Lab workshops bring together professionals, researchers, and community representatives to co-create climate strategies. These workshops facilitate a shared understanding of the challenges presented by climate change and encourage the collaborative design of innovative solutions. They are designed to significantly change participants' perspectives and approaches to face climate challenges. Participants engage in meaningful discussions, share insights, and set ambitious, actionable goals that guide adaptation efforts on the ground.

Together, these consultancy services form the foundation of REACHOUT’s mission to provide impactful, user-centered climate solutions that are built on collaboration, expert insights, and a deep understanding of local contexts. Through these efforts, REACHOUT helps foster a sustainable future where communities are better equipped to navigate the uncertainties of climate change.

3.1.20 Triple-A decision support for climate adaptation

Overview	
Name of the service	Triple-A decision support for climate adaptation
Service description	This service is designed to foster inclusion, empowerment, and active participation of different stakeholders to foster climate resilience in cities. A key feature of the Triple-A service is its flexibility and modularity that can be adapted to local context. It integrates three key components: “Analysis,” “Ambition,” and “Action.” through a process of continuous learning. The service involves guiding participants through structured interactions to enhance multidisciplinary collaboration to better support the common understanding of climate change risk and opportunities allowing cities to address unique challenges and pursue particular goals. This is a premium service as it requires process facilitation and guidance to select the most appropriate tool or combination of tools to make informed decisions.
Benefits of using this service	The benefits of applying this service include a better understanding risks and opportunities associated with climate change, prioritise adaptation measures, and develop effective adaptation strategies. By emphasizing the importance of analysis, ambition, and action, this Triple-A service fosters a continuous learning process that empowers cities to address climate challenges more effectively. It also promotes collaboration among diverse stakeholders, and foster ambitious, climate-resilient futures.
Cost/effort for implementation	This service requires several iteration cycles. So, the cost of implementation can vary according to the city needs and goals City administrations, different policy domains have different planning cycles and deadlines, and different adaptation topics will be part of different policy plans. REACHOUT recommend to have at list two iteration cycles thought which there can be structure the problem, encourage participation, and
Examples	In REACHOUT this process was develop in three learning cycles each taking one year. See a summary about how the Triple-A approach was used in Logrono: https://climate-adapt.eea.europa.eu/en/mission/solutions/mission-stories/building-climate-resilience-triple-a-toolkit-story27

3.1.21 Co-creation of tailored climate service

Overview	
Name of the service	Co-creation of tailored climate services
Service description	There is no solution that fits all. This why this service ensure that the tools and solutions developed are not only relevant but also practical for the specific contexts in which they will be implemented. So, this service supports the collaborative process where tool developers and end-users actively work together to address common challenges, ensuring the solutions meet the specific user needs.
Benefits of using this service	The added value of the co-creation process lies in their adaptability to local needs, ensuring relevance and practicality. Involving stakeholders throughout the development process, the tools are informed by real-world insights and end-user feedback, enhancing usability and effectiveness. This collaborative approach fosters ownership and ensures that tools remain integrated into local processes, promoting sustainability and long-term impact.
Cost/effort for implementation	The effort for implementation can vary depending on factors such as user requirements, ambition, and the specific context. It is a flexible process that can be tailored to the needs of the stakeholders involved, ranging from the integration of the local data appropriately into one of the REACHOUT existing tools, to new technical requirements or visualization needs, depending on the complexity of the issue, the desired outcomes, and available resources. Therefore, the cost and effort for a new development may vary accordingly
Examples	REACHOUT city-hubs have developed tailored climate services. Read the REACHOUT 2nd Policy brief 'Integrating climate services into cities' municipal planning' Next tools are available for tailored co-creation of climate service: • Climate Resilient City Tool (CRCTool) • FloodAdapt Tool • Pluvial Hazard, Risk assessment and Adaptation Tool • REACT Tool • Thermal Assessment Tool • Social Vulnerability Index (SVI) • Adaptation Pathway Generator tool

3.1.22 Transformative co-Lab workshops

Overview	
Name of the service	Transformative co-Lab workshops
Service description	This service provides ad-hoc collaborative workshop facilitation for cities that lack the expertise or time to manage workshops. These workshops are not just about generating ideas or strategies but are designed to significantly change participants' perspectives and approaches to face climate challenges Our experts bring hands-on experience and domain knowledge to facilitate meaningful workshops that drive actionable outcomes for the city.
Benefits of using this service	These workshops promote active participation between researchers, city-planners and/or community representatives while encouraging a collaborative design of innovative solutions as well as fostering a shared understanding of the climate change challenge, ambition or solution.
Cost/effort for implementation	Although the REACHOUT project offers freely available resources to advance on climate resilience, it is recommended to have an experienced facilitator who can structure the problem, manage group dynamics, encourage participation, and balance structure with flexibility to foster creativity and consensus. This facilitation will eliminate the hassle of preparation while achieving impactful outcomes. Therefore, the cost and effort required for workshop development can vary based on the type of resources needed or whether only guiding advice is needed.
Examples	REACHOUT city-hubs have developed several workshops guided by city-hub liaisons. Next tools can be facilitated by REACHOUT partners: • Climate Impact Diagrams • Assessment of Risk management capabilities - • Climate stories • Theory of Change (ToC) • Adaptation Pyramid • Climate Resilient Development Pathways (CRDPs)-

4 Accompanying videos

As an additional output to support the promotion and uptake of the climate services tools in REACHOUT, Ecologic Institute produced two videos accompanying D3.7. The aim of the videos was to provide a visual interpretation of the guidelines for tools (D3.7). The specific objective was to inform urban decision makers and practitioners about how they could apply the tools to respond to policy challenges. Two policy challenges were chosen to illustrate the tools: Urban Heat Island effect and Integrated Flood Risk Management.

The videos were conceptualised and scripted by Ecologic Institute with support from Deltares, CAS, Tecnalia and RCN as well as tool developers. The visual storyboard was developed by members of the research team at Ecologic Institute in collaboration with in-house graphical illustrators. An actor was contracted to perform the narration, which was filmed at the Ecologic Institute studio.

The video on Urban Heat Island effect (3:40 mins) and Integrated Flood Risk Management (4.50 mins) follow the same structure for greater visual coherence. The structure covers 1) an example of a policy challenge that the tools could respond to; 2) the specific technical support that individual tools offered individually and 3) how the tools could be clustered and applied in an integrated way following different stages in the REACHOUT Triple-A approach.

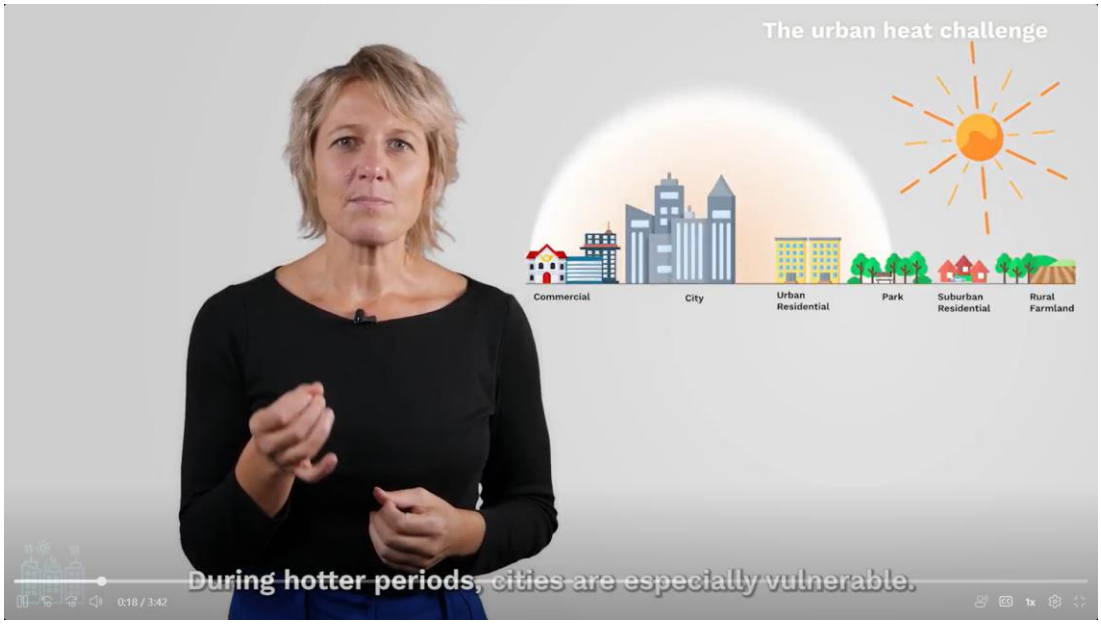


Figure 32. Screenshot of REACHOUT video on Urban Heat Islands

REACHOUT has produced several other videos for different purposes and target audiences such as technical video explainers and social media shorts. The videos for D3.7 were coordinated with other partners in the project to avoid crossovers with the audiovisual material being produced. In the final month of the project, the REACHOUT communications team and WP6 are planning outreach and dissemination of the two videos produced for D3.7 to ensure that they reach a range of relevant audiences. These outreach activities will highlight the videos showcasing of REACHOUT tools and the contribution they make in supporting cities to become more climate resilient.

5 Summary

The REACHOUT project has brought together a diverse suite of different types of tools that have been described in this report. Additionally, a broader and more diverse range of climate adaptation services is needed to support cities and regions effectively. Currently, climate services are overly focused on risk assessments and risk-based approaches, which can lead to incremental solutions that prioritize quick technical fixes over long-term adaptation. True transformative adaptation requires a more holistic, visionary approach that encourages ambition-setting. While risk-based approaches are important for cities, they must be complemented by opportunity-driven strategies that facilitate positive change. Cities are increasingly seeking to integrate climate adaptation with other key priorities such as health, biodiversity, and energy transitions. To meet these goals, climate services must be integrated across policy domains, with data that is visualized, contextualized, and simplified for practical use.

In the Triple A toolkit, REACHOUT combined technical tools (e.g., hazard analysis) with softer methods (e.g., storytelling) and advance service (transformative workshops and co-creation) to demonstrate how climate services can be better embedded in city contexts. A suite of 18 existing and new tools have been compiled into a web-based toolkit (triple-a-toolkit.eu). In addition to analysis tools for vulnerability and risks, it consists of tools that support adaptation action and as a new element also tools that support the setting of ambition for adaptation and urban resilience.

As outlined in the introduction, an aim of the REACHOUT project has been to develop and implement the Triple-A framework and toolkit – a flexible and adaptable approach towards supporting cities in implementing climate services for urban resilience. A key takeaway from the development of this approach is the importance of the flexible and iterative nature of the framework (more lessons learned can be found in D3.10). The interactions between the three components of the framework – Analysis, Ambition, and Action – can be adjusted and adapted as needed for individual contexts.

The final version of the Triple-A Toolkit is a flexible, modular platform for accessing and exchanging tailored climate services. It connects users to tool-based services, city-hub climate stories, best practices, and learning modules to help cities assess risks, prioritize adaptation, and develop effective strategies.

Designed for city planners and decision-makers, the toolkit streamlines the selection of suitable tools and services while connecting users with experts and partners for guidance and support. Acting as a dynamic marketplace, it bridges the gap between the demand for and supply of tailored climate service, fostering collaboration and a thriving community of practice.

REACH OUT
shaping climate resilient cities