

City Living Labs for Sustainability and Resilience of Climate Change

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Abstract – Living labs are open (urban) innovation ecosystems in real-life environments based on a systematic user co-creation approach that integrates research and innovation activities in communities, actively involving all related stakeholders (e.g. users/citizens, knowledge institutes, public and private agents) to co-create, implement, test, and evaluate innovations in real-life situations, to address different issues. Living Labs operate as intermediaries among citizens, research organizations, companies, and government agencies for joint-value co-creation, rapid prototyping and/or to scale up innovation and businesses. Smart Control of the Climate Resilience in European Coastal Cities (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. CCLL is a new approach that expands the living lab concept 10 in coastal cities to address climate change adaptation and resilience issues. The intensification of extreme weather events, coastal erosion, and sea-level rise are major challenges to be urgently addressed by European coastal cities and Turkey. SCORE outlines a comprehensive strategy, developed via a network of 10 coastal city living labs, to rapidly, equitably, and sustainably enhance coastal city climate resilience through an Ecosystem-Based Approach (EBA) supported. Living Labs are user-centered, open-innovation urban ecosystems, where both public and private agents partner to address different issues. The aim is to establish a network of cities learning from one another. CCLLs have been implemented to tackle specific challenges related to sea-level rise, coastal erosion, and extreme events. Their effectiveness has been assessed by different agents through innovative monitoring systems and cutting-edge numerical modeling. Thus, citizens and stakeholders participating in the CCLLs will have access to technology to address climate change issues relevant to their region through participatory engagement.

Keywords – Living labs, climate resilience, ecosystem, SCORE project

I. INTRODUCTION

Living Lab (LL) is a design research methodology that aims to co-create innovation with the participation of conscious users in a real-life environment ([2]). LL, which operates in real-life conditions with a user-oriented approach; Its scope,

aims, objectives, continuity, degree of participation, boundaries are open to definitions by the

participants of the LL. Thus, a LL can be established on the street, in a home, within an organization, or to cover an entire city or industry, depending on a project. Sustainability is an important element of the

living lab phenomenon, and several studies have addressed this ([1], [2]). The concept of LL was first introduced by MIT Media Lab employee Prof. William Mitchell as “perceiving, sampling, validating and refining complex solutions in multiple and evolving real-life contexts as a research methodology”. However, the key features in an LL are: Real-life experimental approaches, Engagement and user engagement, knowledge collaboration and co-production. From a methodological perspective, LLs today are networks of heterogeneous actors, resources, and activities that combine user-centered research and open innovation ([3]). From an infrastructure perspective, they can be seen as facilities that provide experimentation and co-creation with users in real-life environments ([5]). Reference [4] mentions four types of LL. These are; guided by the user, guided by the electorate, Provider driven and consumer driven. Studies have shown that LLs with network structures based on extensive knowledge, information exchange and cooperation among many actors lead to radical innovative studies, while LLs with centralized network structure achieve more marginal innovative developments. ([6]).

There are living labs established and maintained in Turkey and around the world. Başakşehir Living Lab, which is Turkey's first Living Lab and opened its doors to the public in 2013, is an innovation and technology center within Başakşehir Municipality where products and services on information technologies and design are developed. This LL is an environment where information technologies and design products and services can be tested and developed in real-life environments with real users. It is an environment of experience, research and innovation that enables society to see the real added value of new products and services. Within Başakşehir Living Lab, studies on information technologies and design are carried out, and the main focus areas are: Smart Life, Smart Urbanism, Mobile Apps, robotics, Wireless Communication, Wearable Technologies, Design, Mobile Health, Smart Education and Information Technologies Trainings, Renewable and Smart Energy Systems, Sensor Technologies, Information Technologies and Software. Bodrum Living Lab (BOLL) is an application environment where innovative products are developed by real users in real use environments and aims to coordinate all the stakeholders of the

project (public, private sector, universities and local people). The idea of Bodrum Living Lab (BoLL) emerged following the long-term relocation of important actors of the Turkish entrepreneurship ecosystem to Bodrum during the pandemic process. And finally, Mesopotamia Living Lab (MLL) was established to create the Technology and Innovation Center structure. These LL principles; Discovering the most sustainable and restorative farming methods with eco technological agricultural research and practices, increasing the tourism awareness of the Mesopotamian region and Şanlıurfa metropolitan city, enabling young people to create their own employment by strengthening the entrepreneurial spirit and increasing initiatives in the field of technology, promoting Şanlıurfa from local / international platforms through local / global actors. We can list it as setting an example to the world as a co-existing and multinational metropolis by supporting and mentoring incoming immigrants.

Czech Living Lab is focused on collaborative spatial planning and effective forest and territorial management. Territorial/ spatial planning gives geographical expression to the economic, social, cultural, and ecological policies of a region. The living lab partnership includes several research institutions, businesses, and regional authorities in the Czech Republic Frascati Living Lab is located in the small town of the same name southeast of Rome, Italy. The living lab focuses on business incubation in peri-urban areas and precision farming in rural areas. Several stakeholders are involved in the innovation initiatives, including local actors facilitating business incubation, several science and technology centers, and small- and medium-sized agriculture-sector enterprises. The living lab has been in existence since 2006 and continues to date ([14]).

Living Labs are user-centered, open-innovation urban ecosystems where public and private agents partner to address different issues. Coastal City Living Lab (CCLL) is based on the Living Labs concept but focuses on co-designing and co-developing coastal city interventions and activities through novel Ecosystem-Based Approach (EBA). CCLLs have been implemented to tackle specific challenges related to sea level rise, coastal erosion, and extreme events. Their effectiveness is assessed by different agents through innovative monitoring

systems and cutting-edge numerical modeling. This study aims to explain the CCLL approach, which is the subject of a new LL concept, "Smart Control of the Climate Resilience in European Coastal Cities (SCORE)", which was accepted by Horizon 2020 and financed by the European Commission. There is an ongoing LL in Turkey as mentioned before, but with the SCORE project, the CCLL, which is aimed at increasing the resilience to climate change, is aimed to be established in the Kızılırmak Basin in Samsun.

II. MATERIALS AND METHOD

The increase in extreme weather events, coastal erosion and sea level rise, and the occurrence of coastal and sea floods are among the issues that need to be urgently addressed by coastal cities. 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 through a network of 10 coastal city "living laboratories" (CCLLs) to improve coastal city climate resilience. SCORE is a European project on coastal city climate change adaptation in line with the Paris Agreement, by creating a coastal zone management framework to strengthen EBA and smart coastal city policies. Coastal City Living Lab (CCLL) is a new concept that aims to apply the Living Lab approach to coastal cities and settlements. CCLLs will be established to address climate challenges in 10 different cities and the effectiveness of the solutions to be achieved will be evaluated by different stakeholders through innovative monitoring systems and cutting-edge modeling approaches.

SCORE will develop CCLLs in a network of 10 disparate cities given in Table 1. SCORE will incorporate citizen science in providing early warning systems for coastal cities and enable immediate monitoring and control of climate resilience in European coastal cities through open, accessible spatial 'digital twin' tools.

In the SCORE project, it is aimed to establish a living laboratory in coastal cities of Europe and

Turkey to increase resilience to climate change. This study examines the concept of a city living laboratory and its success factors through a Samsun CCLL case study.

Table 1. Coastal City Living Labs (CCLL).

Country	City	Hazards
Ireland	Sligo	Coastal and land flooding, coastal erosion, coastal storm surge
Ireland	Dublin	Coastal erosion, coastal storm surge
Poland	Gdansk	Coastal and land flooding
Turkey	Samsun	Coastal and land flooding, coastal erosion
Slovenia	Koper	Coastal flooding, coastal storm surge
Italy	Massa	Coastal and land flooding, coastal erosion, coastal storm surge
Portugal	Oeiras	Coastal and land flooding, coastal erosion, coastal storm surge
Spain	Benidorm	Coastal flooding, coastal erosion, coastal storm surge
Spain	Barcelona	Coastal and land flooding, coastal erosion, coastal storm surge
Spain	Oarsoaldea	Coastal and land flooding, coastal erosion, coastal storm surge

A. METHOD

SCORE was based on co-design, co-development, deploying, testing, and demonstrating innovative EBAs, smart technologies and hybrid Nature Based Solutions (NBSs), while facilitating financial sustainability. This Framework comprises theories and practices and the methodology known as the Living Lab Integrative process, together with a toolkit for implementation. The Living Lab Framework ensures enhanced stakeholder and citizen ownership of solutions through effective, systematic involvement in co-design, co-development and co-implementation.

SCORE was based on the novel concept of a CCLL that expands Living Labs to a wider vision for coastal cities and settlements (Fig 1). This type of approach will facilitate the interaction between stakeholders, bringing together all actors in the coastal area, whether we are talking about academia, the civic sector, state actors, or the business sector ([12]). 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 will be implemented to tackle specific challenges related to sea level rise, coastal erosion and extreme events

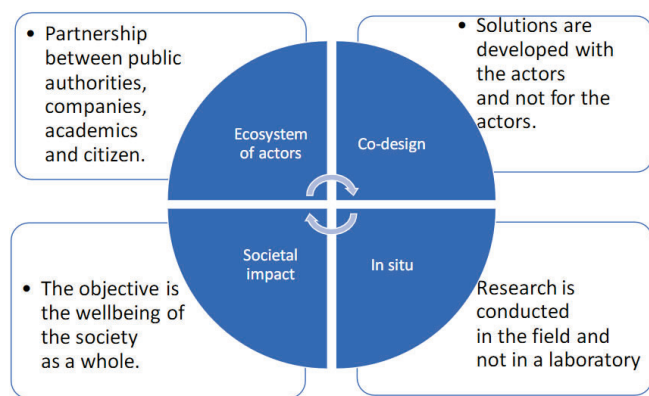


Fig. 1 Key characteristic of Living Lab

B. CITIZEN ENGAGEMENT

The stakeholder engagement process is essential both in setting up a Living Lab and also in developing innovative solutions within the Living Lab. The scoping and identification of the needs of the actors in the Living Lab is a key part of the framework and an important step in the methodology. The aim of citizen engagement is to give citizens the opportunity to decide on the solution that will affect their life later-on. By doing this, the possibility of acceptance and success of the developed solution increases. This engagement can be put into six main categories (Table 2) ([7]).

Table 2. Citizen engagement categories.

No engagement	Symbolic engagement	Engagement by advice	Engagement by weak control	Engagement by doing	Engagement by strong control
Citizens are unwilling or not invited to be engaged in the development	Input from the citizens is requested but not used	Citizen's advice is asked by using interviews or questionnaires	Citizens have more responsibility in the solution development but they can "sign off" at any stage	Citizens are active participants in the solution development and influence decisions in all stages	Citizens have the decision making power and the outcome is influenced by their ideas, needs and expectations

C. CO-DESIGN AND CO-CREATION

The terms co-design and co-creation are often confused and sometimes treated synonymously with one another. Co-design is a specific instance of the broader concept of co-creation and refers to the creativity of designers and people not trained in design working together in the design development process. Co-creation is understood as a process that, based on the identified needs, aims to develop results that involve knowledge flows and absorptive capacities from all actors involved across the entire economic and social environment, referred to the addressed needs ([21]). In the case of SCORE, co-creation was the outcome of the process where different knowledge, values, and expertise evolve to

build a consistent and sustainable CCLL. Moreover, SCORE, the solutions needed to adapt to the climatic hazards each Coastal City faces was co-designed through the CCLL (Fig 2).

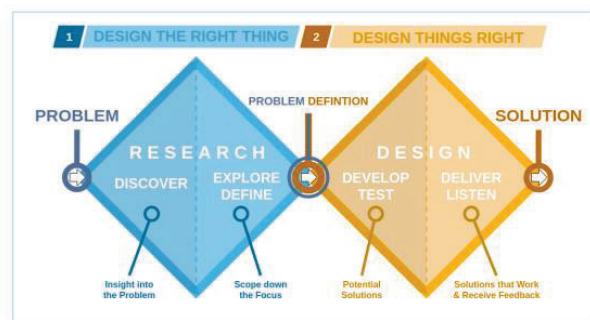


Fig 2. Double Diamond Design Process Model ([19]).

D. COMMUNITY BASED SOCIAL MARKETING

Community-based social marketing (CBSM) has shown to be very effective at inducing behavioral change due to its pragmatic approach ([13]). CBSM is grounded in social and psychological understandings of human behavior. It involves targeting a specific action and then using various tools to reduce barriers to and enhance the benefits of that action ([18]).

Living Lab uses these methods and there are 4 main steps: Uncovering barriers to behaviors; Selecting which behavior to promote; designing a program to overcome the barriers to the selected behavior; piloting the program; Evaluating it once it is broadly implemented.

E. ECO-SYSTEM BASED APPROACHES (EBAs)

Ecosystem-based adaptation (EBA) is among the fastest-growing adaptation concepts around the world ([8]), based on its cost-effectiveness, multiple benefits, and a wide range of applications in different landscapes ([9]). The EBA entails incorporating biodiversity and ecosystem services into the broader adaptation strategy (Fig 3) ([10]; [11])

EBA was an integrative approach combining biodiversity and ecosystem services within climate change adaptation planning to promote urban capacities to adapt to climate change ([20]). Integrating the EBA concept can play a crucial role in achieving wider ecosystem restoration and livelihood goals that a single system cannot reach.

Furthermore, placing ecosystem-based adaptation in the middle of the nexus could help policy planners and decision-makers to design intervention pathways that could lead to multiple environmental and livelihood benefits.



Fig 3. Nature-based Solutions as an umbrella term and conceptual framework for ecosystem-related approaches ([11]).

F. LIVING LAB INTEGRATIVE PROCESS-DESIGN THINKING

Design thinking involves a human-centered vision of innovation, which seeks to establish creative ideas and effective business models that are focused on people’s needs. In the case of Living Labs, the research identifies citizens’ problems or desires and considers them from the perspective of their target users [12]). Some publications pair the living lab methodology with design approaches such as human-centered design ([15]), whereas others see design methods such as design thinking and participatory design as the core methods applied within a living lab structure ([16]; [17]). The SCORE project has adopted and implemented the design thinking-focused Integrative Living Lab Process approach at CCLL, which was established in 10 cities (Fig 4)

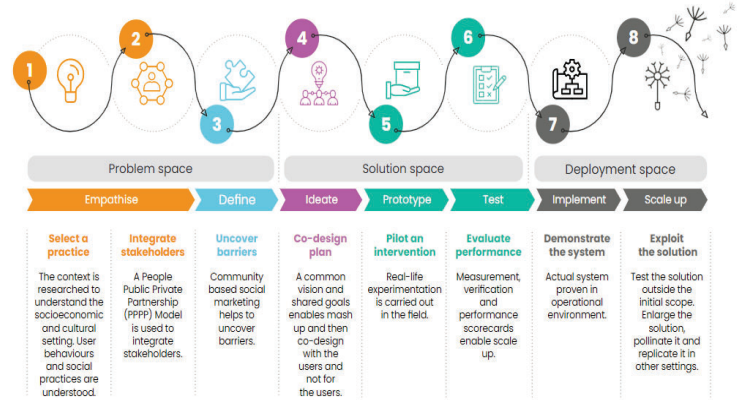


Fig 4. CCLL process monitoring.

III. RESULTS

SCORE was based on the novel concept of a CCLL that expands Living Labs to a wider vision for coastal cities and settlements. CCLLs were based on the Living Labs concept but focused on co-designing and co-developing coastal city interventions and activities through novel EBAs. CCLLs have been implemented to tackle specific challenges related to sea level rise, coastal erosion, and extreme events.

Case Study: Samsun CCLL

Samsun is a city on the north coast of Turkey with a population of around 1.4 million people (Fig 5). It is known that coastal and land flooding and coastal erosion, which are among the identified disasters, cause distress in agricultural areas and loss of cultural heritage.



Fig 5. Samsun Province and Kızılırmak Delta.

To specify the particular objectives for creating and implementing Samsun CCLL, first of all we have revealed the effects and problems caused by climate change in the Kızılırmak Delta. In this way, it was tried to increase the sustainability of the delta by determining the solutions that can be produced against the problems related to climate change. In the meantime, the primary aim is to increase local awareness and contribute to the public in the process of both revealing the problems and producing solutions. During this process, the main challenges posed by the project were identified a) Obtaining the necessary permissions from the state to monitoring and obtaining data for the protected areas in the study area by implementation of new technologies b) Receiving the support of the local administrators in the solution development phase and enabling them to contribute to the project and c) Casualness or resistance of local people to field studies, not being open to cooperation. For these reasons, separate workshops were held in 10 different CCLLs and interactive studies were carried out on the titles of "empathize and define". In Samsun workshop which is held in 23-25 May 2022, the Samsun CCLL team developed their vision-mission which is "A self-sustaining Coastal City Living Lab implementing a roadmap of cooperation among all stakeholders to plan, design and scale up nature-based solutions towards social, economic and environmental resilience of the communities living on the Kizilirmak Basin". To achieve this vision and mission, goals were set at the beginning of the road to increase success which are given in Table 3.

Table 3. Developed goals for the mission and vision.

No	Strategic Goals
1	To build a self-sustaining management board by establishing partnerships with committed stakeholders to get financial and technical support from internal and external resources.
2	To strengthen the knowledge and technical capacity on nature-based solutions by improving the CCLL capacity to produce, collect and share climate-related data.
3	To raise awareness on climate change risks and hazards in the Kizilirmak Basin area and to share

learning experiences on successful climate adaptation solutions.
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To be able to reach the strategic goals, the Samsun CCLL has further defined specific objectives which includes:

- To develop partnerships between public authorities, companies, academics, and citizens, in short, to make collaborations with stakeholders and start to co-creation of the Samsun CCLL.
- To enable a wide range of people to make a creative contribution in the formulation and solution of the problems and challenges.
- to implement and monitor the nature-based solutions produced during the co-design period.
- To produce solutions to protect the coastal line so as to prevent the destruction of the delta soils.
- To list the climate-related problems which is a habitat for many living things in the Kizilirmark Delta areas
- To inform decision makers and administrations against these difficulties.

Stakeholder identification, mapping, and prioritization studies were carried out to help Samsun CCLL achieve its vision-mission-goals. Then, the CCLL created a management structure, and important stakeholders were identified (Fig 6). In addition, operational planning was made for Samsun CCLL. It was determined the most appropriate communication channels for the stakeholders; include emails and mailings (with the SCORE/CCLL Logo), telephone, in-person, social media, and social networks.

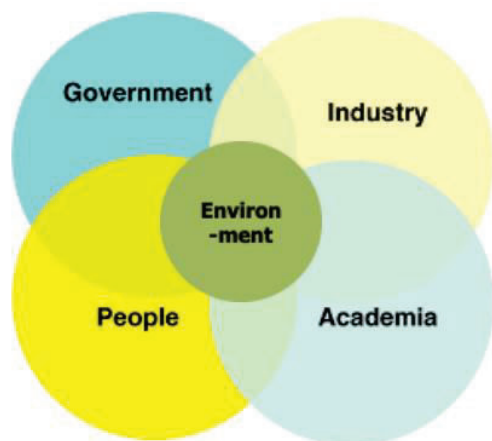


Fig 6. CCLL management structure

IV. DISCUSSION

Biodiversity and ecosystems play a fundamental role in building and increasing the resilience of coastal cities to the adverse effects of climate change. This role is crucial for areas like the Kızılırmak Basin, which are the most vulnerable to the impacts of climate change in our global community and whose ecosystem-dependent livelihoods are already threatened by a combination of climate change and other pressures.

In this study, the concept of Coastal City Living Lab, which is being established within the scope of the SCORE project, is explained and the brand new Samsun CCLL which was established under the SCORE project network is given as a case study.

Samsun CCLL has identified the potential challenges or risks that could prevent it from reaching its objectives, including governance, efficiency, commitment, and short versus long-term focus. These difficulties can be overcome by activities such as increasing focus group and bilateral discussions, ensuring participation in workshops and webinars, and planning social activities.

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