D4.1 - Citizen Science Playbook

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			Hawke, Cavaion, Meulenberg, Pilla April 2022. This updated draft to be called D4.1 Citizen Science Playbook includes: adapted engagement strategy, Living Lab approach, learning modules, SCORE outcomes, tools, and online resources.
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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Meaning / Full text
AI	Artificial Intelligence
CCLL	Coastal City Living Lab
DIY	Do It Yourself
DT	Digital Twin
EBA	Ecosystem-Based Adaptation
ES	Engagement Strategy
GIS	Geographic Information System
GSS	Global Systems Science
IPCC	Intergovernmental Panel on Climate Change
IMOTEE	Invite and Inspire, Motivate, Orientate, Timeline methods, Educate and Evaluate
LL	Living Lab
MOOC	Massive Open Online Courses
NBS	Nature-Based Solution
NGO	Non-Governmental Organisation
POP	Pilot Operational Plan
SDG	Sustainable Development Goal
SEP	Standard Ethical Protocol
WP	Work Package

BACKGROUND: ABOUT THE SCORE PROJECT

SCORE is a four-year EU-funded project aiming to increase climate resilience in European coastal cities.

The intensification of extreme weather events, coastal erosion and sea-level rise are major challenges to be urgently addressed by European coastal cities. The science behind these disruptive phenomena is complex, and advancing climate resilience requires progress in data acquisition, forecasting, and understanding of the potential risks and impacts for real-scenario interventions. The Ecosystem-Based Approach (EBA) supported by smart technologies has potential to increase climate resilience of European coastal cities; however, it is not yet adequately understood and coordinated at European level.

SCORE outlines a co-creation strategy, developed via a network of 10 Coastal City Living Labs (CCLLs), to enhance coastal city climate resilience rapidly, equitably and sustainably through EBA measures and sophisticated digital technologies.

The 10 coastal city Living Labs involved in the project are: Sligo and Dublin, Ireland; Barcelona/Vilanova i la Geltrú, Benidorm and Basque Country, Spain; Oeiras, Portugal; Massa, Italy; Piran, Slovenia; Gdansk, Poland; Samsun, Turkey.

SCORE will establish an integrated coastal zone management framework for strengthening EBA and smart coastal city policies, creating European leadership in coastal city climate change adaptation in line with The Paris Agreement. It will provide innovative platforms to empower stakeholders' deployment of EBA measures to increase climate resilience, business opportunities and financial sustainability of coastal cities.

The SCORE interdisciplinary team consists of 28 world-leading organisations from academia, local authorities, small and medium-sized enterprises encompassing a wide range of skills including environmental science and policy, climate modelling, citizen and social science, data management, coastal management and engineering, security and technological aspects of smart sensing research.

EXECUTIVE SUMMARY

The aim of this document is to present the **Engagement Strategy** (ES) for the Coastal City Living Lab (CCLL) and citizen science activities that was developed within WP4 (Task 4.1). These activities were guided by the impetus of the Paris Agreement and by our Standard Ethical Protocol (SEP), defining the privacy, principles and practice for participatory engagement from citizens and other actors. This report also provides **Learning Modules** developed by WP4 to give CCLL participants the opportunity to gain knowledge on climate adaptation and the SCORE project approaches through description of basic knowledge and the key terminology used (provided as a glossary). The report further provides an overview of website links, videos, webinars and courses with brief descriptions of various resources and tools to educate and instruct further how to set-up citizen science activities for climate-focused CCLLs.

The document's whole content is dictated to empower CCLL stakeholders through transfer of basic knowledge on climate change concepts as highlighted by the SCORE project. Therefore the Engagement Strategy and the Learning Modules detail the use of CCLLs, citizen science, do-it-yourself (DIY) sensor technology, and participatory co-creation and co-design activities, as well as the EBA approach. It guides how to engage and motivate stakeholders and citizen scientist participants using tools and resourses in the CCLL context, by activities executed in a series of capacity building workshops, co-creation workshops, and citizen science and DIY sensor familiarisation workshops.

Familiarisation to principal climate change knowledge is needed to direct, engage and motivate participants. Coastal flooding and erosion, extreme weather events and associated changes in precipitation, are the most striking aspects of climate change related to coastal cities, along with ocean rise in volume and temperature. SCORE addressed those issues along with their impacts, and included those challenges within its framework according to each CCLL primary challenges. The engagement task provided this background information, with the learning modules and tools documented in this report addressing these issues in a more comprehensive fashion.

Participatory engagement is a vital aspect of any Living Lab project. SCORE applied an inclusive participatory engagement methodology, that involved the recruitment of a range of voluntary participants or citizen scientists, primarily adults, who come from a variety of classes, gender, ethnic, religious and cultural backgrounds, as well as from industry and business, academia, general public and governance. Participants were recruited through public surveys, social media platforms and standard multi-media platforms such as notice boards and newspapers, as well as through community networks and public meetings, and participated in a series of 'how to' CCLL capacity building and co-creation workshops, as well as citizen science and DIY sensor familiarisation workshops throughout the project.

As this document will be publicly available after the completion of the project, its orderly representation of the project illustrating consistent interaction with project partners and with external CCLL stakeholders, will be a guide on how to engage stakeholders in citizen science initiatives and can build a CCLL with a climate adaptation focus.

LINKS WITH OTHER PROJECT ACTIVITIES

This document presents the Engagement Strategy to which each LL can adhere. The Work Packages that relate most specifically to the research practice of the CCLLs are **WP2 (CCLL Design, Implementation and Evaluation)**, **WP4 (CCLL Co-warning and Co-monitoring)** and **WP7 (Socio-economic assessment of adaptation strategies and policy recommendations)**. Various aspects of this document have been documented as videos, webinars as well as open learning courses developed within **WP9 (Dissemination, Communication, Exploitation)** with input of various partners, that are referenced throughout this document.

This document relates to the broader **Stakeholder and Engagement Strategy** developed by **WP2 Coastal City Living Labs Design, Implementation, and Evaluation** documented by **D2.3 Evaluation outcomes and sustainability plans of CCLLs** and **D2.4 CCLL Knowledge and Lessons Learned**, and early on, the Pilot Operational Plan (POP) developed for each CCLL (**D2.1** and **D2.2**). The POPs from **WP2** include identifying or scoping stakeholders and what influence they may have and integrating them into the CCLL objectives and the CCLL approach. Some aspects of the ES therefore may be documented more extensively in the overall Stakeholder Engagement Strategy from **WP2**.

Throughout WP4 there are links with other project activities. For example, **Task 4.1** 'Engage' links to **WP2** in terms of the environmental variables to be monitored by citizen participants. **Task 4.2** 'Think' involves workshops with local communities to identify sensing needs and is mainly linked to **WP2**, as well as to **WP3** (**Regional and Local Projections, Analyses, Modelling and Uncertainties**) and **WP5** (**Pre/post-EBA Interventions Evidence Collection and Knowledge Marketplace**) and **WP8** (**Development of integrated early warning support and spatial digital twin solution prototypes**). **Task 4.3** 'Make' is about co-creating sensors and apps for smartphones and links to **WP5** along with data protection policies, and data sharing for early warning systems linked to **WP8**. **Task 4.4** 'Discover' is about data collection linked to **WP5**. And **Task 4.5** 'Validate' references sensors for validation through **WP3**, software interfaces with **WP5** and data sharing for early warning systems in **WP8**. All engagement in WP4 is underpinned by the Standard Ethical Protocol (SEP) which contains consent/assent forms in each language of the participants and outlines the Data Protection Policy (**WP11**).

Most important is the WP axis of **WP2** and **WP4** with **WP7**. Here, co-creation workshops to prioritize ecosystem-based adapations (EBA) in each CCLL were carefully set-up and executed through the multicriteria analysis that are documented in two **WP7** deliverables: **D7.2 Methodological framework for the socio-economic assessment of adaptation measures to climate change** and **D7.3 Results from the participatory socioeconomic assessment of EBA interventions**.

In parallel to this document, the reader is strongly advised to pick up on other WP4 deliverables that area available describing the actual citizen activities in the CCLL as executed throughout the duration of SCORE with numerical figures about the attendance: **D4.4-Citizen science activities press-release**; **D4.5 Citizen science activities in CCLLs**; **D4.6 Validation of citizen science data**.

Section 4 of this document describes more detailed interaction between SCORE **WPs**, while references of interactions with other WPs are also mentioned throughout the whole document.

Contents

1 INTRODUCTION

For the whole 4-year duration of the SCORE project, the Work Package 4 (WP4) **CCLL co-warning and co-monitoring** included a Task 4.1 'Engage' aiming to leverage the stakeholders' networks built in each **Coastal City Living Lab** (CCLL) as part of other project activities to identify pro-active participants of the quadruple helix (public sector, private sector, academia and civil society) within the CCLL. The task was set out to design an engagement strategy at the beginning of the project, by identifying high level targets in terms of environmental variables to be monitored by the citizens. This was done as part of general CCLL workshops encompassing activities of different WPs. The citizen science engagement activities were also outlined with the objective of continuing the engagement of the local CCLL community during the project lifetime and provide the local authorities with a framework and tools for continuing the engagement and citizen science activities after the end of the SCORE project. The resulting broader overview for each CCLL was documented in the Pilot Operation Plan (POP) and lists CCLL-specific goals and objectives (and can be used as a lead for activities, which is not binding, but is adjustable according to resources, capacity and developments).

This deliverable, related to Task 4.1, is called the **Citizen Science Playbook** and explains this **Engagement Strategy** through the related scientific and social-pedagogic theoretical background, along while giving examples of how such frameworks and approaches were executed through the SCORE project. It then continues by presenting **Learning Modules** through which terms and concepts of the SCORE project – and climate resilience in general – were explained to CCLL participants. All these knowledge transfer tools enable reaching the SCORE project objectives. Additionally this document lists the various **outcomes and tools** produced through the SCORE project that both are able to enrich participants on their specific climate adaptation background, as well as help to build capacity and help newcomers to be more effective in reaching Living Lab-enabled climate resilience, as with similar results to the SCORE project.

2. SCORE'S CCLL CLIMATE ADAPTATION THROUGH CO-WARNING, CO-MONITORING AND EBA APPROACH

The general aims of the SCORE project are:

•   to design, develop, monitor and validate robust adaptation measures in coastal and low-lying areas to protect them from increasing climate and sea level risks, including coastal flooding and erosion, to enhance their overall long-term resilience.

•   to co-design, co-develop, deploy, test, and demonstrate innovative **Ecosystem-Based Adaptations** (EBAs) approach, **Smart Technologies** and hybrid **Nature Based Solutions** (NBS), while facilitating financial sustainability.

A specific task of WP4, Tasks 4.1, aims at empowering citizens thanks to low-cost sensors for citizen science activities in Coastal City Living Labs, and raising awareness on EBAs, to complement data from institutional sensors (e.g.

meteorological agencies, government and municipalities) with data from low-cost sensors, capturing more detailed spatial and temporal data in localised high-risk areas. This data will be used to support more robust coastal city early-warning systems and is well suited to each CCLL's identified needs.

Figure 1 – Overview of the SCORE Project Concept
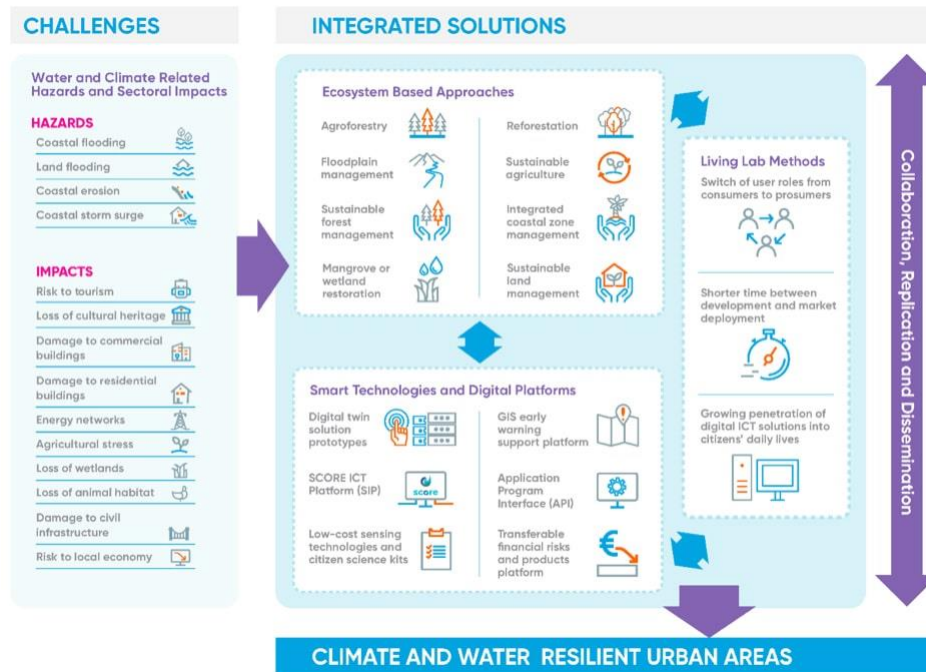
Objectives related to the Task 4.1 described in this deliverable:

- Engage and empower local communities in co-monitoring activities for the assessment of CCLLs' EBAs.
- Build capacity among citizen scientists by providing tools and resources.
- Leverage citizen science and participatory Geographic Information System (GIS) activities to collect data to complement institutional data and models for the SCORE early warning system.
- Develop algorithms and protocols to guarantee the quality of data collected in citizen science activities.
- Complement and integrate by fillings gaps of sparse networks of institutional sensors with a denser network of low-cost citizen science sensors to monitor a set of critical parameters, of interest for each CCLL.

The primary SCORE methods and approaches relevant to Task 4.1 are:

- Ecosystem-Based Approaches (EBAs).
- Smart Technologies and Hybrid Nature Based Solutions (NBSs).
- Life Cycle Approach (using the Iterative Process and Integrative Approach).
- Coastal City Living Labs (CCLL).
- Participatory Engagement, and Capacity Building with Citizen Scientists.

In addition, we will utilize and explain the scaffolding of both the Living Lab and the citizen science operational methods and frameworks.

3. ENGAGEMENT STRATEGY METHODOLOGY

The **Engagement Strategy** (ES) and its individual tasks is predicated on the effective integration between the **Iterative Life Cycle Approach**, CCLLs and **Participatory Engagement**, Smart Technologies and Hybrid Nature Based Solutions. It constitutes the 'How' aspect of the project and engages four different domains of participants, also called the quadruple helix: public sector, academia, private sector, and citizens.

The **Engagement Strategy** proposes details of individual horizontal measures or activities (rather than hierarchical vertical measures) that may contribute to data gathering reflective of adaptations to climate change within the CCLLs. The terms used (exposure, sensitivity, adaptive capacity and vulnerability) have been defined by the **Intergovernmental Panel on Climate Change** (IPCC https://www.ipcc.ch/report/ar6/wg1/) to help countries in climate change adaptation processes. In order to define the baseline, it is necessary to lay the appropriate expert groundwork, which is a considerable challenge for smaller countries, which tend to have limited resources and capacities. The CCLL approach remediates some of those challenges.

SCORE is based on the novel concept of a CCLL that expands Living Labs methodology and style to a specific vision for coastal cities and settlements (https://wayback.archive-it.org/12090/20170107133606/https://ec.europa.eu/digital-single-market/en/news/european-network-living-labs-enoll-explained). Living Labs are user-centred, open-innovation urban ecosystems, where both public and private agents/participants/stakeholders partner to address different issues. CCLLs are based on the Living Labs concept but focus on co-designing and co-developing coastal city interventions and activities through novel EBAs. CCLLs have been implemented to tackle specific identified challenges related to sea level rise, coastal erosion and extreme weather events and their flow on effects in 9 European Coastal Cities and 1 in Turkey. Ideally, their effectiveness should be assessed by different agents through innovative monitoring systems, and cutting-edge numerical modelling, however, the SCORE project has not envisioned to include such monitoring, mainly due to the fact that establishing Living Labs and have them operating and reaching their objectives, runs well beyond the duration of a time-limited EU-funded project. Nevertheless, some assessments on both sustainability of the SCORE CCLLs and the lessons learned can be found in WP2 deliverables: 'D2.3 Evaluation outcomes and sustainability plans of CCLLs' and 'D2.4 CCLL Knowledge and Lessons Learned'.

The four phases (**Empathise and Define**; **Ideate and Co-Design**; **Prototype and Pilot Testing**; **Test and Evaluate**) in the **Life-Cycle Iterative Approach** for SCORE, are underpinned by the **Living Lab Integrative Process** and the citizen science engagement framework **IMOTEE** that are both explained briefly below:

Living Lab Integarative Process and Life Cycle Iterative Approach

Figure 2 – Schematic Depiction of Living Lab Integrative Process Including the Life Cycle Iterative Approach
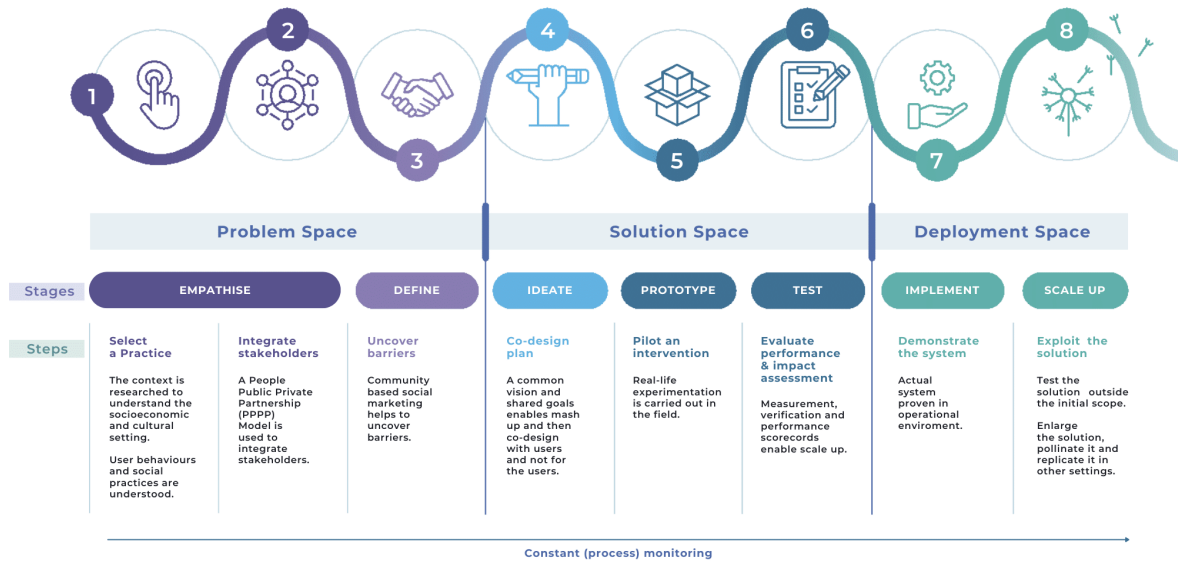
a) **Empathise and Define**: Identification of the actual needs and barriers of all involved stakeholders concerning the climate resilience problems they are facing, and for which the 'solutions' would be developed and tested. This **problem space** phase will also involve research on the effectiveness of existing solutions in place. During the **problem space** phase SCORE organized CCLL capacity building workshops and for each CCLL defined an initial **Pilot Operation Plan (POP)** that documents the CCLLs goals and objectives (and can be used as a lead for activities, which is not binding, but is adjustable according to resources, capacity and developments during the next **solution and deployments space** phases).

b) **Ideate and Co-Design:** Stakeholders are brought together to co-create the solution. They include municipal and governance representatives, citizen scientists and manufacturers. This **solution space** phase continues in an iterative way until all involved stakeholders are happy with the so called **Minimal Viable Product** (MVP). SCORE included CCLL co-creation workshops conducting Multicriteria Analysis (MCA) to prioritize EBAs as well as citizen science and DIY sensor familiarisation workshops.

c) **Prototype and Pilot Testing:** The MVP is placed in real life settings within the relevant CCLLs (**deployment space**). Small local pilots will be conducted to test if the solution is responding to all stakeholder needs ('closed field trial'). Doing this real life experimentation in an iterative way allows the MVP to be rapidly adapted until it meets requirements. SCORE continued the workshops mentioned under the previous **solution space** phase, as well as supported the process with SCORE-generated outcomes and tools more specifically assisting practical knowledge for decision-making and on-going co-creation.

d) **Test and Evaluate**: In the last phase of the **deployment space** the solution is evaluated by a much larger feedback group via validation surveys or 'open field trial'. In an open field trial participants are not necessarily aware of the fact they are 'testing' something out. By following up on the 'natural use' of these larger groups of stakeholders many valuable lessons around adoption of the solution can be taken into account. An iterative process is employed, where the next steps in a project are defined by and based on the validation feedback of involved end-users & stakeholders. The SCORE project did not specifically comprise this phase of Life-Cycle Iterative Approach for the CCLL.

IMOTEE

This specific pedagogical tool and method was applied and will be explained further along in the Engagement Strategy. IMOTEE is an acronym that stands for: a) **Invite and Inspire;** b) **Motivate;** c) **Orientate;** d) **Timeline Methods;** e) **Educate and Evaluate**.

The IMOTEE framework is a more comprehensive version of standard western teaching and learning approaches based on Design, Delivery and Evaluation of curriculum or projects, adapted from the Constructive Alignment method (Biggs, J. 2014. Constructive Alignment in University Teaching. In *HERDSA Review of Higher Education,* 1, 5-22, https://www.tru.ca/__shared/assets/Constructive_Alignment36087.pdf; Hawke, S. and Spannring R. 2022. Editorial. Critical Inter-Disciplinary and Inter-Species Approaches to Water Sustainability and Climate Change Issues. In *Visons for Sustainability,* 7115, 3-10, http://dx.doi.org/10.13135/2384-8677/7115). In this method, intended project outcomes are 'constructively aligned' with project methodologies, and mutually activated between learner and teacher. While IMOTEE is a linear framework (i.e. from beginning to end), it has a circularity component through the potential replication of the project in other settings, and through the empowerment of the participants. As one community (or individual) succeeds in its project it can then act in a mentorship/ambassadorship role to other research and citizen science communities. The most important part of the framework after scoping the community possibilities, is genuine and inclusive invitation into the project for participants that meet the criteria. The IMOTEE framework is described below for the purposes of the SCORE Project.

Figure 3 – IMOTEE

IMOTEE
INVITE & INSPIRE
MOTIVATE
ORIENTATE
TIMELINE METHODS
EDUCATE & EVALUATE

- o **Invite**/recruit citizen science into the project/learning, via multi-media platforms, surveys, and community and public meetings, and **inspire** participation.

- o **Motivation**, garnered through surveys of potential participants/co-learners and mutual motivation.

- o **Orientate:** Explain how the project works to and with different stakeholders of the CCLLs and its alignment with the SCORE intended outcomes and the project ethics.

- o **Timeline Methods**: Plan and execute workshops and methods of ongoing contact and plurilingual engagement that will enhance project success across the timeline of the project.

- o **Engage and activate** CCLLs and their stakeholders to Do-it-Yourself sensor co-creation tasks and associated activities.

- o **Evaluate, validate and congratulate**: Use qualitative and quantitative data to evaluate and thank the participants and ancillary stakeholders for their shared vision and interest in the project and its outcomes.

4. DESCRIPTION OF ENGAGEMENT STRATEGY EMBEDDED IN SCORE ACTIVITIES

Our focus in this section is Task 4.1 which explains the 'Engage' component that is deployed on to the other Tasks in WP4 **CCLL co-warning and co-monitoring** and in the wider SCORE project, especially WP2 **Coastal City Living Labs Design, Implementation, and Evaluation** and WP7 **Socio-economic assessment of adaptation strategies and policy recommendations** (see also the overview of SCORE Work Packages in Figure 4). The **Engagement Strategy** may evolve according to unexpected stakeholder/CCLL needs and unforeseen climatic changes (hence an adaptable **POP for the CCLLs under WP2**). The deliverable of Task 4.1 'Engage' includes: the **Engagement Strategy** in the form of the Citizen Science Playbook that is based on the IMOTEE framework, as well as consecutive **Learning Modules** that explain climate adaptation, the co-development and co-monitoring of sensor development among participants in the CCLLs, the EBA approach and implementation, as well as other SCORE WP activities. The whole content of the deliverable is dictated to empower CCLL stakeholders through transfer of basic knowledge on climate concepts. Hence, to aid in gaining basic climate literacy, it present brief consecutive **Learning Modules**, and lists project outcomes, tools and useful resources.

Figure 4 – SCORE Work Packages and Integration

Thus, the content of this deliverable (D4.1 Citizen Science Playbook) are predicated by the five Tasks in the overall WP4 as well as the SCORE engagement strategy (**Life-Cycle Iterative Approach**; **Living Lab Integrative Process**; **IMOTEE** used throughout WP2, WP4, WP7). The five WP4 tasks have temporal, social and spatial components, and act in conjunction with citizen science learning and teaching practices. Those 5 tasks are:

Task 4.1 Engage

- o Engagement strategy identifying high level targets in terms of environmental variables to be monitored by the citizens as well to built capacity for each CCLL and defining an initial POP for each CCLL > intersects with **WP2**

Task 4.2. Think

- o Workshops with local communities to identify climate adaptation options; sensing needs; prioritize EBAs > intersects with **WP2, WP3, WP5, WP7**

Task 4.3. Make

- o Software interface and smart technology > intersect with **WP5**
- o Data sharing for early warning system > intersects with **WP8**

Task 4.4. Discover

- o Data collection with DIY sensors and smart technology > intersect with **WP5**

Task 4.5. Validate

- o Reference sensors for validation > intersects with **WP3**
- o Software interface > intersects with **WP5**
- o Data sharing for early warning system > intersects with **WP8**

While the relation of WP4 Task 4.1 Engage with the technical SCORE WPs (WP3, WP5, WP8) is not specifically described in this report, an indirect relation is available to read as a research paper entitled '**A New Approach towards a User-Driven Coastal Climate Service to Enhance Climate Resilience in European Cities**' available here https://doi.org/10.3390/su16010335

The primary focus of WP4 is the co-development and co-monitoring of sensor development among participants in the CCLLs, outlined as follows and in connection with other Work Packages as indicated:

Task 4.1. 'Engage', leveraged the stakeholders' networks co-built in each CCLL as part of the WP2 activities. An overall **engagement strategy** was designed at the beginning of the project by WP2 in the form of an adaptable **POP for each of the CCLLs**, and identified high level targets in terms of environmental variables to be monitored by the citizens. WP2 also delivered detailed results from CCLLs questionaires regarding the particularities of each CCLL hazards, impacts and possible solutions through the SCORE project, that assisted WP4 in its mission. The first in situ workshops for CCLLs occured in early 2022: half a year to a year after iniitiation of the SCORE project, with annual follow ups (workshops both on-line and in person). The **citizen scientist engagement activities** were outlined with the objective of continuing the engagement of the local community during the project lifetime (according to the POP) and provided the local authorities with a framework and tools for continuing the engagement and citizen science activities after the SCORE project.

All stakeholders including: municipal bodies and governance, academia, relevant businesses, and citizens were invited to be involved in each task area. Genuine invitation to engage is a fundamental aspect of CCLLs and the activities of this Work Package. CCLLs recognized that participants themselves have concerns in establishing CCLLs that are predicated by experiencing lack of mutual constitution of interest and engagement. Along with invitational gestures, the SCORE project general activities, continued to orientate and motivate stakeholders across the project timeline that eventuated in evaluation and validation of end-users and their devices in Task 4.5: **D4.5 Citizen science activities in CCLLs**; **D4.6 Validation of citizen science data** and as well as of WP2 **D2.3 Evaluation outcomes and sustainability plans of CCLLs**; **D2.4 CCLL Knowledge and Lessons Learned**.

5. KEY CONSIDERATIONS AND PURPOSE FOR ENGAGEMENT

Technology advancement is a significant part of SCORE. Accordingly, SCORE intended to generate a robust, EU-wide evidence base and develop a European reference framework on EBAs and increase climate resilience solutions for regional and local coastal cities authorities, communities, enterprises and other stakeholders about the benefits, economic viability and market profitability of SCORE solutions and related ecosystem services. The following were the key SCORE innovation elements that underpinned the projects purpose of engaging citizen scientists inclusively as participants in consideration of climate challenges:

1. New paradigms for interventions;
2. Active role of citizens in designing and operating technical solutions;
3. High flexibility of adopted solution, easy replicability to other CCLLs;
4. Prompt reaction to risks through early warning support system;
5. Better planning of actions through Digital Twin (DT);
6. Improved planning of activities through EBAs;
7. New financial risk analysis and solution tools.

To enact these initiatives and propositions SCORE has conducted a series of stakeholder workshops in collaboration with the CCLL design team. Some workshops have been executed on-line, and in the capacity of learning exchanges. For Task **4.1 'Engage'** the CCLL moderators leveraged the stakeholders' networks built in each CCLL. Consecutive meetings and workshops were scaffolded into each Task in Work Package 4, which means they followed a Life cycle. For example:

Task 4.2 'Think', in which CCLL leaders worked with local communities to identify sensing needs and co-design of monitoring targets based on sensing technology catalogues and grey literature;

Task 4.3 'Make', in which CCLL leaders taught community participants how to make low grade sensors and develop/use geo-referenced smart technology;

**Task 4.4 'Discover'**, in which CCLLs co-monitored the DIY sensors and EBAs;

Task 4.5 'Validation' of the findings.

To illustrate the timeline of the general WP4 tasks and its integration with WP2 and WP7 a general description of the consecutive workshops during the **Living Lab Integrative Process** is given and Figure 5 illustrating how SCORE executed the **Life Cycle Iterative Approach**.

Figure 5 – SCORE Timeline and Integration of the Living Lab and Citizen Science Activities
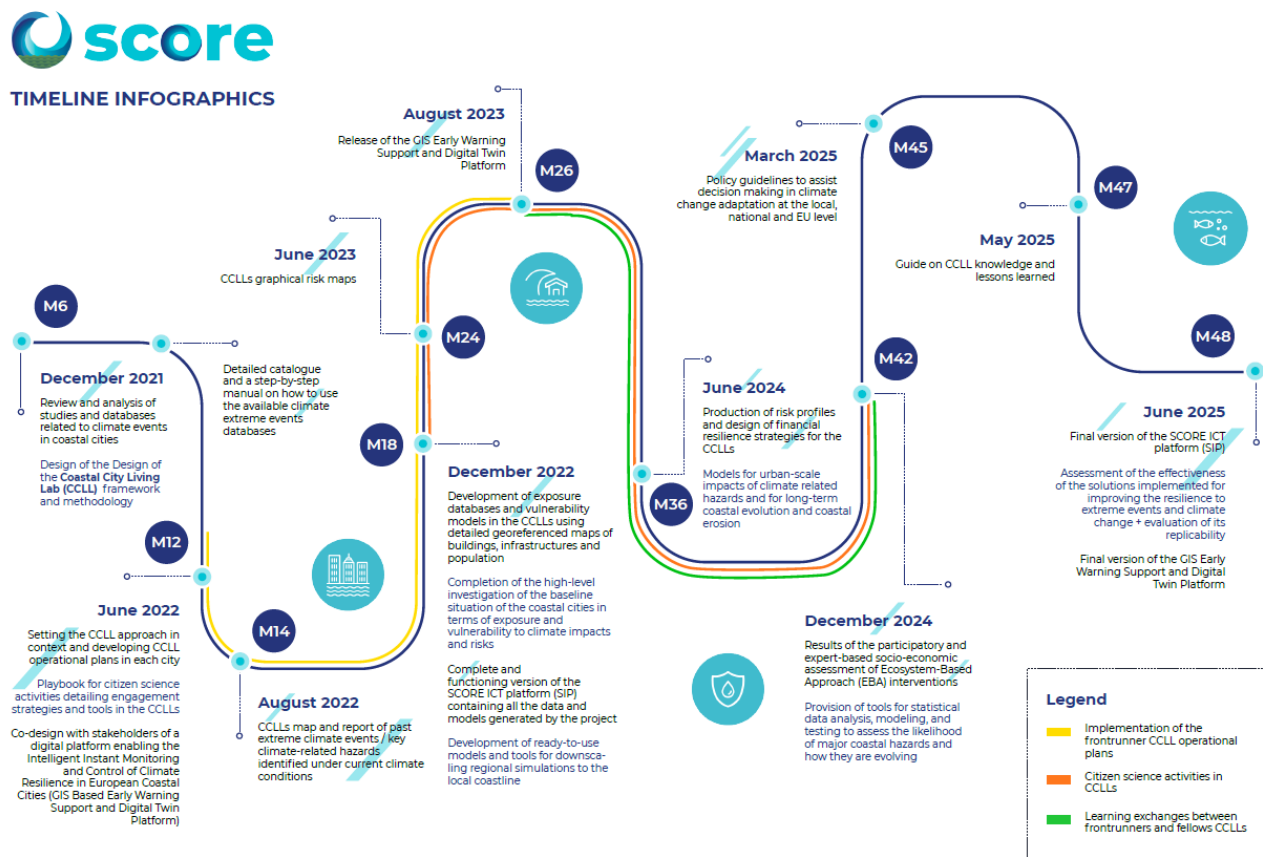
Month 12-24, June 2022-June 2023: Physical Workshop 1 (problem space) was about CCLL capacity building, familiarisation with terms and discovering how things work (the project with all its WPs). Once the participants were selected, co-creation toolkits were designed for CCLL leaders to conduct, with specific focus to each CCLL's local primary climate change challenge, for example coastal flooding. This capacity building workshop allowed to focus the activities to be done as part of identifying the challenges and monitoring requirements for the citizen science activities.

Month 24-30, June 2023-December 2023: Physical Follow-up Workshop 2 (solution space) was about consolidation and experimenting with the Real-Life setting within the CCLL component. It included challenges and successes, as well as deviations from original ideas pertinent to sensors and climate adaptation goals of the CCLL. This co-creation workshop allowed to consolidate the learning from the localized DIY workshops and citizen science co-monitoring activities.

Month 30-40, December 2023-October 2024: Physical Follow-up Workshop 3. This workshop was about validation and evaluation by end-users in the **deployment space** of the project. In line with the Iterative Process it built on the apriori information and results to further test and fine-tune DIY prototype sensors. This co-creation workshop allowed to consolidate the learning related to the usability and performances of the developed DIY sensors.

This brings us to the discussion on why all of this matters, for whom and in what ways.

6. THE WHY, WHO, WHAT, WHERE AND WHEN OF THE ENGAGEMENT STRATEGY

The biggest challenge for proposing a strategic stakeholder engagement plan for SCORE implementation was the wide scope of this task. The target audience is citizen scientists and ancillary agents such as municipalities and NGOs, and in some cases upper secondary school students. They were recruited and invited by means of broad social media advertising, public meetings, questionnaires and surveys and through municipal and print media advertising along with any other stakeholder methods that are in line with the SCORE projects Standard Ethical Protocol (SEP) using a consent form (SCORE's information sheet and consent/assent form in various languages can be found here: https://score-eu-project.eu/wp-content/uploads/2022/01/SCORE-Consent-form.pdf.

This section is organised around the key signifiers of: *Why, Who, What, Where and When* and by discussing each of them, we are providing the stepping stones towards efficient stakeholder engagement planning. Fundamentally, it is the *Right Time, Right Plan and the Right People* to become active in climate change solutions in Coastal Cities.

Why

Because the Anthropogenic effects on climatic patterns and natural environments find the planet teetering on the brink of irreversible catastrophe (See for example: Steffen, Crutzen and McNeil 2007; Hawke and Palsson 2017; Hawke and Spannring 2022), unsustainable possibilities are currently greater than mitigation strategies. Partnering between engineering, hard science and citizen science has been under-developed globally thus far, and represents an innovative practice for mapping, understanding and ensuring water futures in European coastal cities.

The SCORE project was motivated by the critical need to act intelligently and consistently on climate change through a diversity of actors and stakeholders and ecosystem based adaptations (EBA) approach to better ensure the climate resilience of coastal cities. Citizen engagement and empowerment was an intentional aspect of this project. Local and global governance and strategies (such as The Marine Strategy Directive https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm) the Sustainable Development Goals (SDGs https://sdgs.un.org/goals), particularly Goal 13 "Take urgent action to combat climate change and its impacts", and the Paris Agreement, underscore the methods of research and engagement between citizens and researchers.

Who

The 10 CCLLs Sligo and Dublin, Ireland; Barcelona/Vilanova i la Geltrú, Benidorm and Basque Country, Spain; Oeiras, Portugal; Massa, Italy; Piran, Slovenia; Gdansk, Poland; Samsun, Turkey were acting as either 'frontrunners' or 'followers' in activities associated with each WP. Participants were recruited by a range of media both traditional and social as well as public meetings, surveys and questionnaires.

It should not be assumed that potential and ongoing stakeholders have a similar and comprehensive understanding of what the project's Aims and Objectives are, or where and how these aspects will be implemented, despite the best efforts to explain. The emphasis should be on both inclusivity of participants, and building capacity with those participants, as well as performing rigorous research and practices. Hence, stakeholder engagement begins with Step 1: explaining the aims and objectives of the project, but more specifically how the CCLLs work. Defining the CCLL shared vision for the engagement is pivotal. Setting a vision for participants helps to:

- Define and understand key terms, concepts and aims;
- Identify stakeholders (See diagram below);
- Clarify parameters of engagement and responsibilities;
- Identify stakeholders' wants and visions;
- Clarify the projects aims, objectives and outcomes;
- Sustain ongoing support and information for all stakeholders;
- Direct participants with respect, flexibility and integrity;
- Stimulate pro-active inclusive collaboration.

The following Table shows who the Stakeholders/Actors are and how Stakeholder Integration is maintained.

Figure 6 – Stakeholder Integration in Coastal City Living Labs

STAKEHOLDER INTEGRATION	WHO ARE THE ACTORS IN A COASTAL CITY LIVING LAB?
UTILIZERS	'Customers' of the CCLL that use the CCLL to co-create innovation
ENABLERS	Resource (financial) providers/facilitators to sustain the CCLL platform
PROVIDERS	Infrastructure or service providers to be used in CCLL project
USERS	Participants of CCLL activities (panel/user community)
RESEARCHERS	Knowledge generators of the CCLL user and stakeholder to facilitate co-creation)

Adapted from European Network of Living Labs (Leminen et al, 2012; Leminen, 2013; Schuurman 2015; Schuurman et al., 2016)

What and How

What SCORE has been doing is creating a novel CCLL approach to enact climate change resilience in coastal areas of Europe. SCORE established 10 CCLLs to co-create, co-design, test and evaluate mitigation strategies pertinent to the climate change issues noted in the POPs, and specific to each individual CCLL. Most specifically SCORE engaged citizens to co-create low-end weather sensors to provide data that complemented the high-end weather sensors (Digital Twin). SCORE was also interested in implementation of EBA measures based on identified needs of individual CCLLs. For example dune restoration on beaches that have suffered due to extreme weather events and storms, or re-examining fresh water access in the event of extreme events for both citizens and visitors and so on.

For each CCLL a POP was developed that followed an engagement plan built upon the overall Engagement Strategy for any (coastal city) Living Lab project with multi-annual duration similar to the 4-year SCORE project. The implementation addressing the general engagement with Who, What and How was drafted as in Figure 7.

Figure 7 – Proposed Implementation Plan for Project Engagement Strategy addressing Who, What and How
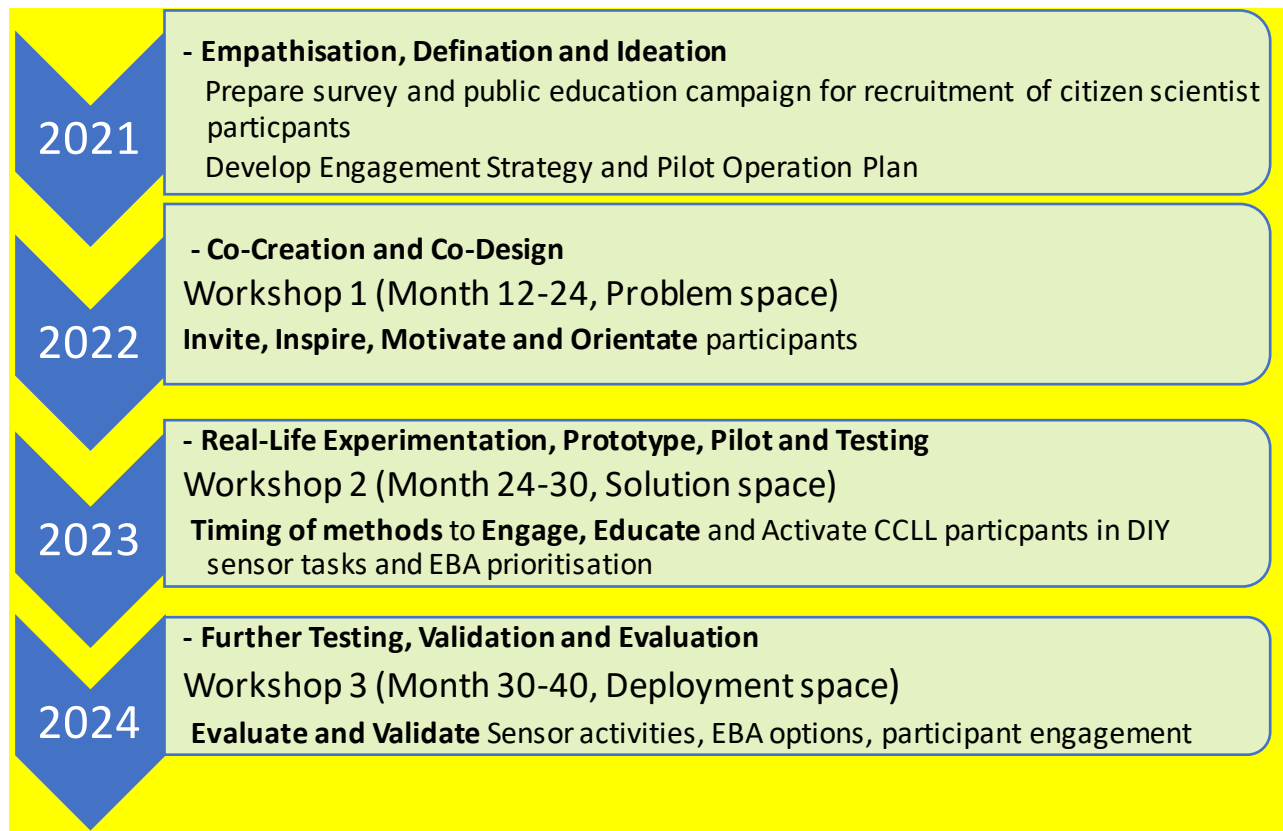
Surveys **For CCLL leaders** **For CCLL participants at the problem, solutions and deployment spaces of the project**	- Gather information about specific issues relative to each CCLL - Gather basic information about potential 'citizen scientists' participant suitability to CCLL aims and objective, and availability - Identify CCLL champions in both Frontrunner and Follower CCLLs for bridging within the CCLL community and between community groups and ancillary agents - Gather baseline data and develop from survey input - Record and store data as per a Data Management Plan - Once specific issues are identified, provide ongoing surveys to add to portfolio of knowledge and human resources
Workshops Years 1-2: workshops – 1 for each CCLL and initial stakeholders Years 2-3: physical workshops/meetings with participants/stakeholders and 2 more CCLL expert workshops Year 3-4 : learning exchanges with other CCLLs	- Present project information to CCLL participants, including ancillary stakeholders, such as municipality, academia, businesses and citizens scientists where relevant - Respect participant engagement and allow time and space for stakeholders to share equitably and ask questions - Use participatory exercises to facilitate group discussions, brainstorm issues, analyse information, and co-develop best approach for individual CCLL based on the Project SCORE outcomes and tools, data from questionaires and activities and on the CCLL overall framework and methodology - Inter CCLL learning exchanges remotely or in person (COVID-19 pending)
Correspondence phone/email, ongoing as required.	- Provide CCLL leader contact information to all participants - Invite stakeholders to meetings/events/request for input in surveys
Public Meetings 1 initial (and more as required)	- Present project information to a large audience of potential stakeholders and citizen science participants as necessary - Invite the group of stakeholders to provide their views, local knowledge and opinions relevant to the project after the presentation of the project to the meeting - Build relationships with neighbouring communities - Distribute non-technical user-friendly project information - Facilitate meetings using SCORE PPT presentations, posters, technical models, videos, pamphlets and project information documents
One-to-one interviews	- Enable stakeholders to speak freely and confidentially about controversial and sensitive issues, such as unexpected findings or conflicts of interest. This may engage the Ethics Committee as required.

Each CCLL will benefit from a series of workshops or information days as a primary method of engagement that will incorporate both IMOTEE as a methodology and the Life Cycle Approach (see Figure 8):

Figure 8 – IMOTEE and Life Cycle Combined

2021
- **Empathisation, Defination and Ideation**
  Prepare survey and public education campaign for recruitment of citizen scientist particpants
  Develop Engagement Strategy and Pilot Operation Plan

2022
- **Co-Creation and Co-Design**
  Workshop 1 (Month 12-24, Problem space)
  Invite, Inspire, Motivate and Orientate participants

2023
- **Real-Life Experimentation, Prototype, Pilot and Testing**
  Workshop 2 (Month 24-30, Solution space)
  Timing of methods to **Engage, Educate** and Activate CCLL particpants in DIY sensor tasks and EBA prioritisation

2024
- **Further Testing, Validation and Evaluation**
  Workshop 3 (Month 30-40, Deployment space)
  Evaluate and Validate Sensor activities, EBA options, participant engagement

The issues listed in order of priority and based on early-on surveys (executed during preparation of the project proposal (pre-submission) with consortium partners, not project identified stakeholders), were:

- Coastal flooding and storm surges;
- Increase in sea level;
- Coastal erosion and subsequent biodiversity loss;
- Damage to coastal infrastructure, buildings and tourism;
- Aquaculture vulnerability;
- Land ecosystem vulnerability;
- Impact on employment, tourism and everyday-life of all of the above.

Early on a set of indicators for measuring participatory engagement and the results of the innovations such as the low-cost sensors within and between CCLLs, was established, indicating gaps in knowledge and challenges to overcome. Resulting in a list of areas to be monitored and to be actively focused on during the project's duration:

- Knowledge exchange within CCLL and with other CCLLs;
- Identification of potential issues, risks and limitations;
- Data collection and integration;
- Clarifying parameters and service requirements;
- Defining service measures, e.g. key performance indicators;
- Interpretation of results.

Where

The location, hazards and impacts of the SCORE 10 CCLLs identified before the start of the SCORE project are indicated on the map below. Interestingly, the actuall hazards addressed during SCORE in each of the CCLL might differ from this map, as these were iteratively selected upon stakeholder preference and CCLL member consent.

Figure 9 – Map of CCLLs and their Hazards and Impacts
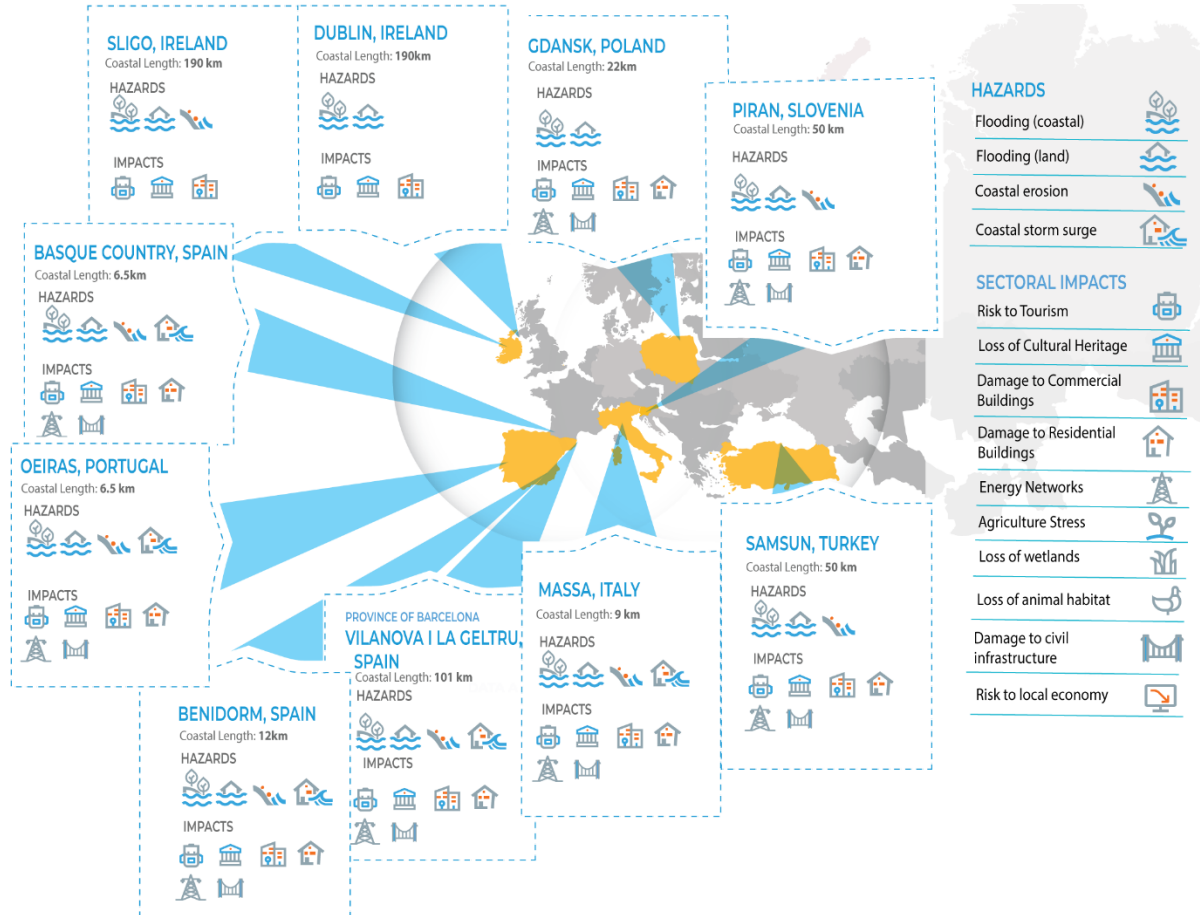
When

The SCORE project was organized over a 48-month period, funded from July 2021 to June 2025. The project began in the ideation phase and then moved for each CCLL on different timepoints into the co-creation phase, the implementation and testing phase, while the evaluation phase was mostly conducted on CCLL establishment, operation, and sustainability. Validation of sensor and implementation of EBA pilots in selected CCLLs were started to be performed towards the end of the project, but not specifically described as project tasks. Engagement with citizen participants occured throughout, from month 8 - 48.

7. INTRODUCTION TO THE LEARNING MODULES

This report, with the Engagement Strategy and the Learning Modules will be available to external user in order to represent the SCORE project consistently and for anybody willing to set up a CCLL that requires interaction with all stakeholders. As explained in previous sections, both the Engagement Strategy and the Learning Modules relate to the broader Stakeholder and Engagement Strategy developed by Work Package 2 under Tasks 2.1 & 2.2 – General Frontrunner CCLL Pilot Operation Plan (POP).

Thus, the Engagement Strategy and the Learning Modules guide towards adaptation to climate change of the SCORE project, through the use of citizen science do-it-yourself sensor technology, and the EBA approach. Coastal flooding and erosion, extreme weather events and associated changes in precipitation, are the most striking aspects of climate change related to coastal cities, along with ocean rise in volume and temperature giving way to sea-level rise. SCORE addresses those issues along with their impact. It includes those challenges within this strategy according to each of the CCLL study areas and climate hazards, supported through the executed SCORE activities, its outcomes and tools and the Learning Modules.

SCORE applied an inclusive participatory engagement methodology, that involved the recruitment of a range of voluntary participants or citizen scientists, primarily adults, who come from a variety of classes, genders, ethnic, religious and cultural backgrounds, as well as from industry and business, academia, general public and governance. Participants can be recruited through public surveys, social media platforms and standard multi-media platforms such as notice boards and newspapers, as well as through community networks and public meetings, and participated in a series of 'how to' CCLL capacity building workshops throughout the project. Participatory engagement is a vital aspect of the project.

WP4 aimed at empowering citizens with low-cost sensors for citizen science activities in Coastal City Living Labs, and to raise awareness on EBAs. By joining climate change action with participatory engagement and education, WP4 integrated the learning and practice of CCLL participants. It intended to have the outcome of complementing the data from institutional sensors (e.g. meteorological agencies, government and municipalities) with data from low-cost sensors, capturing more detailed spatial and temporal data in localised high-risk areas. Resource information relating to this co-creation is available in additional SCORE's Tools and Outcomes (Section 9) and On-line Content (Section 10). This data can be used to produce more robust coastal city early-warning systems and is well suited to each CCLL's identified needs.

The objectives of Work Package 4 were:
- Engage and empower local communities in co-monitoring activities for the assessment of CCLLs' relevance to EBAs;
- Build capacity among citizen scientists including youth and marginalised communities, by providing tools and resources to mutually exchange knowledge;
- Leverage citizen science and participatory GIS activities (DIY sensors) to collect data to complement institutional data and models for the SCORE early warning system;
- Develop algorithms and protocols to guarantee the quality of data collected in citizen science activities;
- Complement and integrate by fillings gaps of sparse networks of institutional sensors with a denser network of low-cost citizen science sensors to monitoring a set of critical parameters, of interest for each CCLL.

The Learning Modules will explain the interdisciplinary methods and multi-stakeholder interactions and discovery methods we have employed, and show how and why they matter. Next to having access to local, regional and EU knowledge, statements, plans and directives, part of SCORE methodology was to empower participants to engage with on-line learning materials to up-skill, as well as to contribute their own local knowledge, and inter-generational knowledge and heritage. The Learning Modules and the consecutive SCORE outputs, tools and online content will be a key resource manual for participants along with the methodology of workshops and training. To achieve success in this co-design methodology, these informations and tools of the SCORE project will be available to individual CCLLs and a broad audience, accompanied with photos, tables and detailed infographics.

Essential information and global goals interwoven in the SCORE project can be listed as following:

- The European Union'ss biodiversity strategy for 2030: https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en

- United Nations Sustainable Development Goals: https://sdgs.un.org/goals

- United Nations 2030 Agenda for Sustainable Development: https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

- The European Union's statement on marine nvrionment and its policies to protect Europe's oceans, seas and coasts: https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm

- The United Nations world water development report: https://unesdoc.unesco.org/ark:/48223/pf0000375751

- A scientific paper by Van der Linden and colleagues on the relations between coastal flooding, uncertainty and climate change: https://hal.archives-ouvertes.fr/hal-01584317/document

Thus, the aims and objectives of the following sections (8 through 10) are primarily to provide stakeholders from local communities, including everyday citizens, business, academia, and governance, with hands-on resources and learning tools to accompany the enactment of the citizen science activities in each CCLL through the life cycle engagement approach that was outlined in sections 1 through 6. As a reminder Figure 10 again, but differently illustrates the life cycle approach with engagement, incluisvity, orientation, co-design, co-creation, enactment, empowerment.

Figure 10 – SCORE's Life Cycle Approach
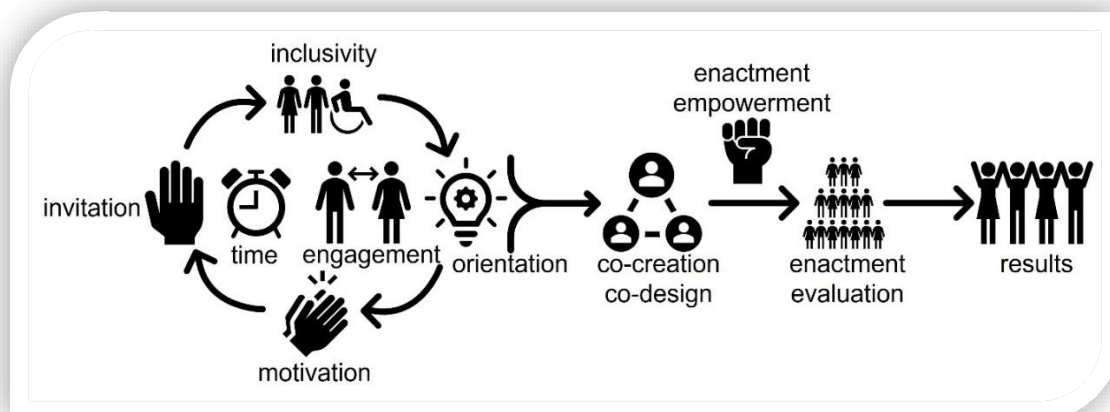
The Learning Modules and glossary (section 8) provides climate change/adaptation familiarisation content, while SCORE also developed further outcomes and tools, complementary to the Learning Modules, like catalogues,

methodologies, surveys and games that are described briefly (Section 9) and are available online for further use and assistance.
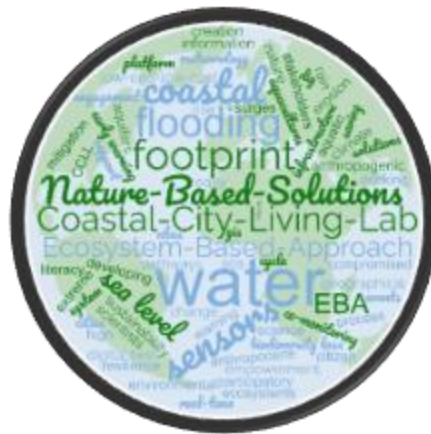
More SCORE online content like videos, policy briefs, webinars, and extensive learning courses in the form of Massive Open Online Courses (MOOCs), are available (Section 10). that can be entered and experienced any time.

All content is designed to be user-friendly, so that people from diverse backgrounds will have to access the material in either a hard copy workbook (printed from PDF), as well as digitally, through future translated versions.

8. LEARNING MODULES

Each of the six learning modules presented consists out of a core thematic text with explanatory figures and links embedded, all introduced by aim, objectives and learning outcomes intended by the module. This is followed by a quiz with multiple-choice questions drawn from the core body of the text, and subsequently the answer given with an explanation. Each module ends with a list of specific references and links cited within the module. Additional resources supporting the content of each module can also be found in the subsequent sections 9 and 10.

To support the learning modules in general and to familiarise one with climate adaptation terms and definitions this section also includes a Glossary (section 8.7), that can be found after the six Learning Modules.

8.1   Past, Present and Future: How we got here

Aims

The primary aim of this module is to learn participants about how we got to the many climate crises that we face today.

Learning Objectives

- to increase environmental literacy by re-visiting the past and knowing what can be learned from past errors and success towards a sustainable future.

- to activate citizen scientist and stakeholder interest through mutual exchange of knowledge and lessons learned from the past toward the future.

- to engage the curiosity of citizen scientists, research scientists and stakeholders about history, and the contemporary world.

Learning Outcomes for this Module

- to build knowledge of past and present habits and practices.

- to understand why some of those habits and practices have become dangerous and unsustainable for Earth and its inhabitants.

- to be able to imagine other possibilities for the future of sustainable life on Earth.

Because our project is focussed taking research action towards climate change and inviting citizens to co-create solutions for the future, it is useful to consider some information of the recent past, such as the Holocene age, which came before the Anthropocene age. Our climate changes did not appear out of nowhere. They have a long history. Some of that history is geological and researchers have mapped the ages of planet Earth, as you can see in the Figure below. Since cultures around the world became increasingly agrarian (growing and trading crops) in the Holocene age, it makes sense that the impact of human beings on the environment would begin to change the face of the earth. This is what has happened in the Anthropocene Age that we are living in. Anthropocene relates to human dominance over the environment. As geologists Steffen, Crutzen and McNeil (2007) have explained: 'the pressure on the global environment from this burgeoning human enterprise is intensifying sharply. Over the past 50 years, humans have changed the world's ecosystems more rapidly and more extensively than in any other comparable period'.

Geological Ages/Epochs/Eras of Earth
From https://www.publicradioeast.org/us/2016-10-01/climate-change-and-the-astrobiology-of-the-anthropocene
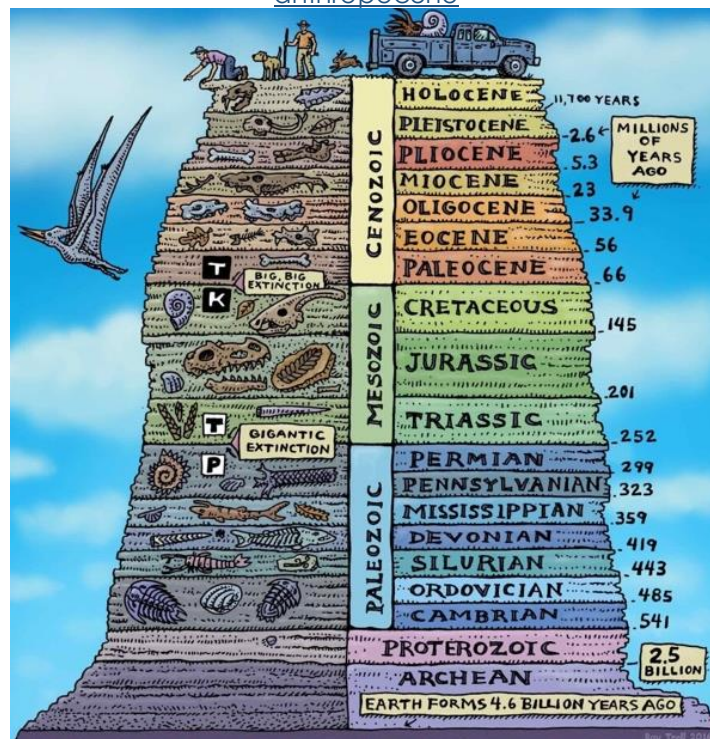
The illustration above shows the movement through time of the different geological ages of the planet. At the very top is where the *Anthropocene* is situated. According to Steffen Crutzen, and McNeil (2007), *the Anthropocene Age* began around the late 1700s, when intense human development brought new inventions and technologies, that added to the growing agricultural practices and the size of cities. By the *Industrial Revolution* and through to the *Cold War*, after World War II (WWII), a 'great acceleration' in human industry occurred. Technology could do jobs quicker than humans and the huge amount of innovation that occurred through WWII was put to the test in world economies. New goods and services and exchange value of goods dominated the western world. The family car became normalised in the last half of the 20th century. Chemical treatments for better crop production also flourished, without full understanding of the side-effects of such widespread chemical use. The result was an increase in pollution, from both industry and agriculture, often pouring into oceans untreated, which effected sea life. Air pollution became normal. We were introduced to smog and acid rain, wiping out forests and species of fauna and making people sick.

There were some good advances during this time, particularly in medicine and education. But it was the hyper-production of goods and services that started to warm the planet beyond a temperature it had ever experienced before. The other issue was the population explosion after WWII. Feeding, clothing and caring for the increased world population became a problem. Some countries had already suffered under colonialism (the expansion of western economics and political control into areas such as Africa and South America, Australia and the Pacific region). Further suffering occurred because of the widening gap between rich and poor, and the change from subsistence agriculture to cash crop economics, such as growing tea and coffee instead of indigenous and local foods. Even in developed economies and cities this gap got wider, which created different problems again, such as lack of social cohesion, marginalisation, racism, and oppression.

There are approximately 7.9 billion people on earth now, compared to approximately 3 billion at the close of WWII. World resources were not being shared equally and many people lived in poverty, and still do. Climate catastrophe will only increase the gap between rich and poor, as well as create species extinction and increased de-naturing of goods and pollution of earth, air and water through the use of chemicals that have been considered to be safe to use at acceptable levels.

After WWII and on into the 1970s, the world was increasingly concerned with developing nuclear weapons and the effects of such development. This was partly because of the perceived threat of nuclear war between the two superpowers of the time: former Union of Soviet Socialist Republic (USSR), and the United States of America (USA). Other countries such as France and Britain were testing nuclear weapons in places such as the South Pacific and Australia, and USA was testing weapons at Amchitka in Alaska. Some scientists, citizen scientists and activists protested about these dangerous activities and there were investigations into the side effects of pesticides and radiation. People of the world demanded more integrity when dealing with the environment that sustains the planet. Eventually scientific research, activism, politics and economics came together to make some reforms. In 1961, for example, the World Wildlife Fund (WWF) was formed to protect endangered animals world-wide; in 1970 on April 22, Earth Day was declared an annual event for people worldwide to focus on care of the planet, and Greenpeace commenced protest activities primarily at sea from 1971 onwards, to ensure protection and diversity of life, and for a future world peace that was sustainable. In regional areas, local activist or special interest groups for change, also flourished. These are just a few examples of global activism. In 1986 the Chernobyl (Ukraine) nuclear reactor exploded creating a wave of radiation across Europe. This disaster renewed calls for better care and development of the planet and its resources.

The Sustainable Development Goals
From: https://sdgs.un.org/goals
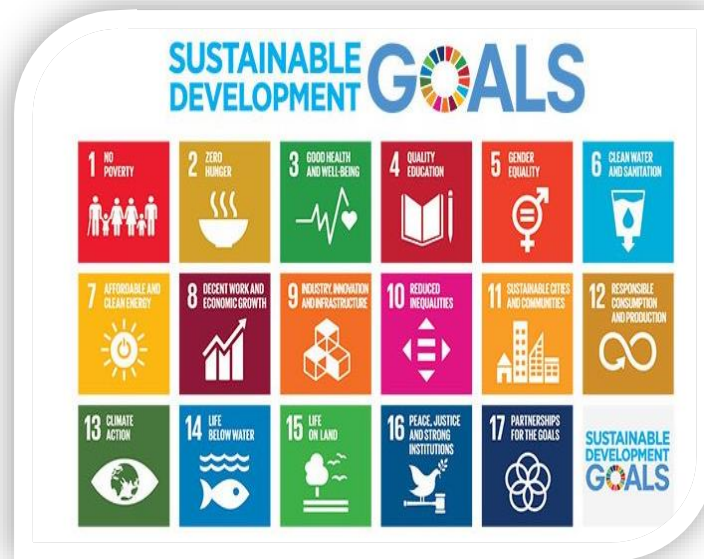
Later, and inspired by world events, activism and climate and chemical tragedies, the people of the world tried to repair the damage in a more unified way, and through research. The *United Nations General Assembly* in 2015 developed the *Sustainable Development Goals* (SDGs), and for example the *European Commission* and other funding bodies provided funds for research to be done towards sustainable and resilient practices, such as this SCORE project.

Each of the SDGs goals was developed to specifically respond to one of the worlds crises. The SDGs became a guiding instrument for sustainable development and its associated politics and economics, along with the *Nine Planetary Boundaries* from the *Stockholm Resilience Centre* in Sweden, that describes how far away from sustainable boundaries we have moved.

Theme 1 Quiz Questions – Past, Present and Future: How we got here

Q 1.   Most scientists agree that we are now in a geological era called the Anthropocene. What was the geological era that came before the Anthropocene?
   a.   The Jurassic Era

   b.   The Paleocene

   c.   The Holocene

   d.   The Icelandcene

Q 2.   How long ago did the Anthropocene Era begin?
   a.   70-250 years ago

   b.   250-400 thousand years ago

   c.   5 million years ago

   d.   11,700 years ago

Q 3.   What is the approximate human population of the Earth?
   a.   7.9 billion

   b.   700 million

   c.   7.8 million

   d.   It is not possible to estimate

Q 4.   The United Nations Educational, Scientific and Cultural Organization (UNESCO), the European Commission and other agencies around the world recognise that the earth is in danger from climate change. Millions of funding dollars are distributed globally every year to help climate change researchers, and uphold the Sustainable Development Goals (SDGs). How many SDGs are there?
   a.   5

   b.   17

   c.   100

   d.   101

Q 5.   Which of the following is not a Sustainable Development Goal?
   a.   Gender Equality

   b.   Climate Action

   c.   Life Below Water

   d.   Life in Outer Space

Theme 1 Quiz Anwers – Past, Present and Future: How we got here

Q 1: The answer is c) the Holocene
If you go to this link: https://www.publicradioeast.org/post/climate-change-and-astrobiology-anthropocene you will see all the epochs mapped out over a time scale. The Holocene comes directly before the Anthropocene.

Q 2. The answer is a)
The Holocene began approximately 11,700 years ago and some scientists argue we are still in that period. However, since the Industrial Revolution (IR) that began in the late 1700s, human impact has had devastating effects on the planet, such as global warming, species extinction, sea-level rise, over-population and extreme weather and climatic events on a scale that has not been evident before. This is called the Anthropocene or the Age of Man. Some scientists date the Anthropocene from the end of WWII /early 1950s and the dropping of the Atomic Bomb and the period of Great Acceleration in militarism and industry. See https://www.nationalgeographic.org/media/age-earth/ and https://www.nationalgeographic.org/media/age-earth/ and https://www.bbc.com/news/science-environment-31836233 and https://www.anthropocenemagazine.org/2020/08/maps-of-the-new-world/

Q 3. The answer is a)
Despite the millions of deaths from the coronavirus disease (COVID-19) pandemic, the world's population is still growing. You can go to https://www.worldometers.info/world-population/ to get detailed information about population growth around the world, or in your area.

Q 4. The answer is b)
There are 17 SDGs that cover all aspects of planetary life. Please visit the following link to find out more https://sdgs.un.org/goals and Stockholm Resilience Centre, What is Resilience? An Introduction to social-ecological research, www.stockholmresilience.su.se for further information.

Q 5. The answer is d) Life in Outer Space.
Life in outer space is not considered sustainable or a development goal, yet the colonisation of space for human habitation could happen in the future if the care of planet Earth does not improve. SDGs were created by the joined efforts of different economies who developed and agreed to enact them. In January 2015, the General Assembly of the UN developed the earlier initiative of the goals from 2015 that culminated in the subsequent adoption of the 2030 Agenda for Sustainable Development, with 17 SDGs at its core, at the UN Sustainable Development Summit in September 2015

Theme 1 Resources and References – Past, Present and Future: How we got here

https://www.earthday.org , has been mobilizing over 1 billion people annually on Earth Day, and every other day, to protect the planet.

https://sdgs.un.org/goals , the 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future.

https://ec.europa.eu/clima/eu-action/adaptation-climate-change_en , adapting to climate change means taking action to adjust to its present and future impacts.

https://www.stockholmresilience.org/research/planetary-boundaries/the-nine-planetary-boundaries.html , the planetary boundaries concept presents a set of nine planetary boundaries within which humanity can continue to develop and thrive for generations to come.

Folke, Carl, Steve Carpenter, Thomas Elmquist, Lance Gunderson, C.S. Holling, Brian Walker. 2002. Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. In *Ambio: A Journal of the Human Environment*, 31(5), 437-440. https://doi.org/10.1579/0044-7447-31.5.437

Palsson, Gísli, *et al.* 2013. Reconceptualizing the "Anthropos" in the Anthropocene: Integrating the Social Sciences and Humanities in Global Environmental Change Research. In *Environmental Science & Policy*, 28, 3-13. https://doi.org/10.1016/j.envsci.2012.11.004

Paulsen, M., Jagodzinski, J., and S. M. Hawke (eds.). 2022. *Pedagogy in the Anthropocene: Rewilding Education for a New Earth* Cham: Palgrave Macmillan. https://link.springer.com/book/10.1007/978-3-030-90980-2

Steffen, Will, *et al.* 2011. The Anthropocene: From Global Change to Planetary Stewardship. In *Ambio: A Journal of the Human Environment*, 40, 7, 739-761. https://doi.org/10.1007/s13280-011-0185-x

Steffen, Will, Paul J. Crutzen, John R. McNeill. 2007. The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature. In *Ambio: A Journal of the Human Environment*, 36(8), 614-621. https://doi.org/10.1579/0044-7447(2007)36[614:taahno]2.0.co;2

8.2 Coastal City Living Labs (CCLLs)

Aims

The primary aim of this module is to explain what Coastal City Living Labs (CCLLs) are and how they work together with the other CCLLs during the SCORE project.

Learning Objectives

- to develop understanding about how scientists and citizen scientists can participate together in innovative scientific research in the context of a Coastal City Living Lab.
- to activate citizen scientist and stakeholder participation in one of the 10 Coastal City Living Labs.
- to engage the broader community in understanding how Smart Cities and CCLLs can work to mitigate climate change and Anthropocene challenges.

Learning Outcomes for this Module

- participants will be competent in CCLL design and practice, and be able to explain to others how CCLLs work and why they are an important part of citizen and scientific climate change practice.
- participants will be empowered (and supported) to share knowledge of how CCLLs work during and after the SCORE project to continue work in climate change action.
- participants will recognise the contribution that they, as citizen scientists, have made to this innovative project about climate change mitigation, and understand the value of their lived experience and personal contribution to the climate change action happening in their CCLL.

SCORE is based on the novel concept of a Coastal City Living Lab (CCLL) that expands Living Labs methodology and style to a specific vision for coastal cities and settlement, also explained in the following introductory videos https://www.youtube.com/watch?v=YLJCiwlZ0AY&t=11s ; https://www.youtube.com/watch?v=tHIa4FppfWk&t=1s. In the beginning of this module an overview picture of the Coastal Cities involved in SCORE is given. How the Coastal City Living Labs can be developed is basically the focus of this module and how this was performed is written here as well as available as a video https://www.youtube.com/watch?v=-isJ6p5axRE&t=12s.

Living Labs are:
- user-centred
- open-innovation urban ecosystems
- designed to engage both public and private agents/participants/stakeholders

These stakeholders come together to address different climate issues. Some of the SCORE project partners have been working on the Living Lab concept for a while now and are sharing their expertise in the project and on project outcomes and tools. For example, The European Network of Living Labs (ENoLL), and the Institute for Housing and Urban Development Studies (IHS) have extensive experience in engagement strategies and as a Network Builder (for ENoLL's experience, read: https://wayback.archive-it.org/12090/20170107133606/https://ec.europa.eu/digital-single-market/en/news/european-network-living-labs-enoll-explained). The colleagues from NAIDER are responsible for the Pilot Operational Plans of the Coastal City Living Labs. Together these experts and their teams will help us all understand the specific plan for each of the CCLL. These teams are also available along with your CCLL leader, to answer any questions you have.

CCLLs are based on the Living Labs concept but focus on co-designing and co-developing coastal city interventions and activities through discussion and consideration of novel Ecosystem-Based Adaptations (EBAs) approach. Each CCLL will tackle specific identified local challenges related to sea level rise, coastal erosion and extreme weather events and their flow on effects in 9 European Coastal Cities and 1 in Turkey. Their effectiveness will be assessed by different agents through innovative monitor systems, and cutting-edge numerical modelling. This means that citizens in the CCLLs will co-design low-cost do-it-yourself (DIY) sensors to gather climatic information data. This data will then be fed into data reading technology, and shared with the high-end sensors, that will yield new data sets.

The method upon which the individual tasks for CCLLs were established rely on the effective integration between the:
- Iterative Life Cycle Approach
- CCLLs and Participatory Engagement
- Smart Technologies
- Hybrid Nature-Based Solutions (NBS), or when specifically adapted to climate change are called ecosystem-based adaptations (EBA).

It constitutes the 'How' aspect of the CCLL part of the project and engages four different types of participants:
- government
- academia
- business
- and citizens

This is sometimes called the Quadruple Helix Model.

Schematic Depiction of the Living Lab Integrative Process Including the Life Cycle Iterative Approach

	Problem Space			Solution Space			Deployment Space	
Stages	EMPATHISE		DEFINE	IDEATE	PROTOTYPE	TEST	IMPLEMENT	SCALE UP
Steps	**Select a Practice**	**Integrate stakeholders**	**Uncover barriers**	**Co-design plan**	**Pilot an intervention**	**Evaluate performance & impact assessment**	**Demonstrate the system**	**Exploit the solution**
	The context is researched to understand the socioeconomic and cultural setting. User behaviours and social practices are understood.	A People Public Private Partnership (PPPP) Model is used to integrate stakeholders.	Community based social marketing helps to uncover barriers.	A common vision and shared goals enables mash up and then co-design with users and not for the users.	Real-life experimentation is carried out in the field.	Measurement, verification and performance scorecords enable scale up.	Actual system proven in operational enviroment.	Test the solution outside the initial scope. Enlarge the solution, pollinate it and replicate it in other settings.

Constant (process) monitoring

The four phases in the Iterative Life-Cycle Approach for SCORE, are underpinned by the Living Lab Integrative Process and the citizen science engagement framework IMOTEE, meaning Invite, Motivate, Orientate, Engage and Evaluate. These all appear below:

Ideation and Exploration: Identification of the actual needs of all involved stakeholders concerning the climate resilience problems they are facing, and for which the 'solutions' would be developed and tested. This **problem space** phase involves research on the effectiveness of existing solutions in place, and, includes the CCLL capacity building workshops directed by your local CCLL leader.

Co-creation and Co-Design: Stakeholders are brought together to co-create the solution. They include municipal and governance representatives, citizen scientists and manufacturers. This **solution space** phase continues in an iterative way until all involved stakeholders are happy with the so-called Minimal Viable Product (MVP). This phase includes a second series of CCLL workshops.

Real-life Experimentation and Prototype Testing: The MVP is placed in real life settings within the relevant CCLLs **(both solution and deployment spaces).** Small local pilots will be conducted to test if the solution is responding to all stakeholder needs. This is called a 'closed field trial'. Doing this in an iterative way allows the MVP to be rapidly adapted until it meets requirements, whether it is the co-creation of the DIY sensors, household water saving techniques or sand-dune restoration materials.

Evaluation and Validation by end-users and stakeholders: In the last **deployment space** phase the solution is evaluated by a much larger feedback group via validation surveys or 'open field trial' for the innovation solutions that are being tested. Also here the iterative process is employed, where the next steps in a project are defined by and based on the feedback of involved end-users & stakeholders. This is where the validation of the solution occurs.

The specific *learning and education tools* and methods we will apply is called IMOTEE – an acronym that stands for:
- **I**nvite and Inspire
- **M**otivate
- **O**rientate
- **T**imeline Methods
- **E**ducate and **E**valuate

We invite you and your interest, and/or lived experience to join in the research process through the CCLL approach. Establish your CCLL leader's name, present their contact details and, after a warm welcome to the community of the CCLL we hope you can inspire them to sign-on to the project.

The SCORE project also especially hopes to be inspired by your interest and local knowledge. So contact us. We will also use this 'getting-to-know-you' time to find out what motivates you, and share with you, what motivates us.

Once we are all acquainted and oriented to the CCLL and its aims and objectives, one can follow a *Timeline* and *informal log-book* process for ticking off our success once going along. It is also good to be involved in *Learning Exchanges* with other CCLLs, as well as increasing our own education and sharing it with friends, families, and communities, as well as business stakeholders. And do not to forget to involve the media for public sharing of your project, wherever possible. Besides, at the end of the project evaluate your activities!

The following are the key SCORE innovation elements that underpin the project's purpose of engaging citizen scientists inclusively as participants in consideration of climate challenges through the CCLLs:

(1) New paradigms for interventions;
(2) Active role of citizens in designing and operating technical solutions;
(3) High flexibility of adopted solution, easy replicability to other CCLLs;
(4) Prompt reaction to risks through early warning support systems;
(5) Better planning of actions through *Digital Twins*;
(6) Improved planning of activities through EBAs;
(7) New financial risk analysis and solution tools.

Overall CCLLs are invested in the linked methods of research and practice.
So, welcome to your CCLL research experience.

Map of CCLLs Across Europe and Turkey and the Hazards & Impacts of Climate Change
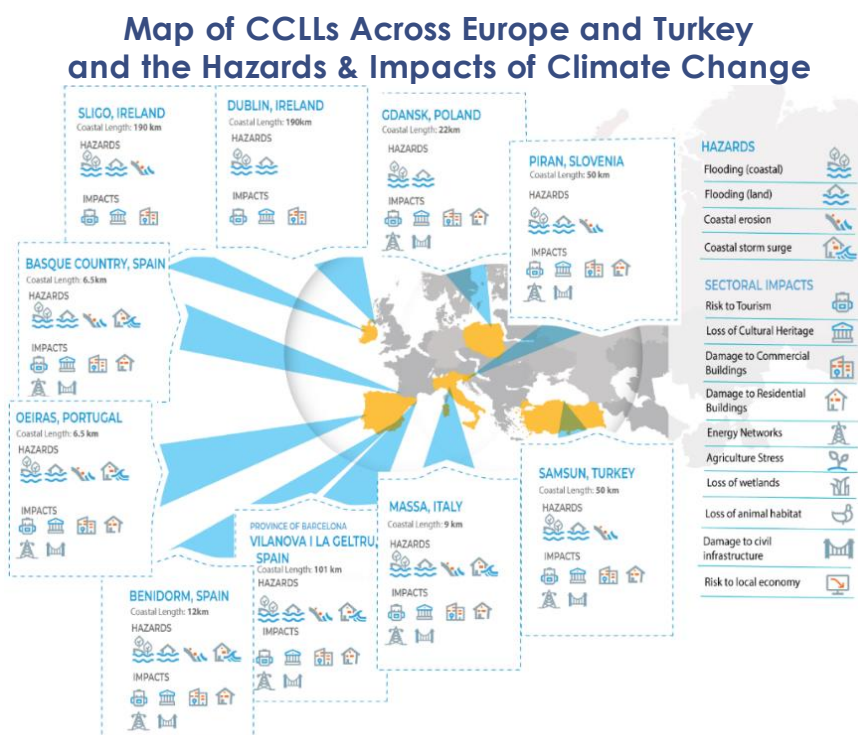
In the CCLL map above, developed early on for the SCORE project, it is noticeable that all coastal cities are located within a European Framework. Besides, for each coastal city its specific climate hazards and its subsequent impacts are listed.

Theme 2 Quiz Questions – Coastal City Living Labs (CCLL)

Q 1.   What is a Coastal City Living Lab (CCLL)?
a.   A research centre or university.

b.   A collaborative, user-centred approach, and an open-innovation ecosystem where citizens, universities and research organizations, companies and public institutions co-design, prototype, test, co-develop and scale up real-life EBA solutions to solve coastal city climate change challenges and contribute to long-term resilience, sustainability and social well-being.

c.   A facility located offshore that provides controlled conditions for scientists to do research on aquacultures.

d.   None of the above.

Q2.   What is the role of a CCLL?
a.   To provide a laboratory to do private research.

b.   To recycle old buildings to provide housing for the homeless.

c.   To enable a space where governments can recruit and train citizens to test their solutions.

d.   To function as a practice-driven organisation, a real-life environment and an intermediary among an interactive multi-stakeholder network to orchestrate research, co-design and innovation processes.

Q3.   What are some key characteristics of a CCLL?
a.   Open innovation, user-centred approach, and co-creation of value based on relevant multi-stakeholder engagement (i.e., academia, industry, government, civil society).

b.   Socio-technical systems design, design thinking and co-design approaches.

c.   Real-life settings and environments to address urban climate change, societal, sustainability and resilience challenges by co-developing CCLL interventions and activities through EBAs.

d.   All of the above.

Q4.   What is co-design in the context of a CCLL?
a.   Citizens of a coastal city designing private solutions for the challenges of climate change.

b.   Actively engage stakeholders in the process of co-designing improvements, innovations and solutions through open collaboration to increase climate resilience in a coastal city, incorporating the skills, knowledge and experiences of all partners involved (e.g., citizens, scientists, researchers, engineers, policymakers, etc.).

c.   A method based on co-creation, in which all departments of a civil protection office work together to design solutions for climate change challenges in a coastal city.

d.   A process of forced engagement on climate change.

Q 5.   Where would a CCLL ideally be located?
a.   On a cruise ship that often anchors off-shore from a coastal city.

b.   In an urban controlled setting.

c.   In an accessible coastal city site (e.g., urban beach, neighborhood, coastal region, etc.) where local communities and all stakeholders can interact with their urban-coastal environment to co-create EBA solutions that address local climate challenges and risks and are tested in a real-life setting and situation, right where they are planned for.

d.   On an autonomous smart offshore platform navigating a coastal area 25 km off the city's coastline, accessible by boat by all stakeholders.

Theme 2 Quiz Answers – Coastal City Living Labs (CCLL)

Q 1. The answer is b)
SCORE is based on the novel concept of a Coastal City Living Lab (CCLL) that expands Living Labs to a wider vision for coastal cities and settlements. CCLLs are user-centred, open-innovation urban ecosystems where many stakeholders actively engage in co-creating, testing, and evaluating innovations in real-life situations. The focus of CCLLs is to tackle specific challenges related to sea level rise, coastal erosion and extreme events through EBAs.
https://enoll.org/about-us/what-are-living-labs/ and https://score-eu-project.eu/ and
https://issuu.com/enoll/docs/ull_handbook_online_version

Q 2. The answer is d)
CCLLs are practice-driven communities that facilitate and foster open, collaborative innovation, as well as real-life environments or arenas. Also, CCLLs act as orchestrators among industry, academia, governments and communities involved in innovation processes.
https://enoll.org/about-us/what-are-living-labs/

Q 3. The answer is d) All of the above.
The core value of CCLLs is co-creation based on multi-stakeholder engagement (i.e., academia, industry, government and civil society) and user-centred open innovation management. Its innovation process uses socio-technical systems design, design thinking and co-design approaches. The urban contexts of CCLLs are real-world settings and environments to address urban climate change, societal, sustainability and resilience challenges. In CCLLs, interventions and solutions are co-created through EBAs.
https://enoll.org/about-us/what-are-living-labs/ and https://www.sciencedirect.com/science/article/pii/S095965262035767X

Q 4. The answer is b)
Co-design means 'collaborative design'. It is a method to ensure the active engagement of a broad range of people directly involved in an issue, place or process in its design, to work together in improvements, innovations and impacts. CCLLs' co-design approach brings together the collective experiences of stakeholder to build solutions that increase climate resilience of a coastal city.
http://ingridburkett.com/wp-content/uploads/2017/09/Introduction-to-Codesign-2.pdf and https://score-eu-project.eu/

Q 5. The answer is c)
The location of a CCLL should be within an accessible site (e.g., urban beach, neighborhood, coastal region, etc.), where local communities and all stakeholders can interact with their urban-coastal environment to co-create EBA solutions. A CCLL needs to cover a physical setting that facilitates the understanding of local climate challenges and risks to co-create and test solutions in a real-life situation.
https://issuu.com/enoll/docs/ull_handbook_online_version

Theme 2 Resources and References – Coastal City Living Labs (CCLL)

https://unalab.eu/en/project-partners/enoll ,the European Network of Living Labs (ENoLL) is a global network of open innovation ecosystems (Living Labs) that places people at the centre of product and service development and innovation. The network and its members provide innovation services for small and medium-sized international companies, the public sector, organisations and citizens.

https://wayback.archive-it.org/12090/20170107133606/https://ec.europa.eu/digital-single-market/en/news/european-network-living-labs-enoll-explained , the collaboration and dialogue between ENoLL and the European Commission has deep roots.

https://www.youtube.com/watch?v=aYHxYD9kPGo,   What is a Living Lab?

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8.3 The Water/Hydrological Cycle
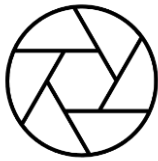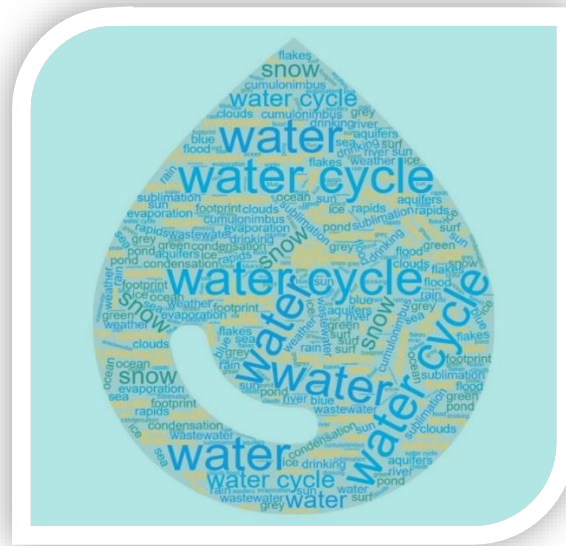
Aims

The primary aim of this module is to remind participants about how amazing water is, as it travels around the planet and nurtures all life.

Learning Objectives

- to increase water literacy by understanding how the Water Cycle/Hydrological Cycle works.

- to activate citizen scientist and stakeholder interest about the bio-social connections of water – between humans and the environment.

- to engage the curiosity of citizen scientists, research scientists and stakeholders about ways to preserve, re-use and re-purpose water.

Learning Outcomes for this Module

- to have developed a wholistic understanding of planetary movement through the different phases of the Water Cycle.

- to have established relevant and local re-use possibilities for fresh water.

- to comprehend the place of 'real time' innovations for the future of sustainable life on Earth through water.

The movement of water around the planet is called the Water Cycle or the Hydrological Cycle. Water is unique – even magical – because it appears as a solid (ice and snow), a liquid (rivers, lakes, ponds, rain) and a gas (vapour from breathing, mist and steam). We also have green water, blue water, grey water, and virtual water. Measuring our water (or aquatic) footprint is a good beginning to understanding the Water Cycle and how water is connected to us. For example, humans are approximately 75% water and so is Planet Earth, and most of its living inhabitants! But most of the Earth's water is locked up in ice caps and glaciers and icebergs. We have access to less than 1% of the world's freshwater reserves for domestic use, agriculture and industry.

The painting below, done by Australian artist and water advocate Leonie Jackson, shows artistically the distribution of water on Planet Earth. Most of the painting is blue/green squares which represent the oceans. The small white rectangle represents the fresh water on the planet, and the tiny blue dot inside the rectangle (look closely!) is how much fresh water is available to us! This is why we must protect all our planetary water from pollution, over-extraction for unsuitable industry and agriculture, and to understand how climate change affects the Water Cycle.

'Less than 1%', painting by courtesy of Leonie Jackson
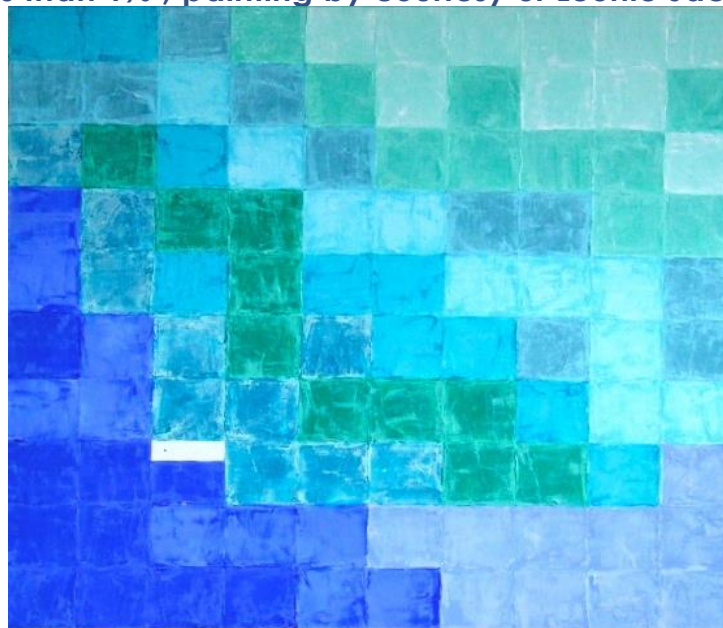
Blue water is visible water such as rivers and seas, and green water is the invisible water that is a major component of plants. Grey water is used or wastewater that is needed to assimilate human pollutants. Virtual water is that which is used in industries such as energy production.

A new field of marine science is looking into how wave energy can be harnessed. Considering the force required to push a wave towards the shore, it makes sense to explore this under-realised opportunity. See for example some of the marine engineers and technological experts working on this project, such as: Dr. Gregorio Iglesias, a Professor of Marine Renewable Energy, at University College, Cork, Ireland; Dr. Salem Gharbia, the lead partner of this SCORE project and a lecturer and researcher in Water and Environmental Science and Engineering at the Atlantic Technological University, Ireland; and Dr. Francesco Pilla, from University College Dublin, Ireland, whose focus is on empowering local communities with cutting-edge technology and enabling them to act on pressing environmental issues in their local

environment and to bring climate change action into education. Their vision gives direction to the SCORE project in which climate adaptation through water-focus is generated together with an international team of European partners who can be heard being interviewed about the SCORE project here: https://www.youtube.com/watch?v=3ioM3Z0LsFs&list=PLUoJeHsSUlVEF0GkX__DDH_TeYLAqDnxT&t=2s.

The Water Cycle
Public domain from United States Geological Survey (USGS)
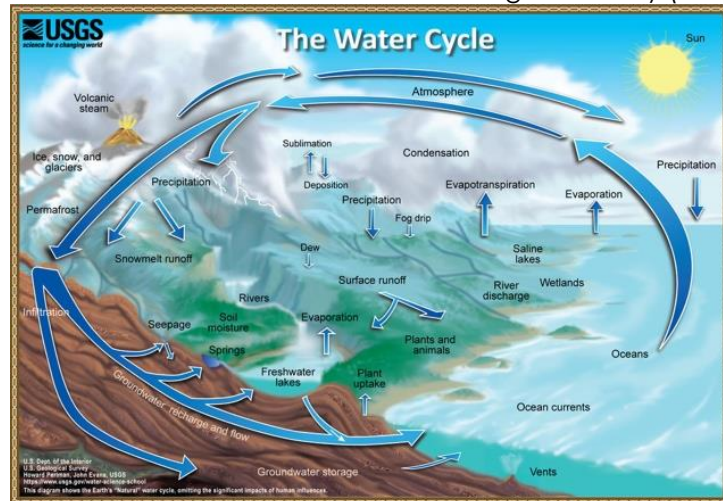
Earth's water is constantly in flux. The natural Water Cycle, also known as the Hydrological Cycle, describes this continuous movement of water on, above, and below the Earth's surface. Water is also continually changing state between liquid, vapor and solid. This has been going on for millions of years. Read about it at the USGS Water Science School - The Water Cycle: https://www.usgs.gov/special-topics/water-science-school/science/water-cycle

Because our project is focussed on taking research action towards climate change and inviting citizens to co-create solutions for the future, it is necessary to understand the Water Cycle at a basic level. All our Coastal City Living Labs (CCLL) for example, are located at sea-level or near sea-level. Understanding the changing effects of the Water Cycle (due to climate change) on local shorelines, land-water interfaces, aquacultures, biodiversity, waste-water treatment, urban and heritage buildings, and infrastructure is critically important. Recent policy briefs illustrate the urgency to built climate resilience particularly at the coastal land-sea interface (https://score-eu-project.eu/wp-content/uploads/2023/11/Adapt4Coast-Policy-Brief-Final.pdf ; https://score-eu-project.eu/wp-content/uploads/2024/03/SCORE-OLLD-Policy-brief.pdf).

For example, do you know where your drinking water comes from, and how much of that water it takes to flush the average toilet? Flushing toilets have only been developed in the last 100 years, and in the western world, the standard average flush uses between 5-10 litres of fresh water! Urinals use different amounts again. Do you know how much wastewater is generated by your washing machine? This is also called grey water. Have a look at this website to understand more about the effects of climate change on the Water Cycle: https://www.unwater.org/ipcc-climate-change-is-intensifying-the-water-cycle/

Theme 3 Quiz Questions – The Water/Hydrological Cycle

Q 1.   How much accessible fresh drinking water is there on the planet?
   a.   Less than 1% of all planetary water

   b.   25% of all planetary water

   c.   75% of all planetary water

   d.   It is not possible to measure

Q 2.   What are some of the parts and processes of the Water Cycle?
   a.   Water turbines

   b.   Precipitation and evaporation

   c.   Condensation and transpiration

   d.   Both b and c

Q 3.   What is an aquatic footprint?
   a.   The volume of water my shoe can contain

   b.   The footprint we leave on wet sand

   c.   The volume of water we use everyday

   d.   The volume of water we waste everyday, individually, and/or globally

Q 4.   What of the following best describes wastewater?
   a.   First use fresh water

   b.   Saline water

   c.   Used water

   d.   Sterilized water

Q 5.   How much water does the average modern western toilet flush use?
   a.   1-5 litres

   b.   5-10 litres

   c.   10-15 litres

   d.   20 litres

Theme 3 Quiz Answers – The Water/Hydrological Cycle

Q 1. The answer is a)

About 72-75% of planet Earth is water. Mostly, that water is oceans and seas, and makes up about 97% of the Earth's water. That leaves less than 3% of fresh water, some of which is locked up in ice caps and glaciers, leaving planet Earth with less than 1% of accessible fresh water to drink, wash, grow food with and support industry and agriculture! Have a look at these links from Europe and different parts of the world:
https://ec.europa.eu/info/research-and-innovation/research-area/environment/water_en   https://www.unwater.org/water-facts/scarcity/ and https://www.usbr.gov/mp/arwec/water-facts-ww-water-sup.html and https://rous.nsw.gov.au/the-water-walk-emigrant-creek-dam

Q 2. The answer is d), or both b) and c)

The Water Cycle or Hydrological Cycle is a complex system of the movement of water around the earth's atmosphere and on the planet in all its shapes and forms. The phases of the Water Cycle as it moves around the world includes: evaporation, condensation, precipitation, interception, infiltration, percolation, transpiration, run-off and storage. Because of climate change there have been observable intensifications in the Water Cycle, for example, bringing more intense rainfall and associated flooding, as well as more intense drought in many regions. For more information please visit:
https://www.unwater.org/ipcc-climate-change-is-intensifying-the-water-cycle/ and
https://www.nwrfc.noaa.gov/info/water_cycle/hydrology.html

Q 3. The answer is d)

There is an important difference between the water we definitely need for our survival and well-being, and the water we waste directly or indirectly. The waste of water is not linked only to leaking pipes and faulty infrastructure, but also things like the showers we take when we are not that dirty and so on. Also, some industries produce wastewater or grey water that cannot be re-used. See the examples below that can help our understanding about water use and waste. Go to:
https://waterfootprint.org/en/water-footprint/what-is-water-footprint/

Green water footprint is water from precipitation that is stored in the root zone of the soil and evaporated, transpired or incorporated by plants. It is particularly relevant for agricultural, horticultural and forestry products use of water.

Blue water footprint is water that has been sourced from surface or groundwater resources and is either evaporated, incorporated into a product or taken from one body of water and returned to another, or returned at a different time. Irrigated agriculture, industry and domestic water use can each have a blue water footprint. The water we drink for example is part of the blue footprint.

Grey water footprint is the amount of fresh water required to assimilate pollutants to meet specific water quality standards. The grey water footprint (used or wastewater) considers point-source pollution discharged to a freshwater resource directly through a pipe or indirectly through runoff or leaching from the soil, impervious surfaces, or other diffuse sources. Domestic water such as laundry and bathroom is a form of grey water.

Q 4. The answer is c) Used Water

Used water or wastewater is the polluted form of water generated from rainwater runoff and human activities such as laundry and kitchen water, and industry and commerce. It is also called sewage. It is typically categorized by the way it is generated—specifically, as domestic sewage and industrial sewage. See for example:
https://www.nrdc.org/stories/water-pollution-everything-you-need-know

Q 5. The Answer is b)

Modern toilets have a dual flush system that use 5-10 litres of water per flush with a half flush option using less than 5 litres, and a full flush option. Older systems, have one option that sometimes uses up to 15 litres of water per flush. This is fresh drinking water that we are flushing our toilets with! It does not make sense to flush our 250 ml of urine in the toilet with up to 10 litres pure drinking water for example. See the following websites for the history of the flush toilet and water usage in litres and volume per activity: https://www.baus.org.uk/museum/164/a_brief_history_of_the_flush_toilet and
https://smartwatermagazine.com/news/smart-water-magazine/cost-flushing-toilet and
https://www.sawater.com.au/__data/assets/pdf_file/0008/6686/Factsheet_Amenities.pdf

Theme 3 Resources and References – The Water/Hydrological Cycle

https://www.earthday.org , has been mobilizing over 1 billion people annually on Earth Day, and every other day, to protect the planet.

https://sdgs.un.org/goals , the 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future.

https://imoox.at/course/AquaMOOC?lang=en , Aqua MOOC - Participatory Engagement with Water.

https://www.nrdc.org/stories/water-pollution-everything-you-need-know , Water Pollution: Everything You Need to Know. Our rivers, reservoirs, lakes, and seas are drowning in chemicals, waste, plastic, and other pollutants. Here's why—and what you can do to help.

https://www.unwater.org/ipcc-climate-change-is-intensifying-the-water-cycle/ , Intergovermentl Panel on Climate Change: Climate change is intensifying the water cycle.

https://www.nwrfc.noaa.gov/info/water_cycle/hydrology.html , an education module about the movement of water on the planet Earth.

https://score-eu-project.eu/wp-content/uploads/2023/11/Adapt4Coast-Policy-Brief-Final.pdf , Policy brief by ADAPT4COAST, Integrated strategies for climate resilience in EU coastal cities.

https://score-eu-project.eu/wp-content/uploads/2024/03/SCORE-OLLD-Policy-brief.pdf , Policy brief, Recommendations on Climate Adaptation from European Coastal Cities.

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8.4 Citizen Science and Participatory Engagement
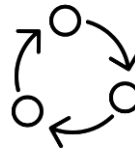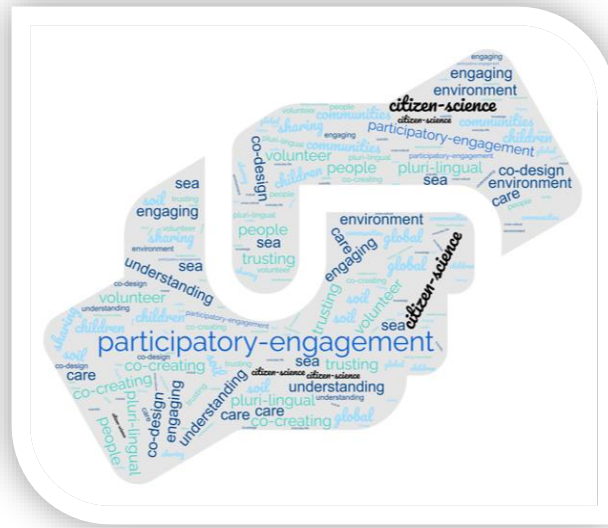
Aims

The primary aim of this module is to explain to participants how participatory engagement works and why their contribution as both citizen scientists and community scientists is important.

Learning Objectives

- to develop understanding about how scientists and citizen scientists can participate together in innovative scientific research.

- to activate citizen scientist and stakeholder imagination about new and different ways of bringing people together to act against climate change.

- to engage the curiosity of citizen scientists, research scientists and stakeholders about what participatory co-creation and co-design can achieve.

Learning Outcomes for this Module

- participants will be able to understand the different aspects of participatory engagement in inter-disciplinary research, and develop a new vocabulary.

- participants will understand their role as active participants in climate change research and how to enact those changes in everyday life.

- participants will understand the value of their lived experience and personal contribution to the climate change actions happening in their CCLL and towards the preservation of Planet Earth through participatory sensing activities.

Terms such as citizen science and participatory engagement are understood quite widely and in different contexts. For us on the SCORE project we offer a definition of citizen science and citizen scientists as people who embody everyday-lived experience in a particular setting or environment – the urban coastal city – and who exchange that knowledge with scientific researchers towards climate change solutions. Participatory engagement is similarly defined. In the context of SCORE it relates to citizen scientists participating in data collection and passive sensing activities for the weather detection apparatus we will be using, as well as technology and knowledge that citizens themselves have. The Green Paper on Citizens Science (2013) defines this kind of participation in the following way:

'Citizen Science refers to the general public engagement in scientific research activities when citizens actively contribute to science either with their intellectual effort, or surrounding knowledge, or with their tools and resources.'

In a more theoretical way, Lewenstein (2004) breaks the definition into three parts, which also applies to the SCORE project:

- The participation of non-scientists in the process of gathering data according to specific scientific protocols and in the process of using and interpreting that data;
- The engagement of non-scientists in true decision-making about policy issues that have technical or scientific components;
- The engagement of research scientists in the democratic and policy process.

In SCORE, we have employed all three methods and definitions to varying degrees. The Green Paper (2013) provides some very clear guidelines about how to do this co-creation research. For example, it states the following as aims for citizen science engagement:

'Citizen observatories, developing community-based environmental monitoring and information and communication technology (ICT) systems using innovative and novel earth observation applications.'

'Global systems science (GSS), combining advanced ICT and citizens dialogues to understand and shape global systems. GSS produces evidence, concepts and doubts needed for effective and responsible policies dealing with global systems.'

Citizen science is at its core, inter-disciplinary. For example, on the SCORE project, we are combining the expertise of engineering and technology, social science, environmental humanities, heritage studies, cultural geography and cultural studies, and pedagogy and education. Therefore, we are cross-cultural as well as inter-disciplinary.

While citizen science and the participatory engagement of everyday people and communities outside academia offers many opportunities to co-produce state-of-the-art research outputs, there are some aspects of this co-creation that need to be re-visited regularly. For example, The Green Paper (2013) suggests mindfulness of pre-existing, present and future questions that may effect the specific research in a section called Open Questions (p. 23). Some of those questions are relevant to our project and include:

- What is the role of Citizen Science in enhancing excellent science?
- How may the level of volunteer involvement change over time and what does this mean for Citizen Science projects and programmes?
- How to include non-scientific disciplines approaches (politics, arts, amateurs...)?
- How could Citizen Science decrease the perceived distances between policymakers, scientific researchers, local and regional governance, and volunteers?
- What are the possible risks, security issues and constraints of Citizen Science?

We too have considered these questions in the preparation of this Engagement Strategy and the workshops we have designed to facilitate the learning exchanges between individuals, communities and the researchers. Because there are several layers of participants and citizen scientists, we sometimes create broader classifications, such as: school students, university students, NGOs and everyday community members, or, community scientists, who are interested in receiving specific training to become more involved in the project development and delivery. We have also factored in privacy concerns, security issues and individual risks which are covered in our Standard Ethical Protocol (SEP). This document is available at all workshops and if you have any questions please contact your CCLL team leader (examples are available here: https://score-eu-project.eu/wp-content/uploads/2022/01/SCORE-Consent-form.pdf).

In this module and in your CCLL, you will have the opportunity to understand and use: Passive sensing (smartphones); Volunteer computing (personal computers and devices which are used for Volunteer Geographical Information); Volunteer thinking (citizen science acquired from local and inherited knowledge), as well as full-scale environmental and ecological observations and participatory sensing. This includes building, testing and deploying scientific tools and methods. An illustrative webinar on how to engage and empower citizens with low-cost sensors for monitoring climate change hazards can be watched here: https://www.youtube.com/watch?v=-uuL2R38xj0. We hope this will be a really exciting journey of discovery for us all!

Returning once again to The Green Paper (2013), we outline below what it considers to be key indicators for the success of citizen science participatory engagement:

> 'The initial phase of involvement, when volunteers need to understand the projects' objectives and opportunities for contribution, has been identified as the most critical one. The majority of volunteers only perform activities one day and do not return to execute more tasks, so the regular minority contribute for the larger proportion of tasks carried out in the project. Once volunteers are involved, the next challenge is keeping them engaged. This requires finding out what motivates them in the long run, but also continuous personal information flows between the involved stakeholders and well-adapted and interesting tasks are important.' (p. 26)

To help us keep you interested in the project and remain with it for the duration, we will conduct many briefing sessions and workshops and face-to-face opportunities as we go and perform together this co-created research. Your motivation and interests are as important as ours. You will have seen early in the Engagement Strategy our methods for:

- finding you
- appreciating and valueing you
- keeping you with us in this research community for the duration of the project

Your input really matters. In fact, we cannot perform the research without your valuable time, interest, knowledge, energy and commitment.

So, thank you once again for joining us.

'The Blue Marble' - Planet Earth - as photographed by the crew of Apollo 17, 1972

Planet earth is the focus of many climate adaptation projects, including SCORE. How citizen scientis can be engaged and collaborate with the scientific community to prepare climate resilient communities and preserve the planter for future generations, is our ultimate goal.

Theme 4 Quiz Questions – Citizen Science and Participatory Engagement

Q 1.   Citizen science explains how everyday citizens do what?
   a.   Help their children with science homework

   b.   Engage with researchers and business to work out sustainable scientific solutions

   c.   Co-create achievable solutions for climate change by sharing local knowledge with visitors

   d.   All of the above

Q 2.   Among the following, what activities does citizen science perform?
   a.   Passive sensing

   b.   Volunteer Computing

   c.   Environmental and Ecological Observation

   d.   All of the above

Q 3.   Which of the following answers is more appropriate for the definition of "participatory sensing"?
   a.   Helping scientists with sensor programming

   b.   Analyse the outputs deriving from the sensors

   c.   Monitoring environmental pollution

   d.   Emphasizes the active involvement of the participants in setting what will be collected and analysed

Q 4.   What are volunteered geographic information (VGI)?
   a.   Geospatial content generated by non-professionals using mapping systems available on the internet

   b.   Geospatial content generated by scientists

   c.   Geospatial content generated by public companies

   d.   None of the above

Q 5.   What is the main role of the "Community scientist" in the citizen science?
   a.   To provide scientific and methodological support

   b.   To train participants and ensure that the project's methodology, tools, apps, and websites are well understood

   c.   To support the development of apps and web-based data collection systems

   d.   To manage and promote communication on the main social media

Theme 4 Quiz Answers – Citizen Science and Participatory Engagement

Q 1. The answer is d) All of the Above
Parents and guardians can help children strengthen their knowledge by checking their science homework and becoming involved in activities at school, thereby enacting a version of citizen science partnerships. Adult citizens can share local knowledge with each other and agencies doing research, who may not have access to historical and local knowledge that they have. They are also called citizen scientists.

Q.2. The answer is d)
Passive Sensing relies on participants providing a resource that they own (e.g., their phone or space in their backyard) for automatic sensing. The information that is collected through these sensors is then used by scientists for analysis. But citizen scientists also observe and engage and make notes digitally or handwritten about their role in any given project that they then send to scientists.
https://www.wilsoncenter.org/sites/default/files/media/documents/publication/Citizen_Science_Policy_European_Perspective_Haklay.pdf

Q.3. The answer is d)
Participatory Sensing is similar to the previous type of observation but gives the participant more roles and control over the process. While many environmental and ecological observations follow data collection protocols that were designed by scientists, in participatory sensing the process is more distributed and emphasizes the active involvement of the participants in setting what will be collected and analysed.

Q.4. The answer is a)
Volunteered geographic information (VGI), that is, geospatial content generated by non-professionals using mapping systems available on the internet, offers possibilities for government agencies at all levels to enhance their geospatial databases. The presumed inaccuracy of VGI is often cited as a barrier to its wider use by official mapping agencies.
https://www.usgs.gov/center-of-excellence-for-geospatial-information-science-%28cegis%29/volunteered-geographic-information

Q.5. The answer is b)
Provides training to participants to ensure that the methodology is well understood and that the information in data sheets, apps, and website is understood by participants. The community scientist/citizen scientists can also help in framing the local problem as a research question that will be integrated into the project.
https://www.wilsoncenter.org/sites/default/files/media/documents/publication/Citizen_Science_Policy_European_Perspective_Haklay.pdf

Theme 4 Resources and References – Citizen Science and Participatory Engagement

https://imoox.at/course/AquaMOOC?lang=en , Aqua MOOC - Participatory Engagement with Water.

Green Paper on a Common Strategic Framework for EU Research and Innovation Funding. Brussels 2011 ISBN 978-92-79-20325-1. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52011DC0048 , this Green Paper launches a public debate on the key issues to be taken into account for future EU research and innovation funding programmes.

Green Paper on Citizen Science Citizen Science for Europe: Towards a better society of empowered citizens and enhanced research. Brussels 2014. https://digital-strategy.ec.europa.eu/en/library/green-paper-citizen-science-europe-towards-society-empowered-citizens-and-enhanced-research , this Green Paper aims to foster the interaction between the Citizen Science stakeholders and the EU policy officers, reinforcing the culture of consultation and dialogue in the EU.

Haklay, M., 2015. Citizen Science and policy: A European Perspective. The Woodrow Wilson Center. https://www.wilsoncenter.org/sites/default/files/media/documents/publication/Citizen_Science_Policy_European_Perspective_Haklay.pdf

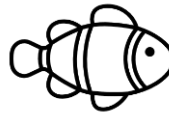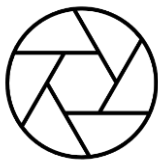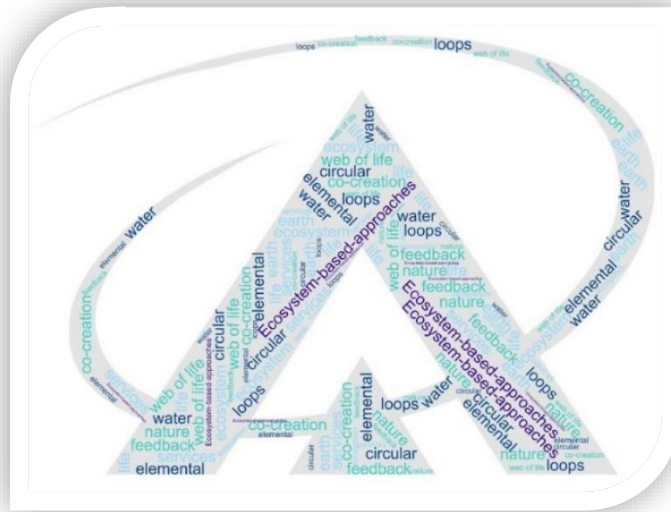Lewenstein, B. V. 2004. What Does Citizen Science Accomplish? In *eCommons: Open Scholarship at Cornell.* *https://hdl.handle.net/1813/37362*

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8.5 Ecosystem-Based Adaptations

Aim

The primary aim of this module is to explain what nature-based solutions/ecosystem-based adaptations approach to climate change hazards are, and how they can be implemented in Coastal City Living Labs.

Learning Objectives

- to understand what nature-based solutions are and how they relate to climate change.

- to understand what ecosystem-based adaptations approach is, how and why adaptations prefer to be implemented in the CCLL strategies.

- to engage the curiosity of citizen scientists, research scientists and stakeholders on ecosystem-based adaptations for research and practice.

Learning Outcomes for this Module

- to have developed understanding of nature-based solutions to climate change.

- to have developed understanding why the ecosystem-based adaptation approach is used within coastal city Living Labs in preference to more economic approaches.

- to demonstrate understanding that the ecosystem-based adaptations are not excluding other measures to climate change adaptation and mitigation, but complement them.

Before human-pushed climate change, the Earth's ecosystems had laid down Nature-Based Solutions (NBS) to its changing environment. Think about mangroves within tropical tidal land-sea interfaces, where the trees that have wide-spread standing roots provide nurseries for many aquatic species as well as with its foliage provide shelter for tree-dwelling species. Eliminate it and you have dramatic loss of biodiversity, release of once safely trapped carbon, and at the same time tides will facilitate coastal erosion. Yet another example that all Europeans might recognize is the rewilding of riverbeds and waterways. Over time human interaction adjusted various waterways for travel and economic purposes. And while the natural water flow has been changed and curves had been straightened, at the same time such interventions created stronger currents, and came at the cost of loss of biodiversity and more flooding. Re-wilding, often brings back the natural adaptive capacity of the ecosystems.

Nature-Based Solutions are often fed by knowledge on the Earth's ecosystem before human interaction, and refer to those actions that protect, sustainably manage, or restore natural or modified ecosystems, whilst simultaneously addressing societal challenges and providing human well-being and biodiversity benefits.

We now acknowledge and experience that the effects of climate change on both human and natural systems result in loss and damage to ecosystems, infrastructure, environment and populations worldwide. Coastal areas, where patterns of human settlements traditionally emerge, face various hazards like sea-level rise, coastal flooding, storm surges, erosion, and salination. The latter is the increase of salt content in soil and drinking water, an often-underestimated threat to human well-being in coastal areas. These coastal hazards and associated impacts have compounding consequences to society and the economy. With that, climate change adaptation – alongside climate change mitigation – is a necessary response.

NBS specifcallly addressing climate change are called Ecosystem-Based Adaptations (EBA). The overall EBA measures as an approach along-side takes into consideration specific geographical, institutional, social, and economic conditions. Besides, each urban system and ecosystem, depending on the time and purpose of its inhabitants, will want to implement local adaptations measures of either character: reactive, pro-active or anticipatory and/or a mixture of these, depending on the economic, political and other context.

The types of adaptation measures can be divided in:
- Hard measures that refer to physical interventions that are intended to prevent or contain hazards, often in the form of engineering-based solutions, like levees, dykes, seawalls, or breakwaters.

- Soft measures which are initiatives aimed at encouraging adaptive behaviour, like awareness raising, and institutional capacity building, land use planning instruments, or strategies and subsidies to strengthen building codes in the form of wet-proofing, dry-proofing, and building elevation.

- Ecosystem-Based Adaptation (EBA) approach that includes climate adaptation-specific NBS interventions implemented at the ecosystem level and often preserve ecological structure and biodiversity, and to ensure ecosystem functions and services provided. For example, shadowing streets by planting trees, green roofs, increase of green urban areas with parks. Also preserving marine species that help sustain a variety of aquacultures.

- Hybrid measures refer to the combination of previous adaptation options.

While the Nature Based Solutions (NBS) give inspiration to all these adaptation types, the EBA are the focus of SCORE. However, the CCLLs of SCORE will not ignore the potential of partnering with hard and soft NBSs, to propose mixed adaptation plans within each CCLL. In principle, EBAs will be considered that are - integrative approaches combining biodiversity and ecosystem services within climate change adaptation planning to promote urban capacities to adapt to climate change.

We have created a catalogue of EBA that includes their description, the objectives and the benefits giving photos and references that can be found online. It is an application to explore EBA measures for coastal areas within combined urban and natural contexts. The case study examples of the implemented measures can be explored through a map tour. The application also allows filtering the options by climate hazard and land category, or through a combined search.

SCORE EBA-Catalogue
From: https://storymaps.arcgis.com/stories/6cdbb2f6ab0744b89dffda2664dd877e
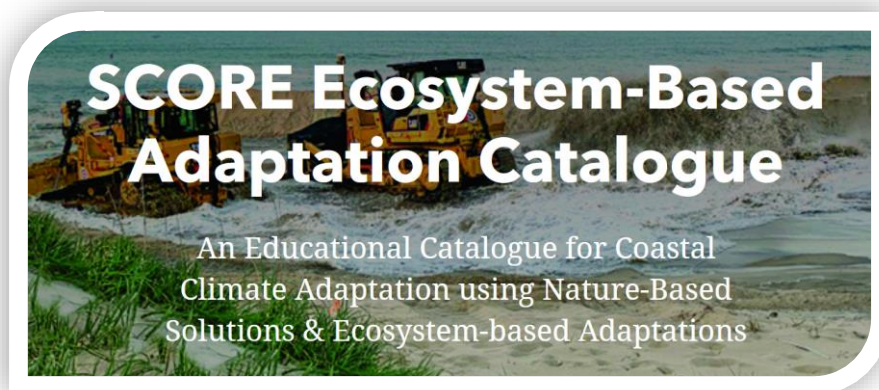
The benefits of implementing EBA are both direct: improving coastal resilience, mitigating greenhouse gases emission and improving biodiversity, water and air quality, and indirect: like enhancing critical ecosystem services, securing water resources to cope with drought and flooding and livelihood diversification to name but a few, it is mainly about the recently identified success factors. As to become successful the implementation of EBA requires involvement of stakeholders, the demonstration of private benefits and co-benefits and the use of trusted intermediaries. This is very much in line with co-creation, co-design, co-implement robust adaptation measures for each CCLL, while improving the social acceptance of such EBA measures (see also the module on CCLL). Linked to this is that stakeholder co-creation leaves opportunities to integrate smart technologies and twin solutions for instant monitoring and control (see the module on Smart Technologies, Co-Monitoring and Sensors) that assist citizens with the EBA integration, and altogether can enhance climate change adaptation and resilience.

Several webinars are available that explain in more detail the potential of ecosystem-based adaptation in coastal areas (https://www.youtube.com/watch?v=oeH3UVu4w8g), as well as integration in the co-creation and co-design approach with examples for nature-based solutions in cities (https://www.youtube.com/watch?v=oeH3UVu4w8g)

Theme 5 Quiz Questions – Ecosystem-Based Adaptations

Q 1.   What is an Ecosystem-Based Adaptation approach to Climate Change Adaptation?
a.   It is an approach which involves using nature for human profit and commercial purposes

b.   An approach that makes use of biodiversity and ecosystem services as part of an overall adaptation strategy to the adverse effects of climate change, and to increase resilience

c.   It is an approach which focuses on fossils to predict the future

d.   It is an approach which causes a lot of damage to living beings and the environment

Q 2.   What could be a Natural-Based Solution to water overflow in cities due to storm surges?
a.   Urban construction of a sports park

b.   Making retainer walls out of sandbags

c.   Expanding protected marine wetlands

d.   None of the above

Q 3.   What strategies can be used to prevent rises in sea level?
a.   Add anti-freeze to the ocean

b.   Reduce the coastal population

c.   Fix broken sewers

d.   Action to reduce global warning

Q 4.   Which of the following is an example of an effective Ecosystem-Based Adaptation to coastal erosion?
a.   Salmon farming

b.   Support of mangrove swamps between land and sea

c.   Urban development on beaches

d.   Banning humans from coastal areas

Q 5.   What effect could excessive salination bring?
a.   Higher flood

b.   Food insecurities and threats to human health and well-being

c.   An increase in production

d.   None of the above

Theme 5 Quiz Answers – Ecosystem-Based Adaptations

Q 1. The answer is b)

There are many working definitions of ecosystem-based approaches (EBAs) and climate change adaptations and/or nature-base solutions (NBS). What they share is development of integrated planning against climate change that involves the natural environment and what it can sustainably provide, in relation to human and other species and what they need. Climate change and global warming has increased the deployment of this methodology in research and practice. See for example: https://climate-adapt.eea.europa.eu/eu-adaptation-policy/sector-policies/ecosystem and https://climate-adapt.eea.europa.eu/metadata/publications/nature-based-solutions-in-europe-policy-knowledge-and-practice-for-climate-change-adaptation-and-disaster-risk-reduction

Q 2. The answer is c) or see below

C is the only correct answer, as it is the only NBS. See for example, the following website for more information about the diverse value of wetlands

https://www.ramsar.org/sites/default/files/documents/library/bn10_restoration_climate_change_e.pdf

Answer b) could partly solve the problem, although it is not always possible due to infrastructure limitations.

Q 3. The answer is d)

Sea levels have increased at most locations along the European coastline. This can be explained mainly by increases in mean local sea levels, found in recent data and simulations. Extreme sea levels can be further increased by storm surges and tidal changes, particularly along the northern European coastline. In the absence of better coastal protection, the sea level rise projected for 2100 will increase the frequency of extreme coastal flooding events by a factor of 10 to more than 1 000 along most European coastlines, depending on the location and the emissions scenario. One way to reduce this prospect is consistent action that reduces global warming activities, including NBS and EBA to adaptation.

Hotter global temperatures due to anthropogenic activities and industry are also melting land ice, like glaciers and polar ice caps, which adds more water to the ocean https://www.eea.europa.eu/ims/extreme-sea-levels-and-coastal-flooding and https://wxshift.com/climate-change/climate-indicators/sea-level-rise and https://sealevel.climatecentral.org/

Q 4. The answer is c) Mangroves

Mangroves are tidal swamp ecosystems that break the erosive force of tidal currents and storms, store carbon, and act as nurseries for young water animals and fish by providing natural protection against predators, enhancing biodiversity. They also build soil defences and bind them together with other microbes. Not common in Europe but essential defences in much of the Southern Hemisphere. Sea grass meadows are another ecosystem that operate in a similar way to mangroves, but from under the water. They both also provide a 'carbon sink' in which they take in and store the carbon from the surrounding areas. Please visit the following website for details about this unique ecosystem service:

https://www.google.com/search?client=safari&rls=en&q=mangroves+as+ecosystem+based+approaches&ie=UTF-8&oe=UTF-8 and https://www.wwf.org.uk/what-we-do/planting-hope-how-seagrass-can-tackle-climate-change

Q 5. The Answer is b)

Salinization is a major problem associated with irrigation, because deposits of salts build up in the soil and can reach levels that are harmful to crops. In addition, the salts can make ground water, which may be in use for drinking, saltier and unsuitable for drinking. https://science.jrank.org/pages/3694/Irrigation-problem-salinization.html#:~:text=Salinization%20is%20a%20major%20problem,saltier%20and%20unsuitable%20for%20drinking

Theme 5 Resources and References – Ecosystem-Based Adaptations

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8.6   Smart Technology, Co-Monitoring and Sensors
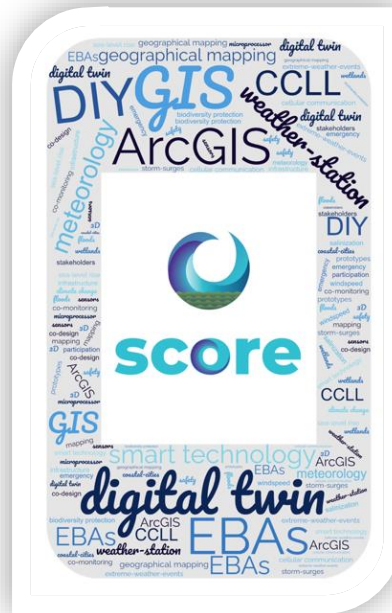
Aims

The primary aim of this module is to co-create sensors with citizen scientists so that they have the capacity to monitor weather and make extreme weather event predictions, to complement the data gained from high-end sensors.

Learning Objectives

- to develop understanding about how simple Do-It-Yourself (DIY) sensors can assist technological science in developing extreme weather warning devices.

- to empower local citizens to become competent in low-end co-monitoring practices.

- to consolidate engineering science and citizen scientist participation in climate change monitoring and adaptation strategies through co-design and co-creation.

Learning Outcomes for this Module

- participants will be able to understand the fundamentals of extreme weather sensing information, and will be able to identify different sensor apparatus.

- participants will become competent in DIY sensor device building and use.

- participants will be able to demonstrate understanding of sensor technology and share that information with others through community engagement.

The ever-growing populations and increasing human activities are associated with a major increase in negative impacts on the environment which are further exacerbated by climate change. We looked at this in the Module on the Past, Present and Future. However, these impacts are still poorly understood due to the complexity of the issues, both locally and globally. Conventional approaches to environmentally monitor are based on networks of sparse measurement stations or human-operated measurements. However, these are expensive and as a result, the environmental variables needed to understand the effects of extreme climate events on local ecosystems are not accessed.

Professional Research-grade Easy-to-deploy Weather Station Kit with Cellular Communication
From: https://www.onsetcomp.com/support/application_solutions/weather-station-kits

The good news is that current advancements in the area of low-cost IT technology are radically changing the conventional approach, allowing for the capture of real-time information that feeds into bigger sensor systems for data collection. An example of this approach is the use of low-cost weather stations to monitor several climatic variables (e.g. rainfall, wind speed and direction, temperature, solar radiation, humidity, etc.) at a local level. These devices can be connected to the home WiFi network and transmit the data to shared online platform in real time.

We have created a catalogue of DIY sensors that includes coverage on the monitored parameters, the installing complexity, their price range, and the climate hazards they could possible address. Including manuals, references and photos and it can be found online. It is an application to explore DIY sensors for coastal areas within combined urban and natural contexts. The application also allows filtering the options by climate hazard and environmental parameter, or through a combined search.

One such DIY low-cost sensor, developed by SCORE partner University College Dublin in Ireland, is the so-called smart Pebbles with which by and through citizens a portable sensor can be fabricated to monitor beach erosion. A video is available https://www.youtube.com/watch?v=gn34HiyhDWg. How to engage and empower citizens with low-cost sensors for monitoring climate change hazards is shown in this webinar: https://www.youtube.com/watch?v=-uuL2R38xj0

As such, citizens can take part in large scale research projects and/or monitoring activities by sharing the data they collect with their weather station. This active participation of citizens in research projects is generally called 'citizen science' as we discussed in one of the previous modules. There is no universally accepted definition of Citizen Science, but all the definitions agree on the main focus, which is the general public being actively engaged in scientific research activities.

SCORE Sensors Catalogue
From: https://sensors.score-eu-project.eu/
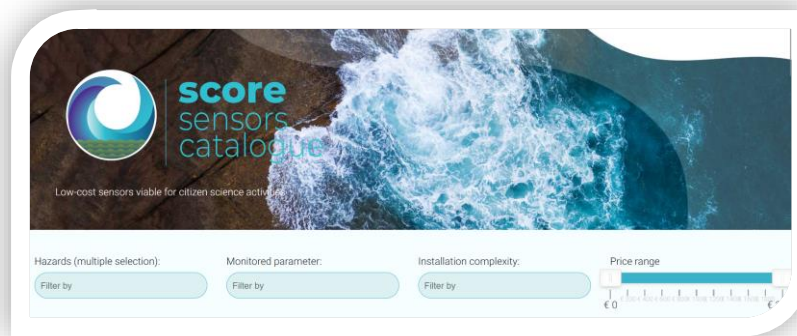
Citizen science activities are not only limited to the use of low-cost sensors and weather stations to monitor climatic variables. Citizen scientists now participate in projects on climate change, invasive species, conservation biology, ecological restoration, water quality monitoring, population ecology and monitoring of all kinds. Adding the skills of data collection from cost effective Do-It-Yourself (DIY) sensors, increases citizen participation in important research projects working on climate change adaptation. It allows research teams to benefit from the help of large numbers of people and collect data in wider areas, which would otherwise not be possible for the research team on its own. Citizen scientists are generally not expert researchers and users of the monitoring devices, so adequate guidelines have to be provided to ensure the data is collected following standards and procedures to ensure the quality.

This is where you come in, and why you are so valuable to our research practice. We invite you to join us to perform citizen sensing with a range of small smart sensing technologies. This means we will train you in the use of simple and some more elaborate sensing technologies to help us collect data. Some of the more simple forms of sensors are apps on smart phones, rain gauges, barometers and weather vanes. These are all useful devices that complement the information we can gather from more sophisticated sources. By joining both kinds of data we can create a more holistic picture of what is happening in the world of weather, and what can be predicted.

Citizens are increasingly interested in weather prediction due to the issues of climate change. This is especially real for coastal cities, where fishing communities, for example, are greatly affected by extreme weather events. Hence, the SCORE project is focused on coastal cities. Nowadays there are a lot of innovative applications and stakeholders that benefit from the data collected by citizens and by other sensors. An example of these are the digital twins (DT). A Digital Twin is an Artificial Intelligence (AI) virtualisation process and program (based on iterative optimisation) that uses historical performance and real-time data of the physical product, process, or service to create a virtual/digital representation. It enables the flow of data between physical and digital versions of the situation or the product, hence the name 'digital twin'. It helps to monitor and analyse systems to predict future scenarios to help prepare for otherwise unforeseen events. A video explaining SCORE's Digital Twin with applications of smart technologies against climate change is available: https://www.youtube.com/watch?v=XDHvaf7Im10 .

How citizen science environmental data collection through low-cost sensors is envisioned to be integrated in local user-driven coastal climate services that support early warning systems while integrating DT and smart technologies, including modelling and predictions, is readable here https://doi.org/10.3390/su16010335 .

Theme 6 Quiz Questions – Smart Technology, Co-Monitoring and Sensors

Q 1.   What is an example of a weather sensor?
a.   A home-made rain gauge

b.   A meteorological app

c.   A barometer

d.   All of the above

Q 2.   Why is it important to be able to predict the weather in coastal cities?
a.   To decide when is the best time to go to the beach for recreation

b.   To prepare for adverse storm effects such as broken roads and water mains

c.   To understand the effects of extreme climate events on local ecosystems

d.   All of the above

Q 3.   What is a digital twin?
a.   A robotic duplicate of a human being

b.   An engineering virtualisation process that uses real time data to create avirtual/digital representation

c.   A digital version of a hard copy text book

d.   A smart phone app

Q 4.   What is a characteristic of a smart sensing technology?
a.   It has a sensor (optical, infrared, temperature, pressure, level and proximity sensors, etc.) that captures data from the physical environment

b.   It has embedded computing resources (microprocessor) for onboard Digital processing of the output of the sensor via programming functions (software)

c.   It has communications capabilities to transmit data over the internet or a private network, and to interact to other external devices

d.   All of the above

Q 5.   What is citizen sensing?
a.   An activity in which citizens transfer data packages with their smartphones to check the Internet connection speed in their city

b.   An activity linked to citizen science in which people use low-cost and self-built (DIY) sensors or use their smart-phones embedded sensors, to monitor local environmental issues. It empowers citizens to share and use the data they collect through action, collaboration and changemaking

c.   An activity in which people use phone apps to play hide and seek and treasure hunt games

d.   None of the above

Theme 6 Answers – Smart Technology, Co-Monitoring and Sensors

Q 1. The answer is d) All of the above

Weather sensors of different kinds, measure wind speed and direction, barometric pressure, temperature, precipitation (or rainfall) and so on. There are of course many weather sensor devices including thermometers and weather vanes. Some are more sophisticated than others.

An example of DIY weather station based on Arduino Open-source electronic prototyping platform - Arduino Weather Station Temp, Pressure, Humidity, Windspeed:

https://www.hackster.io/WJLEX/arduino-weather-station-temp-pressure-humidity-windspeed-c95955
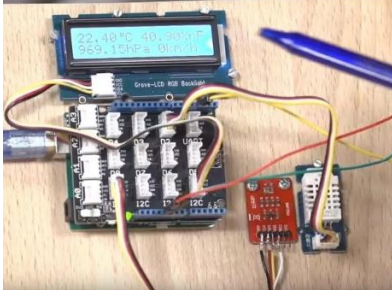
Q 2. The Answer is d) All of the Above

Predicting severe weather events has an impact on all aspects of urban and agricultural life, particularly in coastal cities. If roads are cut off and infrastructure is damaged due to storm damage several essential services cannot get through such as: emergency services; ambulance; food delivery and so on. Weather detection also informs the public of when it is safe or not safe to go for a bushwalk or to the beach. It also helps us to protect delicate ecosystems in advance.

https://ss2.climatecentral.org/#12/45.5898/13.6059?show=satellite&projections=1-K14_RCP85-SLR&level=5&unit=feet&pois=hide and https://sealevel.climatecentral.org and https://www.eea.europa.eu/ims/extreme-sea-levels-and-coastal-flooding

Q 3. The answer is b)

A Digital Twin is an Artificial Intelligence (AI) virtualisation process and program (based on iterative optimisation) that uses historical performance and real-time data of the physical product, process, or service to create a digital/virtual representation. It enables the flow of data between physical and digital versions of the situation or product, hence the name 'digital twin'. It helps to monitor and analyse systems to predict future scenarios to help prepare for otherwise unforeseen events

https://ec.europa.eu/info/sites/default/files/research_and_innovation/green_deal/gdc_stakeholder_engagement_topic_09-3_digital_ocean.pdf

Q 4. The answer is d) All of the above

It is a digital device with a sensor to collect data from the physical environment, a microprocessor that computes on the output of the sensor via programming, and a component with communications capabilities.

https://internetofthingsagenda.techtarget.com/definition/smart-sensor

Q 5. The answer is Answer b)

Citizen sensing, which takes elements from citizen science and participatory sensing, employs low-cost sensors to evidence local environmental issues and empowers citizens to take action using the data they collect. The emergence of sensing with mobile devices, low-cost and Do-It-Yourself (DIY) sensors, and open data platforms has enabled citizen participation in data gathering using these technologies. Citizen Sensing entails a collective endeavour for environmental monitoring using sensor technology in digitally advanced urban environments, reflecting on the motivations of citizens to sense their environment and allowing to create and understand datasets which are beneficial to them.

Theme 6 Resources and References – Smart Technology, Co-Monitoring and Sensors

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8.7   Glossary of Terms

Aims and Objectives of the Glossary

The primary aims and objectives of the Glossary listing accompanying the Learning Modules, are that the key terms related to climate adaptation will be easily understood and translatable.

The Glossary is arranged in English alphabetical order, with terms that are project-related and scientific, yet easily understood. In some definitions there are links to additional information. You can also find links to more information in the Modules and the Quiz questions and answers. These existing terms are relevant to your CCLL focussed on climate adaptation, to aid in building capacity for the terms related to this and future projects.

In brief the aims are:

- Relevance to the project
- Easily understood
- Translatable into other languages
- Build linguistic and scientific capacity
- Co-creation of meaningful terms (regarding climate change and CCLLs)

Anthropogenic/Anthropocene - the geological epoch in which human industry and behavior has had an adverse effect on climate and the environment, such as global warming, and sea level rise, that is unprecedented and challenges the future of life on earth.

Aquacultures are the communities of species that live in aquatic environments while fished, herded/controlled by humans for food.

Aquatic (water) footprint is the volume of water we waste everyday, or that we do not re-use. It can be measured individually or globally. Globally, it means the appropriation of fresh water in volumes of water consumed and/or polluted.

Aquifers are a layer of porous rock that both stores water and allows it to filter through underground rocks, gravels and caves.

Biodiversity loss is a decline in varieties, number and genetic variability and resilience of species in a particular area.

Citizen science (and citizen scientists) are everyday people from varying communities (for example fishing communities) that come together with research scientists, businesses and/or governance to co-develop solutions for environmental problems, by applying their local knowledge and lived experience to research processes that may include data collection and analysis.

Climate Change is a change or variation of the climate. Climate change may be caused by natural internal processes or by external forces, such as volcanic eruptions, or persistent anthropogenic actions imposed by humans, such as over industrialization and global warming.

> **Climate Change Adaptation** includes developing capacity within communities to respond to both the local and global changes in environments due to climate change issues. Adaptation strategies often include ecosystem-based adaptations (EBAs) approach along with social and political and economic re-evaluations and reforms.
> **Climate Change Exposure:** condition in which the system is exposed to the climatic phenomenon or trend because of its geographical location.
> **Climate Change Hazard:** a natural or human-induced event that may cause adverse effects on systems, such as coastal flooding, sea-level rise, coastal erosion, and storm surges.
> **Climate Change Impacts:** the impact of climatic events on the ecological, economic and socio-cultural aspects of a system.
> **Climate Change Mitigation** is action to reduce the overall amount of greenhouse gases released into the atmosphere. The result is the deceleration of climate change activities that result from human activities.
> **Climate Change Vulnerability:** predisposition to be adversely affected. Vulnerability is determined by sensitivity to damage and the lack of capacity to respond and adapt.

Coastal cities are those cities which lie at sea-level or close to sea-level and which might have a port.

Coastal City Living Labs or CCLLs are open urban spaces (or urban innovations ecosystems) that equally orchestrate activities and research between: citizens, businesses and industry, governance, academia and research science (sometimes called the Quadruple Helix Model) to co-create, test, and evaluate climate change innovations in a real life setting, for example, coastal erosion and flooding, and storm surges.

Coastal flooding is a situation in which a village, town or city at sea level becomes partially submerged due to the impact of adverse weather events and storm surges causing coastal flooding.

Coastal Erosion is the process by which local sea level rise, strong wave action, and coastal flooding wear down or carry away rocks, soils, and/or sands along the coast, that compromises and impacts shoreline stability.

Co-creation involves the Living Lab working with key audiences on a common problem towards a common goal, by identifying needs. Co-creation aims to develop results and knowledge flows across social, economic and environmental scenarios.

Co-design is part of co-creation and refers to the creativity of designers or people not trained in design, by working with trained designers in the development process.

Co-developing and Co-monitoring is the shared development and monitoring of a project, or an aspect of a project in collaboration with others from a diversity of backgrounds, including citizen scientists and research experts, governance and business.

Compromised infrastructure occurs in extreme weather events, where coastal cities infrastructure such, as sewerage pipes and buildings can be damaged, compromising the safe and hygienic passage of effluent, and also goods and services to and from the people.

Digital Twin (DT) is a computer programme (or virtual representation of the real world) that serves as the real-time digital counterpart of a physical object or process. It creates simulations to predict events and their variations under certain conditions.

Drinking water is clean and safe water for drinking and domestic household use, provided by city utilities, or rainwater tanks. In 2017, 71% of the planet had access to drinking water. By 2025, it is estimated that 50% of the worlds people will live in areas of high-water stress, meaning scarcity of minimal-quality drinking water.

Ecosystem Based Adaptations (EBA) are nature-based solutions (NBS) particularly on climate adaptation and make use of (or are inspired by) natural occuring ecosystems providing biodiversity and ecosystem services as part of an overall adaptation strategy, that results from the adverse effects of human induced climate change. EBAs increase resilience of one system or a collective of systems and work with nature, rather than against nature.

Ecosystems are units made up of living organisms and non-living components and their relationship with the physical, chemical and biological components of their environment or habitat. A river is an example of an ecosystem.

Early warning system describes technology required to create and disperse real-time warning information of dangerous events, to enable individuals, and communities, to make relevant preparations ahead of the environmental hazard that may reduce harm or loss to life and infrastructure.

Early Warning Support Platform is a non-civil support platform of all early warning capacity to inform of extreme weather events.

Earth is a planet also referred to as the: planet, world, Gaia, globe, terra firma. It is the most dense planet in the Solar System. It is made up of solids, liquids and gases and is the only planet so far to be populated by multiple life forms. In research we refer to the Earth as the planet we live on. When spelled with a small 'e', the inference, is earth as soil or solid ground of some kind.

Empowerment is a process by which everyday citizens feel supported and confident in their discoveries and activities in everyday life which includes valuing their contribution, self-determination, and autonomy.

End User(s) are those people identified as being in a position to apply a given unit of knowledge (Knowledge Outputs/KO) to create the desired eventual impact of that knowledge. The KO, and Key Exploitable Results (KER) may need to evolve in order to reach the end user, i.e., the person/s the product/service was designed for.

Environmental literacy is about understanding the movements of the natural environment, by listening, observing and trying to read natural phenomena, such as understanding the flows of a river – by reading the river. It is sometimes called eco-literacy, or water literacy.

Extreme events are unprecedented or predicted weather events, such as a storm surges or a Tsunami that effects the ecological, economic and socio-cultural aspects of communities.

Geographical Information Systems or **GIS** are digital frameworks that capture geographical data to develop maps, and helps users understand and analyze contextual geographic patterns and interactions.

IMOTEE is a learning framework that cycles through the following steps: **I**nvitation, **M**otivation, **O**rientation, **T**imeline Methods, **E**ngagement and Enactment, and **E**valuation of the learning scenario(s).

Indigenous is a term that relates to people, flora or fauna that are local to a specific area. For example, in biology, an indigenous tree species, is a species of tree that has its origin or home/place in a particular place.

Indigenous or First nations people are those who originate from a particular area. For example, The Inuit People are indigenous to arctic and sub-arctic parts of Greenland, Canada and Alaska.

Iterative feedback is where stakeholders refine and improve products/services based on feedback gathered from previous steps as part of a 'trial and error' process.

Knowledge Outputs (KO) are the desired results of the meaningful creation of knowledge.

Key Exploitable Results (KER) are the participatory process-integrated knowledge ready for further use and transferability.

Mitigation pathways, particularly those related to coastal flooding probability, aim to reduce the severity of environmental, social and economic losses caused by extreme coastal floodwater and other climate change damage. Early weather sensing systems are an example of mitigation pathways that can forewarn of impending extreme weather events.

Meteorology is a field of science that studies the atmosphere and forecasts the weather.

Multi-method approach is about the drivers for each CCLL, and that employ a range of methods and scientific disciplines towards a desired outcome.

Nature-Based Solutions (NBS) are natural landscapes and ecosystems that by their informed knowledge on nature and the health status of ecosystems can help prepare for stability across the economic, socio-cultural and ecological systems that support sustainability and adaptation.

Participatory engagement is the invitation to citizens to actively participate in research, joining the 'everyday-lived experience' of citizen knowledge, with research expertise to expand the base of knowledge in a given area, and recognize participants as part of the solution.

Prototyping is an experimental process where ideas are transformed from paper to product following the phases of Technological Readiness Levels 1-7 (TRLs).

Rain sensors can be simple or complex devices that detect rainwater volumes in a period of time.

Real-time Process allows real-time monitoring of environments under observation that integrates both environmental and weather models with real-time data, gathered from installed sensor networks.

Resilience (to extreme events) is the ability of a system and its component parts to anticipate, absorb, accommodate, re-organise or recover from the effects of a hazardous event so that they maintain their functionality, identity and structure, as well as conserving their capacity for adaptation, learning and transformation, within new parameters to respond to future challenges.

Sea-Level is the level of the sea which informs the height of geographical features such as mountains and cliffs. Towns and cities that exist at Sea level (such as each of our CCLLs) are considered to start at the level of the sea. Some slowly rise towards hills or cliffs, while others have a more gradual incline.

Sea-Level Rise occurs when temperatures rise as water expands and subsequently warms the water which then rise. The melting of ice caps and glaciers running off into the sea also contributes to the rise of sea level.

Sensors
Low-end low-cost DIY sensors are sensors to monitor environmental variables (rainfall, windspeeds, etc.) to be assembled by local communities using – Do-It-Yourself (DIY) off-the-shelf components. These sensors are considerably cheaper than the high-end sensor equivalents which are generally used by local authorities. But less accurate.
High-end sensors are complex institutional sensors applied to monitor environmental variables used by local authorities and professionals for environmental monitoring, reporting or alert purposes.

Stakeholders are all parties that either effect or can be affected by certain problems and their solutions.
Multi-stakeholder participation is the cross-collaboration between citizens, businesses and industry (small and large), governance, and academic/research science (The Quadruple Helix Model), representing a holistic view.

Storm surges are abnormal or unprecedented rises in sea level caused by the meeting of winds with ocean surfaces creating extreme weather events that rank in the 90-99th percentile over a measured period of time.

Sustainability refers to those economic, ecological and social practices that are life sustaining; in other words, the achievable balance, equity and access between the socio-economic, ecological and political needs. For example, Ecosystem-Based Approaches (EBAs) are part of sustainability plans along with socio-cultural practices (such as farming and fishing styles), and profit and loss margins of socio-economic factors. The Sustainable Development Goals (SDGs) put forward by the United Nations, outline key areas to be addressed for sustainable futures.

Water is unique because on Earth it comes as a solid (ice and snow), liquid (rain and dew) and a gas (clouds and vapour). It can be seen and unseen: Blue or visible water includes lakes, rivers, oceans; Green or invisible water is caught up in plants and so on; Grey water is water that has been used or polluted.

Water Cycle describes the journey of water from land and sea, through the atmosphere and then back to the surface of the earth. The water cycle involves several phases, for example: condensation, precipitation, evaporation, transpiration.

Water saving is one or a series of practices that aim to 'reduce, re-use or re-purpose' fresh water. For example, repurposing shower, bath and basin water to flush the toilet, saves fresh water and the pressure on city infrastructure, outflows to aquacultures of the sea, and so on.

Resources – Glossary of Terms

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https://sdgs.un.org/goals , United Nations, Sustainable Development Goals.

https://earthobservatory.nasa.gov/features/Water/page2.php , NASA Earth Observatory, A Multi-Phased Journey. The water, or hydrologic, cycle describes the pilgrimage of water as water molecules make their way from the Earth's surface to the atmosphere and back again, in some cases to below the surface.

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9. SCORE OUTCOMES AND TOOLS

The four-year SCORE project aiming to increase climate resilience in European Coastal cities had planned over seventy deliverables all describing the executed activities over the various work packages. While the deliverables are available on-line (https://score-eu-project.eu/deliverables/), additionally the content often led to produce outcomes and tools not originally planned and hence not included in specific deliverables. Many of these additional outcomes and tools can aid participants in climate-adaptive Living Labs to be supportive in reaching their goals, and educate further. This section is listing those outcomes and tools relevant to empowering stakeholders, and gives brief overviews with additional links to the more detailed content.

9.1 Co-Creation Toolkit

Cities, as highly complex and dynamic systems, influence and are influenced by many stakeholders that live, use and shape urban spaces. When managing and shaping urban development, co-creation is more than necessary so the complexity can be effectively tackled. The 'co-create your city' toolkit brings together a collection of tools for engaging stakeholders in co-creation in interactive, engaging, and attractive ways.

The Co-Creation Toolkit is available as the following website: https://www.ihs.nl/en/advisory-training-and-research/tools-and-toolkits/co-create-your-city-toolkit alongside audio and translation aid, and is also available as a video lecture here: https://www.youtube.com/watch?v=CdYEPVWmXco&t=18s , while creators can be contacted through Laura Quadros Aniche (quadrosaniche@ihs.nl).

The 'co-create your city' toolkit page provides to anyone interested in engaging in an integrated urban development process, incorporating social, economic, environmental and spatial dimensions, a set of tools for various different processes of urban development. The Co-Creation Toolkit is structured upon five core categories, depending on the target you may set for your co-creative activity. Those categories are: 'Need Identification & Analysis'; 'Ideation & visioning'; 'Strategy Development'; 'Prototyping & Testing'; 'Feedback & Evaluation'.

The tools are basically for anyone interested in engaging others in an urban development project, small or large, and this collection of tools can assist you in facilitating a multi-stakeholder process or activity related to urban development. The wide variety of tools range from 'Participatory Mapping' to 'Focus Group'; 'Roadmapping'; 'Blink Testing' to 'Dotmocracy', with every single category being aided by multiple tools, and each tool is provided with an in-depth exploration giving instructions how to execute, which materials are needed, providing tips and pinpointing limitations.

Need Identification & Analysis: The tools in this category will help to explore and uncover different needs, views, values, and goals the participants may have upon a specific topic/issue, help to understand and analyze the present and thus plan better for the future.

Ideation & Visioning: The tools in this category will help stimulate the participants' creativity in attractive and interactive ways to get inspiring and innovative ideas and solutions.

Strategy Development: The tools in this category will help the participants plan concrete actions for the future to achieve the goals of the project in the long run.

Prototyping & Testing: The tools in this category will help to experiment with the developed solutions or actions, testing them in a real-life setting.

Feedback & Evaluation: The tools in this category will help to evaluate your participants' reactions, preferences or oppositions towards the developed solutions or actions.

9.2 Ecosystem-Based Adaptation Catalogue

This tool is an educational catalogue for coastal climate adaptation using nature-based solutions and ecosystem-based adaptations.

The SCORE Ecosystem-Based Adaptation Catalogue tool is available through the following website: https://storymaps.arcgis.com/stories/6cdbb2f6ab0744b89dffda2664dd877e, is also available as video lecture here: https://www.youtube.com/watch?v=TqciUm3-Bv4&t=396s, while creators can be contacted through Mar Riera Spiegelhalder (info@ent.cat), Cécil Meulenberg (score@zrs-kp.si), Chiara Cocco (score@ucd.ie).

With the SCORE's Ecosystem-based adaptation (EBA) catalogue, participants are invited to explore EBA measures to address climate change hazards e.g., **sea-level rise**; **coastal flooding**; **land and river flooding**; **coastal erosion**, **storm surge**; **droughts and heatwaves**; **landslides,** occuring in urban and natural coastal areas.

This storyline provides an application to explore EBA solutions for coastal areas within combined urban and natural contexts. The case study examples of the implemented measures can be explored through the map tour. The application also allows filtering the options by climate hazard and land category, or through a combined search.

Multiple EBAs are grouped in six categories based on the landscape: **urban green**; **sustainable urban drainage systems** (SuDS); **river floodplains**; **wetlands**; **coastal shoreline**; **marine waters**.

The 'Case Study Map Tour', explores different EBA options by selecting a pinpoint and reading the description, objectives, benefits, and the picture related to the selected measure. Additionally, this tool allows to apply filters related to climate hazards and/or land typology and learn more about the suitable alternative options. An interactive map provides a global view of the case study locations illustrating deployed EBA.

The introduction, restoration, protection, stabilization and nourishment suggested through these EBAs is based on activities that encourage the use of indigenous and climate-resilient plant species and locally available resources.

Several webinars are available that explain the potential of ecosystem-based adaptation in coastal areas (https://www.youtube.com/watch?v=oeH3UVu4w8g), as well as integration in the co-creation and co-design approach with examples for nature-based solutions in cities (https://www.youtube.com/watch?v=oeH3UVu4w8g)

9.3 Sensors Catalogue

This tool lists low-cost sensors available for citizen science activities.

The SCORE Sensors Catalogue tool is available through the following website: https://sensors.score-eu-project.eu/, while creators can be contacted through Chiara Cocco (score@ucd.ie). How to engage and empower citizens with low-cost sensors for monitoring climate change hazards is shown in this webinar: https://www.youtube.com/watch?v=-uuL2R38xj0

The tool allows to apply filters for the selection of sensors according to the participant's interest. The filters are related to climate hazards (coastal erosion; coastal flooding; droughts and heatwaves; land and river flooding; landslides; sea level rise; storm surge), monitored parameter (water levels; surface waves; topography; precipitation; shoreline; soil moisture; water quality; atmospheric pressure; wind speed; wind direction; humidity; temperature; UV level; light intensity; water detection), installation complexity (very easy; easy; neutral; difficult; very difficult), and price range (0 to 2000 Euro).

Each low-cost sensor comes with a general description of application, technicalities and dimensions; operation instructions; and main features. The properties of the sensor and links to documentation are provided, as well as its operational complexities (addressing purchase, assembly/calibration, deployment, deployment costs, data analysis), and citizen science usage (activities, public assembly, public deployment, public data analysis, target users).

One such DIY low-cost sensor, developed by SCORE partner University College Dublin in Ireland, is the so-called smart Pebbles with which by and through citizens a portable sensor can be fabricated to monitor beach erosion. A video is available https://www.youtube.com/watch?v=gn34HiyhDWg.

9.4 Community Geosurveys

This tool empowers local communities and stakeholders to actively participate in urban environmental monitoring by collecting spatially distributed observations, ground-level data, and geotagged media focusing on local concerns, common interests, or identified data gaps crucial for their communities and local organizations.

The SCORE Community GeoSurveys tool is available at the following website: https://geosurveys.score-eu-project.eu/, by pressing the *Map Your Community!* -button, while creators can be contacted through Chiara Cocco (score@ucd.ie). How to use the Geosurvey in your Living Lab for engaging and empowering citizens is shown in this webinar: https://www.youtube.com/watch?v=-uuL2R38xj0 .

This participatory mapping platform facilitates the co-creation of data and local knowledge, engaging citizens in urban coastal sustainability efforts and discussions. It also enables place-based, data-driven dialogues within communities to better manage their places and resources.

The platform allows users to design their unique maps with customizable questionnaires and survey configurations, supporting the gathering of various types of data and content. It also offers diverse methods for community engagement and social interaction, including commenting, supporting or voting, and social sharing.

9.5 GeoDesign Game

This is an interactive tool designed to simulate urban planning scenarios, allowing participants to take on various roles (from authority to citizen to any optional community subpopulation) and collaborate on Ecosystem-Based Adaptations approach implementation strategies. The GeoDesign Game fosters a deeper understanding of planning complexities and local priorities by engaging communities and local authorities.

The GeoDesign gaming tool will be available through the following website: https://score-eu-project.eu/geodesign-game/, and creators can be contacted through Chiara Cocco (score@ucd.ie), with instructions of the game given here: https://score-eu-project.eu/wp-content/uploads/2025/01/SCORE-Geodesign-Game-Instructions.pdf.

The Geodesign Game is an interactive tool that leverages OpenStreetMap (OSM) to engage communities and local authorities in co-creating ecosystem based adaptation (EBA) solutions. Rooted in Geodesign and Serious Gaming principles, this digital platform facilitates participatory spatial decision-making by addressing conflicting perspectives and promoting collaboration.

Participants work together to propose, discuss, and vote on EBA solutions tailored to the region's specific ecological, social, and economic needs. This process encourages inclusive decision-making and fosters innovative, community-driven solutions for sustainable development.

The tool can facilitate different game sessions with different designs and objectives, adapted to the specific local area and using local languages.

Other example games for younger audiences are available here (https://score-eu-project.eu/communication-material/):

- SCORE Board Game (https://score-eu-project.eu/wp-content/uploads/2024/08/SCORE-Board-Game.pdf)
- SCORE Kid's Game (https://score-eu-project.eu/wp-content/uploads/2024/08/SCORE_kidsgames.pdf)

9.6 Multicriteria Analysis for Ecosystem-Based Adaptations Prioritisation

To prioritise EBA measures tailored to address the most relevant climate risk of each CCLL study area, the SCORE project adopted the Multicriteria Analysis (MCA) as a reliable method.

MCA offers a dynamic framework that facilitates inclusive decision-making by engaging relevant stakeholders with different backgrounds, knowledge, and professional expertise. It enables the integration of individual values, understandings, and perceptions, in order to rank and prioritise adaptation alternatives against a predefined set of criteria.

Thus, stakeholders assign values to indicate their preferences, enabling the integration of non-monetary metrics in the assessment. To ensure a comprehensive evaluation, the set of criteria encompass social, environmental, economic, and risk reduction implications.
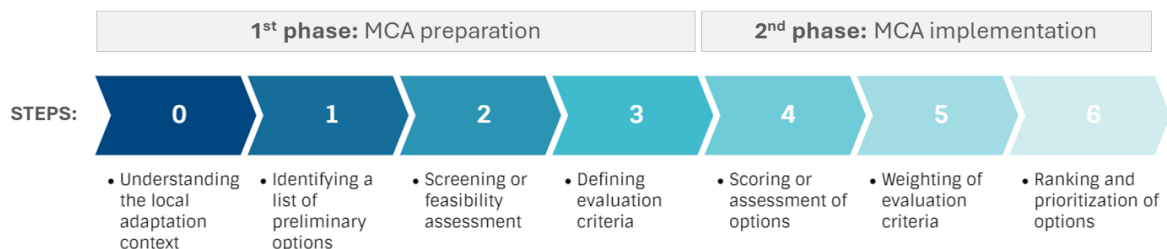
The SCORE CCLL MCA for EBA Prioritisation tool is described over two SCORE deliverables: D7.2 (D7.2 Methodological framework for the socio-economic assessment of adaptation measures to climate change) and D7.3 (Results from the participatory socioeconomic assessment of EBA interventions), describing both process and methodology in detail here: https://zenodo.org/records/11242292 , with more practical examples of the executed MCA processes over the 10 SCORE CCLLS showing the implemented results of the 10 SCORE CCLLs here: https://zenodo.org/records/14546380

Based on an iterative approach the users can **co-define**, **co-design**, and **co-create** climate change adaptation solutions with stakeholders from the Quadruple Helix group, comprising **industry**, **government**, **academia**, and **citizens**. The MCA iterative approach comprises a series of organised on-site and on-line participatory workshops with participation of selected stakeholders who evaluate and rank the proposed adaptation options.

The primary objective of the MCA is to address the most relevant climate hazard in the study areas and to propose suitable EBA measures to mitigate the associated risk(s). The MCA enables to serve a diversity of study areas, where geographical and socioeconomic features, climate hazards, and proposed solutions vary significantly across territories. For instance, while some regions might be interested to propose EBA options to address flooding and coastal erosion municipality-wide, others can focus on specific locations such as intermittent rivers, perennial rivers, or old town city centres, proposing measures for hazards such as inland flooding or droughts.

Hence, the MCA approach has been designed to be adapted to the different local contexts of the ten CCLLs.

The developed MCA methodology has been described in *D7.2 Methodological framework for the socio-economic assessment of adaptation measures to climate change* (Etxebarria et al., 2022), and basically unfolds in two main phases (preparation, implementation) by a sequence of seven steps. There is a preliminary step, step 0, to understand and define the study area, followed by 6 steps to prepare and implement the MCA.

	1st phase: MCA preparation			2nd phase: MCA implementation		
STEPS: 0	1	2	3	4	5	6
• Understanding the local adaptation context	• Identifying a list of preliminary options	• Screening or feasibility assessment	• Defining evaluation criteria	• Scoring or assessment of options	• Weighting of evaluation criteria	• Ranking and prioritization of options

Phase 1. MCA Preparation

0. Understanding the local adaptation context: The facilitators, based on the needs and preferences shown by the CCLL, co-define the study area and the objective of the exercise.

1. Identifying a list of preliminary options: inspired on the SCORE | EBA catalogue, the inputs from the CCLL, and the review of complementary practices when appropriate, facilitators elaborate a preliminary list of EBA options suitable to the case studies.

2. Screening of feasibility assessment: participants are invited to assess the proposed measures, scoring them from 1 (very low) to 5 (very high). The feasibility assessment criteria are: stakeholder acceptability; technical feasibility; ease of implementation; and financial feasibility. Either a paper and pen or an online voting tool (like Mentimeter) facilitate the collection of individual assessments. After presenting the results, discussion is initiated among participants to reach a consensus.

3. Defining evaluation criteria: The facilitators propose an initial set of criteria (about six), to be discussed and agreed with participants. The criteria are defined according to the potential benefits associated with the proposed measures. A list of criteria, closely related to ecosystem services, are organized into four core categories:

Risk reduction:
- Perception of risk reduction function concerning the primary hazard identified in the CCLL.
- Perception of risk reduction function concerning additional hazards identified in the CCLL.

Social implications:
- Increase in recreational opportunities.
- Improvement in social cohesion.
- Improvement in human health.

Economic implications:
- Creation of job opportunities.
- Reduction of public costs.
- Provision of goods (specify the good(s) according to the EBA proposed, e.g., timber, food, water, etc.).

Environmental implications:
- Maintenance and enhancement of biodiversity.
- Increase in habitat area.
- Water quality improvement (relevant depending on the hazard addressed).
- Air quality improvement (relevant depending on the hazard addressed).
- Carbon storage and sequestration.

Phase 2. MCA implementation

4. Scoring of EBA options: each EBA option is individually assessed by the participants in terms of its contribution towards the proposed criteria, using a scale from 1 (very low) to 5 (very high). Either a pen and paper or an online voting tool (e.g., Mentimeter) facilitates this process. Measures are then ranked, according to their aggregated mean score. These results are discussed among the participants to achieve a consensus.

5. Weighting of evaluation criteria: participants must show their preference for each of the criteria assigning a weight, being 0% the least preferred and 100% the most preferred. The sum of all weights must be 100%. The individual weighting is based on an online voting tool, followed by an overall weighting aggregation, which is open for discussion among participants.

6. Ranking and prioritization of options: The facilitators calculate the final score and ranking combining the scores given to EBA options (step 4), and weights assigned to the criteria (step 5). This is based on a weighted sum method, where scores for each criterion are weighted according to the mean value and aggregated on a linear function. The final ranking is reviewed by the participants to achieve consensus.

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10. SCORE ONLINE CONTENT

10.1 Massive Open Online Courses (MOOCs)

Continuing the brief introductory Learning Modules of part 2 and the short descriptions of the Output tools of part 3, **WP9 Dissemination, Communication, Exploitation** with input of the SCORE partners also established massive open-online courses (MOOCs) for which participants from around the world can learn more details about the specific topics of the SCORE project, utilising a variety of mediums, including videos, user forums, quizzes, reading materials, links to external supplementary materials.

Thus, the following overarching goals are addressed through the SCORE MOOCs:
- Increase knowledge of the CCLL concept and its functions.
- Increase knowledge of the usefulness and effectiveness of Nature-Based Solutions and Ecosystem-Based Approaches for coastal cities.
- Foster the utilisation and understanding of citizen science in climate change education.
- Cultivate an appreciation for how digital and green solutions can be used in tandem to tackle climate change.
- Raise awareness of the impact that the SCORE approach can have on local communities.

The MOOCs are available here: https://score.thinkific.com/ , also as part of a Deliverable from WP9 D9.4 Lectures and workshop materials as MOOCs (https://zenodo.org/records/11243000).

Course #1: What are Nature-Based Solutions?

https://score.thinkific.com/courses/what-are-nature-based-solutions

Also available in into Spanish and Catalan

Level of difficulty: Introductory

Target audiences: the general public, students, citizen scientists, municipalities / local policymakers, participants in CCLLs or Living Labs, and sustainability enthusiasts.

Objectives: The key learning outcome of this course is to provide learners with the necessary context to understand the role that Nature-Based Solutions and Ecosystem-Based Approaches can have in climate resilience. By the completion of the course, learners will have:

- Journeyed through the geologic past and uncovered how human activities have played a significant role in shaping the planet.
- Considered the essential workings of the water cycle, understanding that it has a profound impact on the health of the planet, influencing everything from climate patterns to freshwater availability.
- Gained a deeper understanding of the urgent need for sustainable solutions to safeguard our planet's delicate resources and ecosystems.
- Explored the concepts of Nature-Based Solutions (NBS) and Ecosystem-Based Approaches (EBAs).

Course #2: Ecosystem-Based Approaches: Introduction to Implementation

https://score.thinkific.com/courses/ecosystem-based-approaches

Level of difficulty: Introductory - Intermediate

Target audience: students, citizen scientists, policymakers, sustainability enthusiasts.

Objectives: The key learning objective of this course is to provide learners with a thorough understanding of what EBAs are and how they can be implemented into real-world scenarios. Through the completion of this course, learners will gain a comprehensive understanding of:

- What Ecosystem-Based Approaches are and how they are useful in creating sustainable, resilient, and adaptable communities in the face of a changing climate.
- The design, implementation, and evaluation of dynamic and collaborative Living Labs as a means to test and evolve various EBA solutions.
- The differences between co-creation and co-design, and how these processes are important to consider when developing solutions to climate challenges.
- Effective strategies for engaging with the public, including examples of citizen science and innovative uses of technology to reach new audiences.
- The importance of identifying and modelling disaster risk to inform more effective management schemes.

Course #3: Coastal Monitoring for Resilient Communities

https://score.thinkific.com/courses/coastal-monitoring

Level of difficulty: Intermediate - Advanced

Target audience: citizen science programme organisers, policymakers, technical teams within municipalities.

Objectives: The key learning objective of this course is to equip participants with the knowledge and skills needed to implement effective coastal monitoring strategies, leveraging innovative tools and community engagement to enhance climate resilience in coastal regions. Through the completion of this course, learners will gain a comprehensive understanding of:

- How to identify the key impacts of climate change on coastal communities to build resilience.
- Practical approaches for engaging local communities in coastal monitoring efforts.
- The latest tools and platforms for collecting, storing, and analysing coastal monitoring data.
- How technology can enhance both data accuracy and community participation in coastal resilience planning.

Course #4: Navigating LIving Labs: Lessons Learned from SCORE's 10 Coastal City Living Labs

https://score.thinkific.com/courses/navigating-living-labs

Level of difficulty: Intermediate - Advanced

Target audience: Those seeking to create and implement Living Labs or Coastal City Living Labs, such as policymakers, teams within municipalities, or academics.

Objectives: The key learning objective of this course is to provide learners with the key lessons learned from the creation, implementation, and evaluation of the 10 SCORE CCLLs. By sharing these experiences, this course aims to contribute to the broader Living Lab community, providing actionable insights for those looking to establish, manage, or refine their own co-creation practices. Through this course, a learner will discover:

- The key elements of a CCLL and the SCORE approach to LLs.
- How to navigate the different phases of a Living Lab, from the Problem Space to the Solution Space, including practical insights and best practices.
- The of role of Living Labs in European-funded multisite projects, compiling recommendations for designing and implementing Living Labs projects.
- Real-life examples of implementing and iterating technologies into a CCLL framework and the importance of local contributions.

Course #5: Serious Games for Participatory Planning

https://score.thinkific.com/courses/serious-games

Level of difficulty: Intermediate

Target audience: Those seeking to utilise unique tools for communicating complexities and gaining insights from stakeholders for participatory planning: primarily academics and public sector planners.

Objectives: The key learning objective of this course is to show learners the value of integrating serious games into stakeholder engagement and decision making. Through the course, a learner will understand:

- What serious games are and how they are of use in planning.
- How to facilitate a serious games workshop, with practical advice on best practices for ensuring stakeholder success.
- Two examples of Serious Games developed by SCORE – the GeoDesign Game and the EBA Craft Game – and their applications.

10.2 Webinars and Videos

Webinars and videos are available that support both visually and auditory the topics of the Learning Modules in section 8; the short descriptions of the Output tools of section 9; and the Massive Open-Online Courses (MOOCs) of section 10.1. An overview of the videos available, is given on the SCORE website (https://score-eu-project.eu/videos/), more specifically webinars and videos are available on the following topics:

Developing Coastal City Living Labs (https://www.youtube.com/watch?v=-isJ6p5axRE&t=12s)

Living Lab Integrative Process (https://www.youtube.com/playlist?list=PLUoJeHsSUlVHIQFwTpEymBD1X4mSB-0kL)

The Potential of Ecosystem-Based Adaptation in Coastal Areas (https://www.youtube.com/watch?v=oeH3UVu4w8g)

Co-Creation and Co-Design – Examples for Nature-Based Solutions in Cities (https://www.youtube.com/watch?v=oeH3UVu4w8g)

Risk Modeling and its Role in Designing Strategies to Increase Financial Resilience (https://www.youtube.com/watch?v=a_TsA0sUnDc)

Collecting and Managing Environmental Data: the SCORE ICT Platform (https://www.youtube.com/watch?v=u01wPhJ9u2U)

From Global to Local scale: Predicting the Effects of Climate Change on Coastal Cities (https://www.youtube.com/watch?v=hg3zuZdhfR8&t=2s)

Engaging and Empowering Citizens with Low-Cost Sensors for Monitoring Climate Change Hazards (https://www.youtube.com/watch?v=-uuL2R38xj0)

The SCORE Digital Twin - Application of Smart Technologies Against Climate Change (https://www.youtube.com/watch?v=XDHvaf7Im10)

Mapping the Baseline Exposure and Risk of Extreme Climate Impacts on Coastal Cities (https://www.youtube.com/watch?v=0a4qjama5O8&t=3s)

Tools to Enhance Climate Change Adaptation in Coastal Areas (https://www.youtube.com/watch?v=q4Lcg5u7ZUI)

Introduction to the SCORE project (https://www.youtube.com/watch?v=YLJCiwlZ0AY&t=11s)

SCORE presentation by the project coordinator (https://www.youtube.com/watch?v=tHIa4FppfWk&t=1s)

Meet the SCORE team with the SCORE Interview series (https://www.youtube.com/watch?v=3ioM3Z0LsFs&list=PLUoJeHsSUlVEF0GkX__DDH_TeYLAqDnxT&t=2s)

Smart Pebbles | Monitoring coastal erosion with students in Ireland (https://www.youtube.com/watch?v=gn34HiyhDWg)

10.3 Policy Briefs

Policy briefs on various climate change topics that were developed by the SCORE project or in collaboration with synergy projects are available here (https://score-eu-project.eu/other-publications/), and can be downloaded in PDF format:

When will a 2-meter rise in sea level occur, and how might we adapt? (https://score-eu-project.eu/wp-content/uploads/2023/03/Joint_policy-brief_Sea-level-rise.pdf)

ADAPT4COAST - Integrated strategies for climate resilience in EU coastal cities (https://score-eu-project.eu/wp-content/uploads/2023/11/Adapt4Coast-Policy-Brief-Final.pdf)

Joint Policy Recommendations on Climate Adaptation from European Coastal Cities (https://score-eu-project.eu/wp-content/uploads/2024/03/SCORE-OLLD-Policy-brief.pdf)

Nature-Based solutions for Resilient Coastal Cities (https://score-eu-project.eu/wp-content/uploads/2024/10/Seaties-NbS-Brief-DecisionMakers.pdf)

Deliverable D7.5 Policy guidelines aimed at different levels of governance, supported by evidence-based adaptation planning tools and use scenarios (https://zenodo.org/records/15640379) produced three policy briefs as part of Task 7.5 – Policy recommendations to assist decision-making in climate change adaptation at the local, national, and EU levels. Each brief targets policy makers at a specific level: EU, national, and local. More detailed background, such as how each recommendation was developed, SCORE's specific contribution, or the policy gaps being addressed, can be found in the actual Deliverable 7.5 Policy Guidelines.

10.4 Deliverables and Scientific Publications

SCORE produced many reports as project deliverables that go deeper in the briefly touched topics of sections 1 through 8. These can be found here https://score-eu-project.eu/deliverables/. Most of these can be downloaded in PDF format and include the references to the scientific literature available (for further, more detailed reading). A selection has been highlighted here, that can inform and aid all quadruple stakeholders in various degrees on the topics of section 1 through 8.

Regarding **Mapping of baseline exposure and risks of extreme climate impacts on coastal cities**:

D1.1 Literature review report (https://zenodo.org/records/11241846)

D1.2 Map and report of key climate-change hazards (https://zenodo.org/records/11241916)

D1.3 Map and report of baseline exposure and vulnerability (https://zenodo.org/records/13960772)

D1.4 Report of baseline risk analysis (https://zenodo.org/records/11241949)

Regarding **Coastal city Living Labs design, implementation, and evaluation**:

D2.3 Evaluation outcomes and sustainability plans of CCLLs (https://zenodo.org/records/15640023)

D2.4 CCLL Knowledge and Lessons Learned (https://zenodo.org/records/15640106)

Regarding **CCLL co-warning and comonitoring**:

D4.1 Citizen science playbook (this document)

D4.2 Catalogue of low-cost sensors viable for citizen science activities (https://zenodo.org/records/11242082)

D4.3 Citizen science DIY framework (https://zenodo.org/records/11242108)

D4.4 Citizen science activities press-release (https://score-eu-project.eu/wp-content/uploads/2024/01/D4.4.pdf)

D4.5 Citizen science activities in CCLLs (https://zenodo.org/records/13960815)

D4.6 Validation of citizen science data (https://zenodo.org/records/13960853)

Regarding **Strategies to increase the financial resilience of coastal cities**:

D6.1 Risk characterisation report for all CCLLs (https://zenodo.org/records/13960883)

D6.2 Exposure and vulnerability assessment methodology report (https://zenodo.org/records/11242238)

D6.3 Exposure database and vulnerability curves for the frontrunner CCLLs (https://zenodo.org/records/7494631)

D6.4 Residual risk assessment report for the frontrunner CCLLs (https://zenodo.org/records/13960892)

D6.7 Financial strategies selection tool (https://zenodo.org/records/13960908)

D6.8 Financial strategy and guidelines for CCLLs (https://zenodo.org/records/15640295)

Regarding **Socio-economic assessment of adaptation strategies and policy recommendations** :

D7.1 Synthesis of socioeconomic assessment methods, databases, and studies addressing EBAs and other adaptation strategies (https://zenodo.org/records/11242253)

D7.2 Methodological framework for the socio-economic assessment of adaptation measures to climate change (https://zenodo.org/records/11242292)

D7.3 Results from the participatory socioeconomic assessment of EBA interventions (https://zenodo.org/records/14546380)

D7.4 Results from the expert based socio-economic assessment of EBA interventions (https://zenodo.org/records/15640333)

D7.5 Policy guidelines aimed at different levels of governance, supported by evidence-based adaptation planning tools and use scenarios (https://zenodo.org/records/15640379)

Additionally, scientific publications from the SCORE project are listed here: https://score-eu-project.eu/scientific-publications/ and https://zenodo.org/communities/score-eu-project/records .

10.5 SCORE website and CCLL GeoStories

For more info on SCORE – Smart Control of the Climate Resilience in European Coastal Cities please visit: https://score-eu-project.eu/ or contact contact@score-eu-project.eu .

It is important to notice that the newsletters issued during the project remain available on the website (https://score-eu-project.eu/news/).

Also, each SCORE CCLL has a dedicated page with **GeoStories** where descriptions and updates on community CCLL interactions and events are reported (https://platform.score-eu-project.eu/catalogue/#/?f=geostory). **Often in their own words and their own languages! The described activities are an inspiration for freshly starting Living Labs.**

The final SCORE brochure presents an overview of the main results from the project and is available here (https://zenodo.org/records/15656049).

The SCORE final press kit is is aimed at the press and the general public, and presents each CCLL individually and is available here (https://score-eu-project.eu/wp-content/uploads/2025/06/Press-Kit-2025_SCORE-Web.pdf).

SCORE project's legacy towards the climate resilience of European coastal cities was released during the final SCORE event in Rimini, Italy on 16th of June 2025 is available here: (https://score-eu-project.eu/wp-content/uploads/2025/06/2025-06-12_Press-release-dates.pdf).