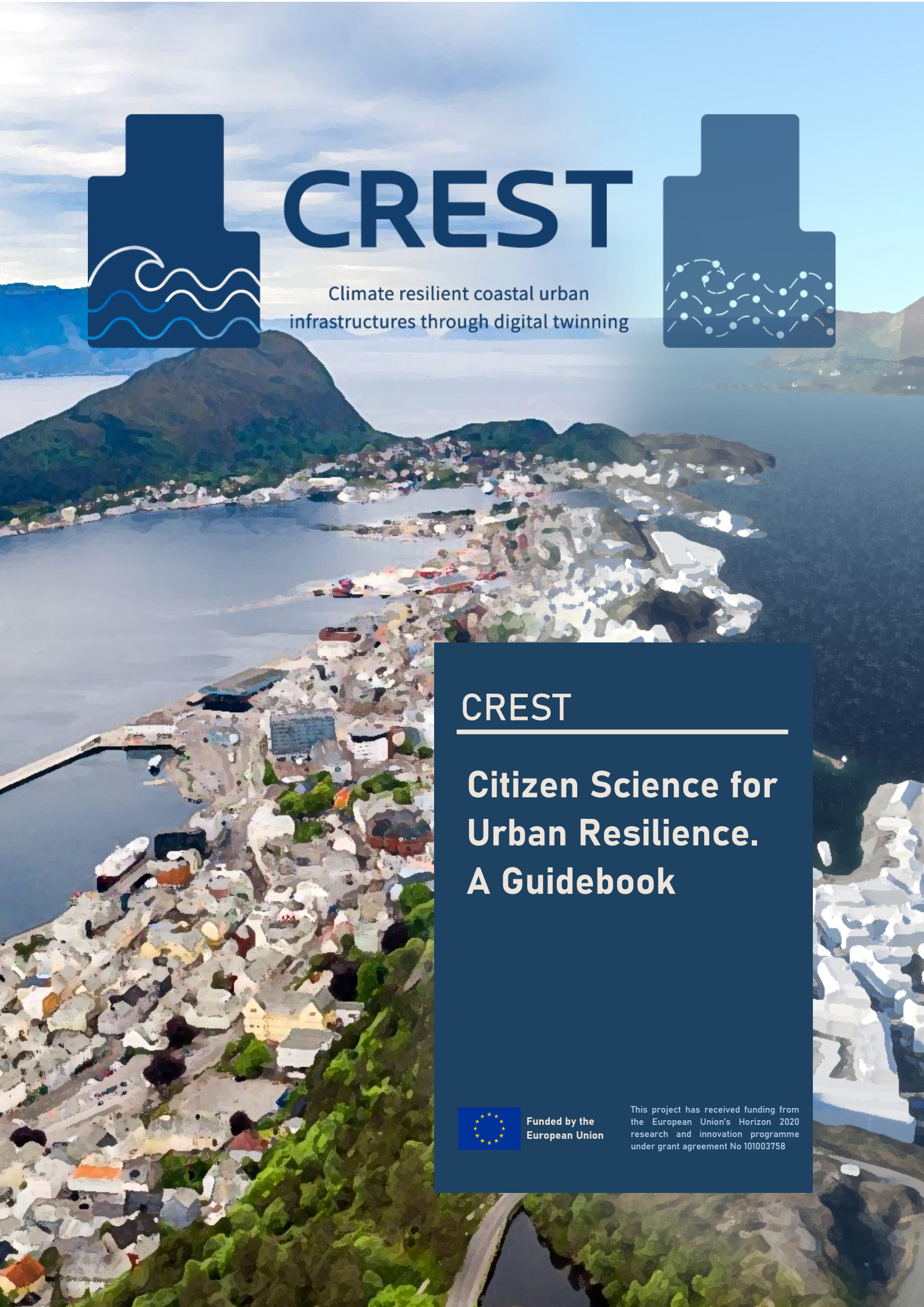

CREST

Climate resilient coastal urban infrastructures through digital twinning

CREST

Citizen Science for Urban Resilience. A Guidebook

Funded by the European Union

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Citizen Science for Urban Resilience. A Guidebook

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GMINA KOŁOBRZEG

INnCREASE

Accent Sud

IRMiR INSTITUTE OF URBAN AND REGIONAL DEVELOPMENT

INRAE science for people, life & earth

BxSE Bordeaux Sciences Economiques Bordeaux School of Economics

cnrs

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„Change is the only constant in life”

Heraclitus

„Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has”

Margaret Mead

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Introduction

The project *Climate-Resilient Coastal Urban Infrastructures Through Digital Twinning* (CREST) consisted of researching urban 'resilience' in the context of climate change in selected European coastal areas (Bordeaux, Kołobrzeg, and Kristiansund) between 01.04.2022 and 01.04.2025. Our main goal was to develop an effective and possibly universal model of cooperation between various urban stakeholders, supported by digital tools so that the resilience of these communities and the cities they inhabit increases in response to current climate challenges.

Anyone who has ever (co-)organised similar projects involving various urban stakeholders knows that mistakes can occur at different the project stages. These mistakes can significantly reduce the effectiveness of the entire project and make the social collaboration process less efficient. Despite our best efforts, these activities do not bring the expected results. This is why we decided to develop this guide, hoping that such a systematic approach to assessing the benefits and challenges of our project can be helpful in other projects and processes.

The aim of the Guidebook is, on the one hand, to provide information about the results of the CREST project, urban resilience issues, the organisation of co-creation processes and social dialogue, and the potential use of digital technologies in these areas. On the other hand, the Guidebook has a practical dimension. The objectives and tools of the proposed MOST model for increasing urban resilience may be applied in other cities, while the proposed conclusions and recommendations for local authorities can help to draw attention to the most important components and risks of designing and implementing climate protection measures and avoiding the past mistakes.

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What Do You Need to Know to Get Started?

What is Citizen Science?

Citizen science is defined as:

"The involvement of citizens or communities without specialised scientific training in various stages of scientific research: the formulation of research questions, the collection/interpretation of data, the publication of results" (Haklay, 2015).

According to the definition, citizen science (CS) is the co-creation of knowledge with the public to broaden the perspectives of those involved in the scientific process. Bridging the gap between science and societal needs is the first step towards expanding knowledge in various fields, including digital technologies. The creation of a communication platform based on cooperation and partnership between scientists and representatives of various social groups participating in scientific projects provides an opportunity for dialogue that reduces barriers related to a lack of understanding of the needs of specific groups while dealing with scientific correlations within a given research topic. The quality of this relationship is particularly important not only at the level of exchanging information and co-creating solutions, but also in the processes of implementing the achieved results and popularising them. This mainly refers to the applying of science in everyday life and the developing a knowledgeable and educated society. The participation of the public in the research process provides the opportunity to verify the assumptions made, introduce the perspective of research beneficiaries, or evaluate the entire research process.

For many years, the development of digital technologies has provided opportunities to create constantly improving platforms enabling data collection and sharing on an ever-increasing scale. This can be achieved through crowdsourcing, which involves collecting information or opinions from a large group of people who upload their data via the Internet, social media and smartphone applications. Examples include Wikimedia Commons, which allows users to share multimedia such as photos, videos and audio files, creating a publicly accessible and free collection of resources. On the other hand, OpenStreetMap is a crowdsourcing project where users create and update geographical maps, making them available to others free of charge and supporting the development of open map resources worldwide.

The citizen science approach refers to collaborative research efforts between **professional researchers** and **citizen researchers**, serving as a valuable way to expand scientific knowledge and scientific education. This method, as an approach that supports professional researchers' data collection methods, is gaining popularity in many countries. Different research projects tend to attract slightly different types of participants, depending on the nature of the project and its subject matter. However, the most important thing is that the residents' strong identity and attitudes favour this type of method while increasing the trust in the research results obtained in this way among other residents.

The civic approach supports forming an information society and developing civic attitudes. Making science more open is increasingly viewed as a way to positively influence the level of public trust in science.

The majority of citizen science projects are typically rooted in areas related to biology. In recent years, however, there has been a noticeable increase in interest in this methodology in various disciplines, including the social sciences.

As a rule, citizen science projects simultaneously serve scientific, educational, civic, and recreational purposes, although the emphasis on individual objectives may vary.

INTERESTING FACTS ABOUT CITIZEN SCIENCE

The term *"Citizen Science"* was first used in 1989 in the MIT Technology Review, to describe initiatives by local community labs to study environmental issues.

One of the best-known projects is Zooniverse, a platform that engages people in activities such as classifying galaxy images, transcribing diaries from World War I or identifying animals.
Between 2007 and 2014, more than one million people participated in the project.

Since the 1990s, interest in citizen science has steadily increased. In 2016, the Council of the European Union recognised citizen science, along with open access, reuse of research data, and reliability and integrity of research, as an important element of open science and part of the implementation of European innovation policy. Today, the development of citizen science is one of the eight key challenges identified in the European Union's open science policy.

The goal of including citizens in the field of science is, among other things:

- to raise new research questions,
- to address issues that are important to society,
- to increase the scope of conducted research (including expanding the extent of generated knowledge),
- to promote an interdisciplinary approach to research,
- to transform one-way scientific communication into a dialogue with members of the public,
- to promote scientific knowledge in society,
- to increase the level of understanding and trust in science among the public,
- to increase the use of scientific solutions in everyday life by individuals and in the activities of public institutions and market organisations.

Of course, being aware of the challenges associated with citizen science applications is a good idea. Here are some of the most important ones:

- Data quality and standardisation: citizen science projects often involve information collected by non-professionals with varying levels of expertise. Ensuring data quality and standardisation can be a significant challenge. Open repositories must implement data verification and validation measures to maintain data integrity and reliability. Clear data collection protocols and quality control procedures must be established to minimise errors and inconsistencies.
- Privacy and data security: citizen science projects may involve sensitive or personal data, particularly in health or social science areas. Ensuring the appropriate anonymisation of information, obtaining informed consent, and complying with data protection laws are essential to protecting participants' privacy and maintaining ethical standards.
- Data ownership and intellectual property. Citizen science projects can involve collaboration between multiple stakeholders, including researchers, citizen scientists and institutions. Determining who owns the data, how it can be used and under what licence conditions can be complicated. Clear rules and agreements should be established to address these issues and ensure proper attribution and sharing of materials.
- User engagement and loyalty. Maintaining user engagement in open repositories can be a challenge. Citizen scientists must feel motivated and appreciated, to continue participating in projects and contributing to the repository. Providing feedback mechanisms, valuing contributions, and creating a supportive and inclusive community are key to keeping users engaged. In some projects, gamification mechanisms are made, or even games are designed. This is because keeping users interested is a major challenge.

The development of citizen science can be limited by various social, political and cultural factors, such as:

- Low public awareness and knowledge of what citizen science is, what are its goals and how projects work, and what are the benefits of its development.
- Low level of trust (between scientists and non-scientists) regarding the reliability and accuracy of knowledge acquired in citizen projects, scientists' reluctance to adopt an interdisciplinary approach and to deal with practical issues.
- Institutional barriers preventing the cooperation with volunteers in research
- A general lack of willingness to engage in research and work on data collection and analysis and a low level of motivation to participate in citizen science programmes, related, for example, to a lack of knowledge about the benefits of participating in such projects.
- Low level of trust of policymakers and society (e.g. public opinion, local communities) in knowledge generated within the citizen science framework and the willingness to use and implement its results.
- Lack of or inadequate communication between scientists and the public, e.g. barriers resulting from scientific jargon or one-sided communication (Sobieraj, 2023).

Citizen science encompasses a wide range of involvement forms of citizens who are not professional researchers (including lay citizens and representatives of non-governmental organisations or patient groups) in the process of creating scientific knowledge. Through citizen involvement, scientific knowledge is expanded, and citizens gain input into its development, thereby increasing the overall level of confidence in science. Therefore, the use of citizen science by local governments can result not only in solutions that are more effective and tailored to the needs of all stakeholders but also in solutions that people are more likely to accept.

The benefits of citizen science for local governments are mainly concentrated in three areas:

1. **Gathering new data and insights** with a function that is not only informative but also used in decision-making and urban policy-making.
2. **Increasing citizens' involvement in local governments' activities in** contributing to and deciding on important local projects and the development directions of a given administrative unit, among other things.
3. **Building social capital** and increasing acceptance of various types of change. For example, we are witnessing how citizen science projects strengthen support for issues such as road safety, water quality, biodiversity, climate, health, etc.

Key benefits of using citizen science in local government policy-making processes:

1. **Gathering new data and insights,**
2. **Increasing citizen involvement,**
3. **Building social capital.**

Resilience

This word comes from the Latin verb **resilire**, which means 'to rebound', 'to bounce back' or 'to return to its original state'. The essence of resilience is the peculiar ability of a (urban) system to recover from a shock or crisis.

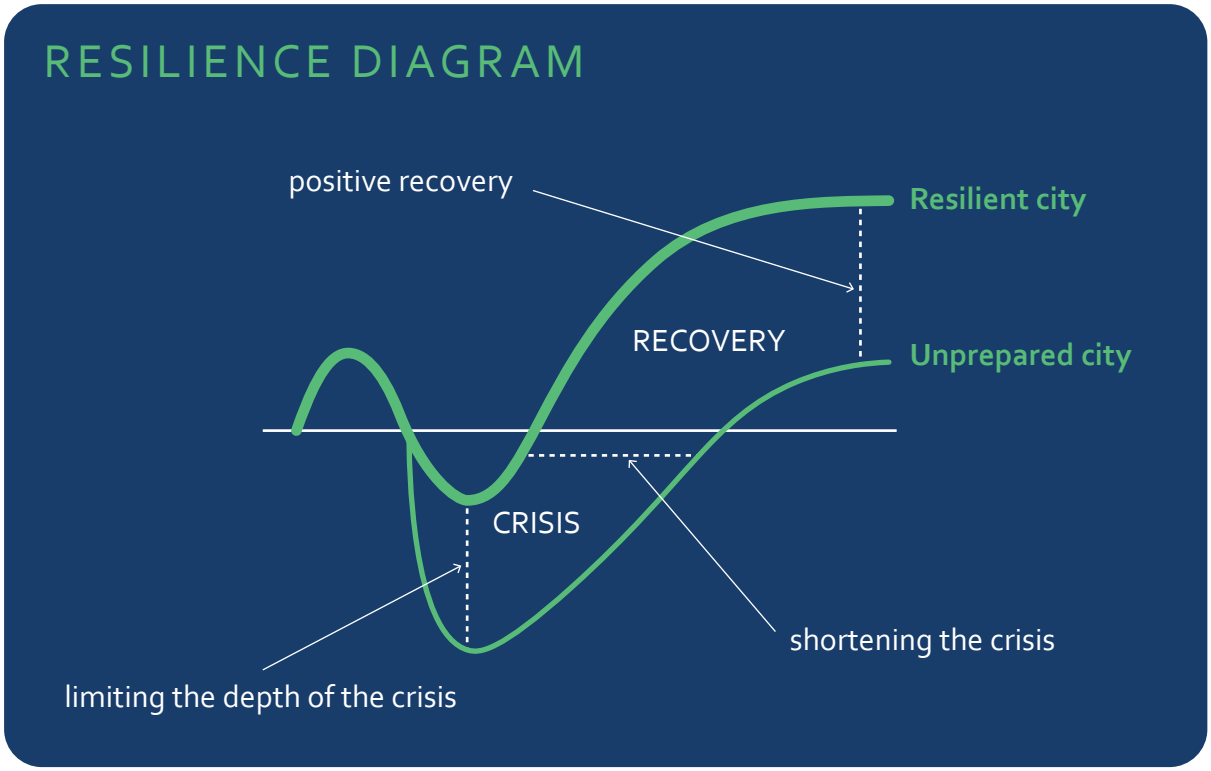
Resilience is commonly defined as the ability of individuals or systems (e.g., ecological or economic) to survive in a rapidly changing world marked by extremely complex and unpredictable crises and tensions. The need to adapt to climate change (*adaptation*), as well as the need to mitigate it (*mitigation*), are subjects of a generally accepted consensus, which has led to the implementation of

appropriate measures, such as strategies and policies at international, national or regional and local levels. However, it is essential to note that the concept of resilience **is constantly evolving**.

As a result, the literature contains several definitions, each focusing on different aspects and research areas. Our study adopts a participatory approach in an urban context, so we draw on the most relevant definitions of resilience from this perspective.

Modern cities are centres of dynamic social, economic and cultural activities. However, they are also the focus of numerous problems and challenges. Changing climate conditions, rapid population growth, urbanisation and pressure on natural resources make cities increasingly vulnerable to various types of crises, hence their central place in implementing adaptation measures. In response to these challenges, resilience is becoming a key element of urban planning, and building resilience is becoming an imperative for sustainable urban development. Due to the proximity of local governments and residents, institutions, or businesses of all kinds, it is most often local governments that are the first line of response in the event of some kind of disaster or emergency.

FIG . 1. RESILIENCE DIAGRAM.
Source: Urban Resilience - methodology and research tool developed for the City of Gdynia. Report developed by the Green Dealers Foundation for UrbanLab Gdynia, Gdynia 2021.



A resilient city is a prepared city that can respond quickly to an unexpected crisis. This rapid response is the result of prior analysis, scenario development and preparation of measures to implement them. This shortens the duration of the crisis phase and the transition to the recovery phase. Therefore, a 'positive rebound' is observed here compared to a non-resilient city, that is, a city unprepared to respond to a crisis (including climatic, political, social, economic, etc.) (Fig. 1).

Climate Resilience

"The ability of social and economic systems and ecosystems to cope with hazardous events, trends or disruptions by reacting or reorganising in ways that maintain their essential function, identity and structure, and in the case of ecosystems, their biological diversity, while maintaining the capacity to adapt, learn and transform" (IPC, 2022).

Urban Resilience

"Urban resilience refers to the ability of an urban system – and all its social-ecological and social-technical network components in all temporal and spatial scales – to maintain or quickly return to desired functions in the face of disturbances, to adapt to change and to quickly transform systems that limit current or future adaptive capacity" (Meerow, Newell, Stults, 2016).

Social Resilience

"Reflecting the collective and unique abilities of people to manage and adaptively respond to the extraordinary resource demands and losses associated with natural disasters" (Cox, Perry, 2011).

Examples of various resilient solutions in cities:

- **Copenhagen, Denmark** – System of retention basins and parks to absorb heavy rainwater
- **Rotterdam, Netherlands** - floating buildings to protect against flooding
- **Barcelona, Spain** - superblocks to increase green space in the city and reduce vehicle traffic

Value-Sensitive Design (VSD)

Value-sensitive design (VSD) is a design concept based on a well-established approach to designing technologies, systems, or research with human values in mind. These values include privacy, trust, fairness, informed consent, and freedom from prejudice (see Tab. 1).

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TAB. 1. HUMAN VALUES (OF ETHICAL IMPORTANCE), OFTEN ASSOCIATED WITH VALUE-BASED DESIGN (VSD).
Source: VSD book (p. 28). Reprinted partly from Friedman et al. (2006a, p. 364-365).

Human values	Definition
Human welfare	Refers to the physical, material and psychological well-being of people.
Ownership and possession	Refers to the right to possess an object (or information), use it, manage it, derive income from it and pass it on as an inheritance.
Privacy	Refers to an individual's claim, power or right to determine what information about himself or herself may be shared with others.
Freedom from prejudice	Refers to systematic injustice committed against individuals or groups, including pre-existing, technical, and emerging social prejudices.
Universal usability	Refers to making all people successful users of information technology.
Trust	It refers to the expectations that exist between people who may experience goodwill, show goodwill to others, feel vulnerable and experience betrayal.
Autonomy	Refers to the ability of people to decide, plan and act in a way that they believe will help them achieve their goals.
Informed consent	Refers to obtaining individuals' consent, including the criteria of disclosure and comprehension as well as voluntariness, competence and consent.
Integrity and Responsibility	Refers to characteristics that ensure that the actions of a person, group of people or institution can be clearly attributed to that person, group of people or institution.
Courtesy	Refers to treating people with courtesy and respect.
Identity	Refers to how people perceive their identity over time, encompassing both continuity and discontinuity.
Peace	Refers to a calm and composed mental state.
Environmental sustainability	Refers to maintaining ecosystems in such a way that they meet current needs.

It is worth noting that any design and implementation process that includes socially sensitive values is not neutral and can be used for good or bad purposes. An important issue is also the question of formulating universal values and reflecting on whether such values exist, how they are defined, whether they gain social recognition, how they can shape design processes, and what is their potential for social benefit or perhaps harm. On the one hand, using a value-based design concept enables the methods, scope, and content to be designed in line with the participants' values in the

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participatory processes. On the other hand, it encourages designers to focus on human well-being, dignity and justice—values of a universal nature (Tab. 2).

VSD was first introduced in the last decade of the 20th century as an approach to incorporating human values into the design of tools and technologies (in this case, information technology) that are fundamental to the quality of human existence. They create the infrastructure through which communities participate in social dialogue at various levels, access information and educational resources and systems, conduct business, participate in public life, engage in important issues, such as those related to shaping the environment, and perform many other activities related to professional and personal life. For many people, access to technology provides the opportunity to access information, but only while maintaining values such as privacy and dignity. Such tools and technologies are the result of human imagination. It is not at all obvious how to design tools and technologies so that they are more likely to support activities, relationships, institutions and experiences, enabling all stakeholders to thrive.

TAB. 2. COLLABORATIVE VALUE CREATION SPECTRUM.
Source: Austin, J. E., & Seitanidi, M. M. (2012). Collaborative Value Creation: A Review of Partnering Between Nonprofits and Businesses: Part I. Value Creation Spectrum and Collaboration Stages. Nonprofit and Voluntary Sector Quarterly, 41(5), 726-758. https://doi.org/10.1177/0899764012450777 (Original work published 2012)

	Sole-Creation ----------> Co-Creation
SOURCES OF VALUE	
Resource Complementarity	Low----------> High
Resource Nature	Generic ----------> Distinctive Competency
Resource Directionality	Unilateral----------> Conjoined
Linked Interests	Weak/Narrow----------> Strong/Broad
TYPES OF VALUES	
Associational Value	Modest---------- > High
Transferred Resource Value	Depreciable----------> Renewable
Interaction Value	Minimal----------> Maximal
Synergistic Value	Least----------> Most
Innovation	Seldom----------> Frequent
STAGES	**Philanthropic-->Transactional-->Integrative-->Transformational**

Citizen Science and Digital Development

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We suggest looking at the relationship between citizen science and digital technologies from two perspectives:

- the importance and role of citizen science in the development of digital technology,

- the importance and role of digital technologies in participatory processes or social communication.

The main tenets of *Citizen Science*, namely inclusivity, collaboration, and scientific development, can help better link digital technologies to the needs of all social groups, thereby minimizing the exclusion of some.

Inclusiveness in this context can be interpreted as considering into account in the research processes, the needs of all social groups, especially those the least privileged (the elderly, people with disabilities, etc.). A key assumption in this process is also **cooperation,** i.e. shaping the conditions for participation, but especially the involvement of the public in the processes of technology development (their design, implementation), which can lead to a better understanding of them and thus more effective participation and dialogue. An increase in knowledge, on the one hand, regarding technological capabilities and, on the other hand, the needs and expectations related to the values important to the social groups in question leads to better results. These desired results should be understood as an increase in social trust in technological solutions, an increase in the application of social utilitarian principles in technological processes, and an expansion of digital technology use, leading to its dissemination and development. The third premise of *Citizen Science* is the **development of science,** which, in the field of digital technologies, can address the development of the field by strengthening its consideration of the human element in design processes. As a result, this will lead to a better understanding of the needs of users/recipients, including, in particular, the needs of special social groups that face various limitations (mobility, perception, etc.).

The relationship between participatory processes and technology is reflected in the following contexts:

Digital democracy (e-democracy)

Information and communication technology (ICT) allows citizens to participate more in public life by providing new channels for more effectively accessing public information and monitoring the activities of public administrations at various levels.

The scope of ICT's impact on political processes and state-citizen relations is so large that the literature uses new terms to describe this phenomenon, such as teledemocracy, digital democracy or cyberdemocracy (Grodzka, 2009). Regardless of the name adopted, common to the aforementioned concepts is the belief that the various functions of new technologies - interactivity, faster mode of data transfer, possibility of feedback communication, and large amount of information - can positively affect democratic mechanisms (Białobłocki et al., 2006).

According to a survey conducted by the Institute for Direct Democracy in 2023 in Poland, 88% of respondents admit that they have too little influence over local affairs in relation to local authorities and other interest groups (Lubbezposrednio.pl, 2023). ICT provides an opportunity for change not only in terms of increasing citizens' sense of agency and increasing their knowledge of the actions

taken by public authorities but also in increasing citizens' participation in democratic processes, both in quantitative terms and in the form of real influence exerted by individuals on the functioning of public institutions (Porębski, 2009).

Digital participation (e-participation)

Participation is the foundation for efficient and effective communication with the local community. It enables the voices of those who will be directly impacted by the actions taken by those in power to be heard.

Digital participation refers to the increasing public involvement in public policy-making processes and social life through digital tools (ICT). New channels of communication and increasingly better digital tools support the effective and efficient collection of citizens' opinions and other data with spatial context, such as information on the area where a particular phenomenon occurs.

Digital participation can be related to digital democracy, as well as to digital community development and education. It can build public trust, shape community involvement, and improve the transparency of public management. Participatory processes supported by digital tools will enable all stakeholders in a given process —policymakers, designers, audiences, and others— to better understand the diverse perspectives on a particular issue. This, in turn, will influence a better understanding of the topic and, as a result, make optimal design decisions, minimise the occurrence of social conflicts and, finally, efficiently and effectively manage the activity.

Digital education

The development of society by enabling people to strengthen their skills with the help of digital technologies. Digital education encompasses two primary streams: the development of digital competencies in learners and the pedagogical application of digital technologies to enhance and improve learning. The European Digital Competence Framework for Citizens, also known as DigComp, provides a detailed description of model digital competencies and has been adopted by many European countries. DigComp divides digital competence into five areas: (1) information and computing competence; (2) communication and collaboration; (3) digital content creation; (4) security, and (5) problem-solving (Europa.eu, 2024)

What are the potential risks associated with the widespread adoption and development of digitisation?

- Increasing social disparities and unequal access to digital technologies
- Spatial exclusions - limitations in access to efficient Internet networks (peripheral, degraded, problem areas)
- Economic exclusions - low quality and availability of equipment
- Social exclusions – senior citizens, people with disabilities, homeless people

Considering the above-mentioned risks, citizen science appears to be extremely important in this context. Applying citizen science principles and methods to the development of digital technology can help emphasise the importance of values in the process of designing and using digital solutions.

Digital technologies in processes

Digital technologies are a new form of social communication and have thus significantly influenced the type of relationship between communities and government officials, and in the case of participatory processes, scientists or social activists. This relationship is primarily about shortening the distance between them and basically means changing its form from physical to virtual. Travelling a certain distance requires a lot of time and money, both for the travel expenses of all parties involved and for the organisation of on-site meetings. In addition to these factors, it is always a challenge to find a location and schedule the meetings at a time and place that is optimal for the majority of potential participants. Digital technologies have revolutionised quantitative research in terms of their responsiveness. They also speed up the process and offer unlimited possibilities for analysing the collected data.

The reduced distance should not only be understood as the physical distance between the parties involved but also as the psychological distance. Participants in participatory processes may feel more comfortable at home and at a time of day that suits them, expressing their views on a given topic, with the additional opportunity to think about and formulate their position for a longer period of time, or even to revise it.

Three concepts are important for understanding virtual reality:

- **Immersion** - Immersion is what we experience when the virtual world affects our senses similarly to the surrounding reality.
- **Psychological presence** - a sense of personal engagement in a virtual situation, real participation in it.
- **Embodiment** - the feeling of being in a virtual body that has a direct impact on feeling the reality of an experience.

The use of digital technologies in participatory processes can be passive or active, involving stakeholders in different ways and turning them into participants who co-create databases or design solutions. Passive use of technology involves using websites, email or social media to inform stakeholders about the activities being undertaken. Active, on the other hand, has a wide range of tools, from simple online surveys, computer visualisations, and geo-surveys **to immersive technologies**, which combine real and virtual worlds (see Tab 3). Immersive technologies create a virtual representation of a given environment, allowing users to fully immerse themselves in a digital world that is either entirely new or familiar and realistic, but with additional elements. Thus, they allow a psychological presence in a given process, which translates into an increase in the intensity of the participants' experience. This is an essential element of participatory processes that not only increases the involvement of participants, who experience the 'embodiment' of the conditions or project processes but also affects the maintenance of their concentration during them.

Virtual Reality technology allows us, or users, to move into a fully computer-generated environment. The three-dimensional image makes it possible for us to 'enter' a realistic simulation and move freely in it, while being completely cut off from external stimuli. Augmented Reality, on the other hand,

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involves superimposing digitally generated elements on the real image. The combination of the two technologies allows you to enter a completely different space without moving from your seat by using a smartphone, console or goggles and controllers. VR goggles and controllers allow 360-degree technology to move freely in the virtual world and interact with it in various ways (Witkowska, 2024).

Among the immersion technologies can be distinguished:

- Virtual reality (VR) uses computer modelling and simulation to create a fully immersive digital environment.
- Augmented reality (AR) superimposes digital elements on the real world to improve the perception of the environment, creating a composite view that connects the two worlds.
- Mixed reality (MR) seamlessly blends the virtual and physical worlds and, more importantly, enables interaction between the two.
- Extended reality (XR) - a general term that includes VR, AR and MR, used to describe any technology that alters reality by adding digital elements (Meta, 2024).

TAB. 3. TYPES OF DIGITAL TECHNOLOGIES WITH DIFFERENT LEVELS USED IN PARTICIPATORY PROCESSES
Source: Authors

Basic/traditional IT tools	3D technology tools	Tools using spatial data	Virtual reality and augmented reality technologies
Email, Websites, Social media tools	computer visualisations (photo realistic simulations of design solutions)	Geographic Information Systems (GIS) geo surveys	Interactive educational games, VR games and apps
Information Systems (Web Surveys)		Community Volunteered Geographic Information (VGI)	Digital Twin

Digital Twin

Digital Twin technology was initially used to monitor the operation and study the performance of facilities such as oil rigs, but has also found applications in the planning, monitoring and operationalisation processes of urban environments (Batty, 2018; Chaplin et al., 2020).

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Urban-scale Digital Twin (DT) technology was initially designed to enable optimal development goals, smart operations and infrastructure management, responding to an influx of detailed real-time monitoring data from its physical counterpart.

Its use quickly goes beyond this initial application, as new possibilities for using these technologies on an urban scale are constantly being analysed. One example is the use of DT to simulate the effects of political/public sector interventions in contemporary cities in terms of realistic behavioural responses to hypothetical public intervention, for example, simulations of residents' transport behaviour (Papyshev, Yarime, 2021).

DT is a tool that can also be used in participatory processes, integrating digital participation methods that have been used in participatory processes for over 15 years. These include geographic information systems (GIS), virtual reality (VR) technologies, Volunteered Geographic Information (VGI) computer visualisations or social media tools, among others.

A digital urban twin can be a tool for integrating these technologies in order to develop an effective method of social participation used in the design phase of spatial or infrastructural solutions. Thanks to collaborative planning and active involvement in project processes, DT enables the implementation of changes, the rapid verification of their effects, and the evaluation of achieved results, which is also possible in a comparative analysis of different design solutions. This co-creation/co-design process has several benefits. The first one is educating stakeholders on the subject of a given project, allowing them to understand better all the dependencies related to the subject and thus formulate their opinions, comments or recommendations more consciously. The second is to minimise conflicts arising from different needs or expectations of stakeholders, which sometimes result from insufficient understanding of the topic. The third benefit is the reduction of actual costs associated with the need to introduce changes to the project or its implementation methods or delays resulting, for example, from resolving submitted comments or complaints.

The complexity of a city and the interdependencies between its elements (people, infrastructure, and technologies) have made it a challenge to integrate these elements and create a platform for community engagement (Dembski et al., 2020).

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TAB. 4. OVERVIEW OF PARTICIPATION LEVELS, TYPES, OBJECTIVES AND THE DIGITAL TOOLS THEY INVOLVE.
Source: Authors

Level of participation	Target		Digital tools (GIS, Internet)
Informing	Provide the public with balanced and objective information to help them understand the problem, alternatives, opportunities and solutions	passive	Newsletter, a different form of sending information about an ongoing project
Consulting	Obtain feedback on analyses, alternatives and decisions	passive	Survey of residents' current and preferred activities using a geo-survey. Gathering feedback, comments on materials posted online
Engaging	Work directly with members of the public to ensure that their concerns and needs are understood and taken into account	active	Online discussion about proposed solutions with the participation of designers and active search for participants on social networks
Collaboration	Establish partnerships with the public in every aspect of decision-making, including the creation of alternatives and identification of a preferred solution	active	Establishing criteria used to evaluate proposed solutions by representatives of the public. Electronic voting on proposed solutions, ending with a recommendation
Empowerment	Enable the public to make the final decision	active	Legally binding electronic vote on the introduction of a solution

What Have We Learnt about Social Engagement Through the CREST Project?

Voice of the people

As part of the summary of the CREST project results, interviews were conducted with the people involved in the project. Their primary objective was to gather conclusions and reflections on evaluating the effectiveness of achieving the intended goals within the participatory processes conducted and the degree of stakeholder involvement in the project.

When evaluating the established and achieved project goals, the majority of responses confirmed the positive results of the conducted processes. It was particularly emphasised that the achievement of the set project goals was facilitated using various activities and project implementation methods. Increased involvement of citizens in the processes of climate change mitigation was possible due to the provision of information to stakeholders about the scope and objectives of the CREST project and clarification of doubts and ambiguities regarding terminology and issues related to climate challenges. Filling this information gap enabled better cooperation efficiency in the later phases of the project. Moreover, the co-creation processes helped improve the exchange of information and communication between representatives of local governments, the public, other stakeholders and participants of the CREST project team, which served to develop joint solutions aimed at the specific challenges of the studied urban centres. An unquestionable asset in the participatory processes was the use of digital technologies (Digital Twin). A digital twin model was developed to visualise scenarios on climate challenges in each administrative unit thanks to collected data on climate, infrastructure, and local climate problems. All the results achieved by the CREST project can be applied in the field of spatial development planning for individual cases, enhancing citizen involvement and preparedness for emergencies within the municipality.

Among the positive factors contributing to the achievement of the stated project goals were:

- Joint efforts and close cooperation between stakeholders (local authorities, citizens, experts and project partners) that facilitated the successful implementation of activities. The administrative units participating in the project established effective communication channels that enabled easy exchange of information among all stakeholders and implementation of project activities;
- Great interest among citizens in the topic and project activities, who showed particular interest in visualising climate change with a digital twin;
- The use of digital tools to help understand not only the climate challenges themselves but also possible scenarios for planned actions, positively influenced the turnout among all stakeholders, especially residents, and increased their level of involvement. In addition, numerous positive responses and feedback received through the citizen survey and focus group discussions helped identify the main climate risks in the studied areas. Participants emphasised their willingness to familiarise themselves with the project's results, which demonstrates their high level of commitment and increased awareness of potential climate risks.

- Existing data resources available to some of the units involved in the project, such as Kristiansund, facilitated the collection of data for comparative monitoring of sustainability and resilience for this project.
- The ability to adapt to local conditions and the flexibility to adapt the scope and methodology of the questionnaires to the local context helped to engage participants more effectively. To better understand the topic, native languages were used and non-technical language and technical terms in the questionnaire were paraphrased to fit the context;
- Support from technology partners, and in particular AugmentCity's experience in developing a digital twin, which provided valuable technical support and the development of the optimal functionality of this tool to meet the project's goals.

Among the negative factors that hindered or prevented the achievement of the project's stated goals, most people pointed to:

- recruitment challenges, which involved several aspects. First, the difficulty of engaging participants representing all the groups studied, was especially true in small centres such as Kristiansund. Second, the inconsistency in contacting project team members to engage in these activities and prioritising participants in co-creation processes from among experts, local associations, citizens and communities;
- Communication gaps, for example, in managing communication between international partners with different understandings of project activities, which led to delays in planning and implementation;
- differences in the context of the administrative units under study - the different scale and varied challenges, especially in comparing small centres with other twin cities, sometimes made it difficult to apply the design framework directly.

Interviews with city officials, activists

We also interviewed stakeholders who have experience in participatory processes, having acted in them in various roles - either as representatives of local authorities, the private sector, or as community activists. We asked them how they evaluated the intended and actual goals of the participatory processes in which they participated. All of them indicated an overwhelmingly positive assessment of the results achieved through public consultations. At the same time, they distinguished between two types of these activities, depending on who initiates them. One type of these activities are *bottom-up* initiatives, undertaken by local activists, residents in most cases to convince local authorities of their ideas (e.g., to build new roads, sidewalks or to implement the desired development of particular areas), or to express their opposition to investments planned by the authorities, or other projects. The second group, on the other hand, are *top-down* initiatives, *i.e.* those organized by local authorities to collect comments and proposals during the development of planning documents, strategic documents or other projects. Some people here pointed to the problem of low involvement of local authorities in participatory processes when they treat these processes as merely fulfilling an obligation imposed as part of the procedure for enacting documents, or "for the show".

Among the positive factors that fostered the achievement of the set goals, the most frequently mentioned were:

- proper organisation of meetings in terms of location (good transportation accessibility), timing (during non-holiday/holiday periods), time of day (afternoon hours), and even appropriate seating arrangements (shortening the distance between participants in the process);
- The great commitment of the organisers, the presence of a person professionally and impartially moderating the discussion;
- Adequate information campaign about the participatory/consultative process;
- Early networking among stakeholders to better prepare the entire process and effectively mobilise as many participants as possible;
- The possibility of financing the entire process in terms of organisation, informational materials, etc.;
- A variety of forms of resident participation that facilitate the gathering of broader opinions of residents/experts/respondents on a given topic.

We also observed that the setup of the room (tables in between participants, chair layout) and the way the workshop is set (number of speakers, their nonverbal communication) can impact the interactions. One positive behaviour that led to a positive observation is having the person presenting sit down after the introduction was done among the participants, rather than standing up next to a screen. This greatly increases the feeling of participants being in a safe space and appears to increase the number of solutions proposed by participants.

Paul Halas, Augement City

Among the negative factors that hindered the achievement of the set goals, the most frequently mentioned were:

- The seeming inaction of the authorities, for example, when they initiated participatory processes too late, the outcome of which no longer had a real impact on previously made decisions;
- Partial lack of knowledge and willingness to have a substantive discussion;
- Poor organisation of workshop meetings in terms of both their dates and comfortable room conditions, allowing for the proper seating of participants, among other things.

There is a little interest among residents in general issues affecting the entire city, not just the immediate neighbourhood.

Agata Chełstowska, UM Kraków

We also asked our participants if they were familiar with the concepts of Citizen Science, Value-Sensitive Design, or related ideas and if they had been present in the participatory processes in which they participated.

In most cases, these concepts were not known. Still, after learning about their principles, many people admitted that elements of them were (unconsciously) introduced into the processes in which they participated. At the same time, it was mentioned that the discussion of values and their perception can be difficult in many cases, as, according to their observations, male and female residents are most likely to talk about specific solutions, e.g. technical and infrastructural solutions related to the immediate surroundings. Rising above the level of everyday concerns is difficult but possible.

Piotr Windak, Department of Strategy and European Funds - Kraków City Hall

The only concern I have is that even such a nice change will not be effective if it is not introduced from the top, if the decision-makers are not convinced of the idea, then without faith in it, they will not care about it.

Jagoda Lipska, Local Activist

All of them expressed interest in participating in CC or VSD-based participation processes, as they believed that they could be a valuable factor in promoting the effectiveness and achievement of the participation process objectives and would help in understanding local values and needs.

Through participation, activities in the public space (e.g. environmental or infrastructural protection) take place in understanding with local values and needs.

Irena Stęposz, Local Activist

The important role of digital technologies was also emphasised, both in terms of the increased interest in participatory processes and also in terms of a better understanding of the subject in question and, thus, better results of the whole process. One of the shared experiences involved

situations in which people start to doubt the data presented to them, and the discussion quickly focuses on this data instead of on solutions. Interestingly, even if the quality of the data is insufficient, the fact that it is presented in a different format or using modern technology (e.g. a digital twin) significantly increases attendance and engagement, which is a good conclusion for the design of co-creation processes.

A key element of the introduction of advanced digital technologies is to explain the entire process and present the tools that will be used (e.g. digital twin). By presenting the tool before use, participants develop a more positive attitude and a higher level of overall knowledge, which gives them a sense of comfort as users and increases their willingness to actively participate in the entire process - people understand better what is being presented. Therefore, digital tools skilfully used in participatory processes help participants better understand the problems and thus increase their involvement and engagement.

There is always something to learn, but ideally, participants should leave the room in good spirits and with a better level of knowledge/feeling that they made a significant contribution.

Paul Halas, Augement City

Theoretical Assumptions of the Model

The ever-increasing frequency of emergencies caused by climate change, such as floods, storms, fires, heat waves and droughts in recent decades, requires urgent and effective action. Initiating and carrying out adaptation processes in cities and regions to the effects of climate change (CC) rests on the shoulders of local territorial units supported legally and financially at the regional, national and European levels. Local authorities are responsible for recognising local climate risks and developing action scenarios adapted to changing economic, social and climatic conditions.

The adaptation of cities to the effects of climate change is based on the process of building their resilience, which can be understood as three variants of action (Tab. 5):

- Top-down: conducted by local authorities (may be legislative, educational and informational based on expertise, etc.),
- Grassroots: initiated by residents, social activists (in the form of e.g.: social actions, education and information, etc.),
- Hybrid: linking local government representatives and their experts with other stakeholders, such as residents and other users of the areas in question.

TAB 5. EXAMPLES OF DIFFERENT UNDERSTANDINGS OF THE PROCESSES OF BUILDING AND IMPROVING URBAN RESILIENCE.
Source: Authors

Option 1	Option 2	Option 3
Top-down actions	**Bottom-up activities**	**Hybrid activities**
Understanding key competencies and opportunities for resilience building within the local authority's power	Understand key competencies and opportunities for building resilience within the reach of residents, community activists, and others	Understand key competencies and opportunities for building resilience within the reach of local government, residents and other community groups
Recommendations for local authorities		
Understanding key competencies and opportunities for resilience building within the local authority's power	Understand key competencies and opportunities for building resilience within the reach of residents, community activists, and others	Understand key competencies and opportunities for building resilience within the reach of local government, residents and other community groups
Legal forms and recommendations	Participation, volunteering	Co-creation, citizen science

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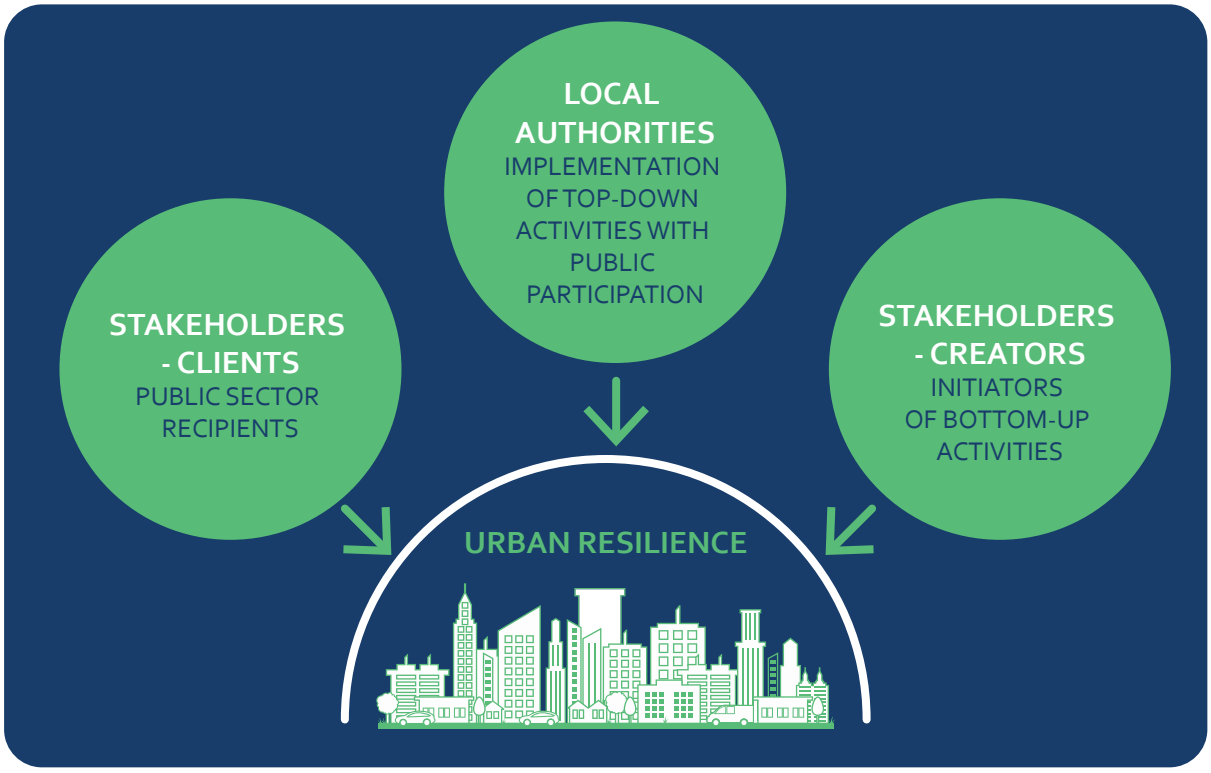
The success of the measures taken depends on several factors, among which are:

- An accurate diagnosis of conditions and risks,
- The quality and compatibility of the proposed solutions and activities
- An optimal action plan with proper prioritisation of tasks
- Efficient coordination of the entire process,
- Funding sources
- Evaluation and monitoring of the process of achieving the goals
- Stakeholder involvement (residents, activists, entrepreneurs, etc.).

The listed factors are related to the competence of local authorities in the substantive preparation and implementation of the entire urban resilience-building process. However, it seems that the last of the mentioned factors—related to stakeholder involvement, is the one that should be looked at with special attention in the context of the topic. At the same time, it is essential to consider two primary types of public involvement or stakeholder groups. The first involves participation in participatory processes organised by local authorities or community organisations. Participants are more or less actively engaged in discussions, workshops, or other forms of implementing these activities. This type of stakeholder can be called a client of participatory processes. The second type of public involvement concerns stakeholders — creators who initiate various types of actions, such as educational, informational, or collaborative efforts aimed at developing standard solutions and proposals (see Fig. 2).

FIGURE 2. TYPES OF STAKEHOLDER INVOLVEMENT IN URBAN RESILIENCE-BUILDING PROCESSES.
Source: Authors.



Community engagement brings multifaceted benefits. One of them is the exchange of experience and knowledge about a given area of project activities. This is because residents, as daily users of cities, can share their often-long-standing observations about the phenomena or other events occurring there. Secondly, they can propose out-of-the-box solutions to promote innovation tailored to a specific city or part of a city, as well as the expectations of its residents. This, in turn, is combined with a third direct benefit, which is to minimise social conflicts and maximise the efficiency of the implementation stage of a given project. The practical application of solutions to stimulate urban resilience requires the interaction of the largest possible group of stakeholders, i.e. people who, through their acquired knowledge and commitment, can contribute to better results in the process of mitigating the negative effects of climate change.

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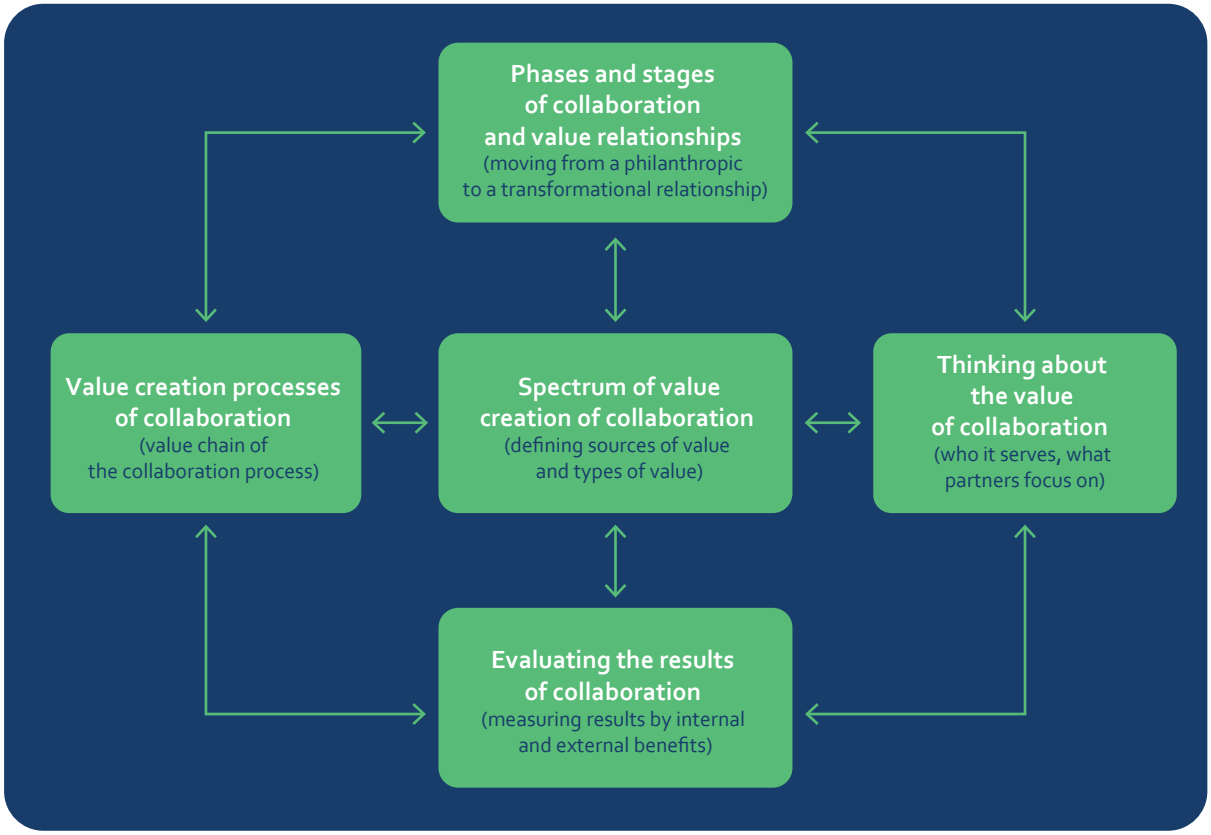
FIG. 3. COLLABORATIVE VALUE CREATION MODEL
Source: Ćwiklicki 2015, p. 62.



Theoretical context of the model

- **The concept of man from the concept of "homo oeconomicus", homo sociologicus, homo socio-oeconomicus.**

Economic sociology distinguishes three concepts of man in the economy:

Economic Man. This concept places the individual focused on achieving particular interests as the subject of consideration. The economic man is guided by rational calculation and acts on the principles of free choice; the space of his actions is the market and the private sphere. He subjects his actions to mathematical analysis to accurately predict the chances of profit or the potential threat of loss.

Sociological Man. Sociological man is most often a collective subject (a group, a community, or an individual as a member of a group or a community). A sociological man's actions are motivated by values such as tradition, solidarity, equality, and faith, among others. This subject evaluates his actions in terms of good and evil rather than profit and loss. He can put aside his gain for the greater good. Habits and principles of social justice often guide him. The space of action of the sociological man is society (the market is a public institution), the public sphere.

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Socio-economic Man (institutionally rooted). An optimal combination of two extreme concepts. It assumes that man makes decisions on both economic and sociological grounds (Wojcieska, 2014).

The behaviour of the socio-economic man can be put into the following analytical scheme:

Rules-institutional patterns. They are external to an individual, the person is rooted in them. These patterns can relate to the family, community, etc. They influence, for example, voting behaviour or forms of cultural participation.

Individual choices. These are satisfactory decisions made based on available information, considering a person's level of aspiration.

Mental models. The individual makes cognitive interpretations of the environment based on his own experiences and observations of external patterns. Cognitive models are internal and act as a kind of pattern that helps individuals make decisions.

Behaviour of the individual. These are the real actions and experiences of a person in the economy.

In **our model** approach, we strive to consider a broad range of human attitudes and diverse motivations. We are aware, of course, that the exemplary citizen scientist in the EU is a person who is both highly motivated and, in a sense, predisposed to such activity. In building our model, we aimed, on the one hand, to intentionally appeal to those with the most proactive and self-generated attitudes and, on the other hand, perhaps even more so, to eliminate possible access barriers and increase the appetite for collaboration within and for the community among those who are often seemingly indifferent or uninterested. In the following section of our guide, we outline the factors, based on our project experience, that can effectively influence the level of individual and community involvement.

- **Theory of social interdependence**

The theory of social interdependence assumes that (...) the structure of people's goals in a certain situation determines how its participants interact with each other, and the types of interactions determine the results of the situation (Johnson, Johnson, 2005). A goal is a desired future state of affairs, the final result of certain activities. The structure of the goal determines the type of interdependence between the goals of individuals, which in turn determines how individuals must interact with each other to achieve their goals. In interaction between individuals, there is the possibility of others supporting and facilitating the achievement of the goal or inhibiting and blocking them. It is assumed that interaction is (...) the simultaneous or sequential actions of individuals that affect the immediate and future outcomes of others involved in the situation (Johnson, Johnson, 2005). It can occur directly or indirectly. In a group that interacts, its members can inform each other of their capabilities and thus promote each other's success through direct or indirect interaction.

- **Economic theory**

Behavioural economics examines the impact of psychological, social, and emotional factors on individuals' economic decision-making. Unlike classical economics, which assumes rationality and utility maximisation, behavioural economics takes into account irrational behaviour, emotions and heuristics that influence decision-making. Research in this field often employs laboratory and field experiments to investigate how various factors, such as context, information presentation, and social pressure, influence consumer choices. The results of these studies have important implications for

public policy, marketing, and management, as they enable the design of more effective interventions and strategies that take into account actual human behaviour (Thaler 2021).

The basic principles described in behavioural economics influence the decisions people make.

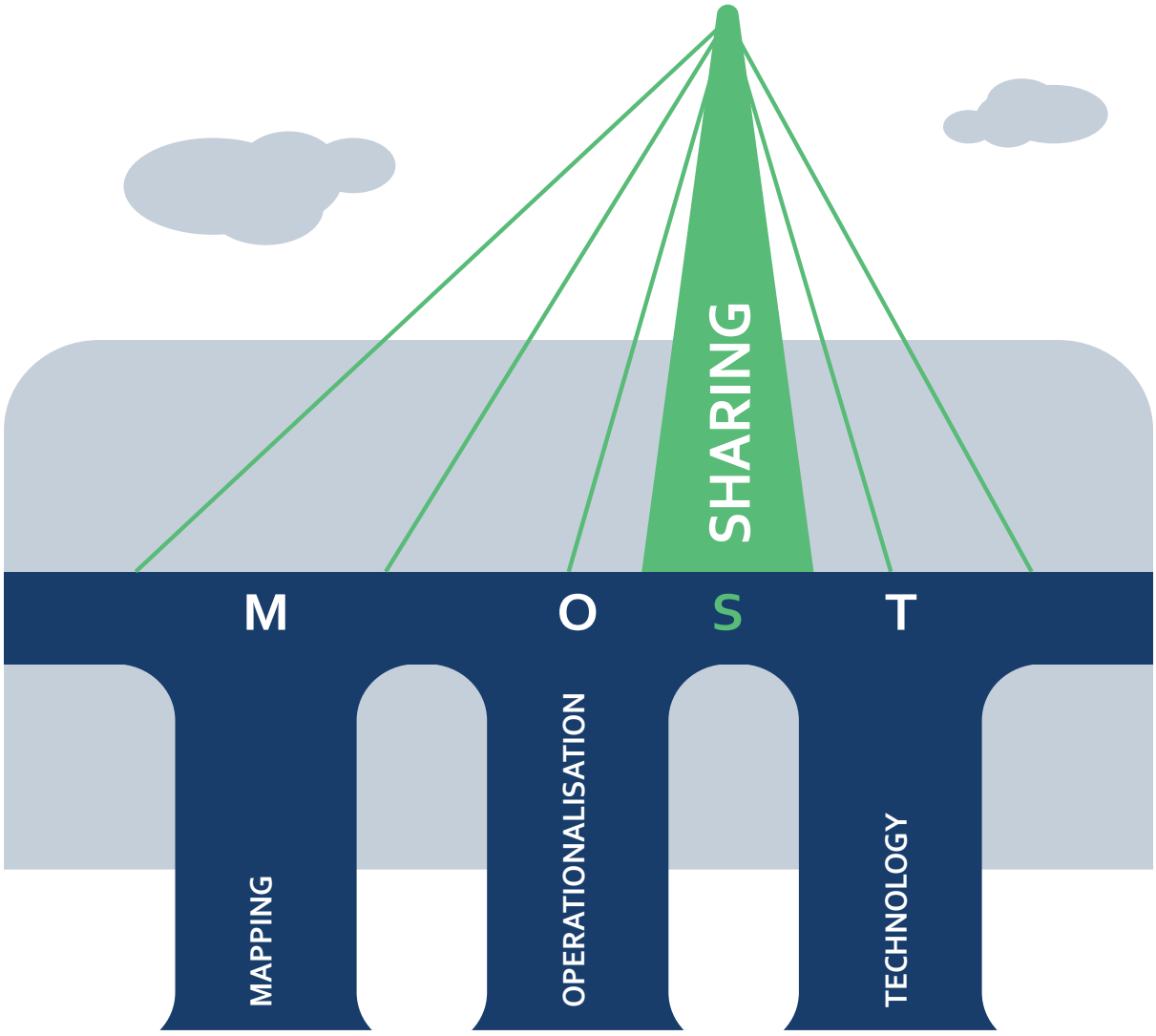
- **Limited rationality**: People often make decisions based on simplistic models of reality rather than a complete analysis of available information.
- **Heuristics**: In everyday life, people use simple rules (heuristics) to make quick decisions, which can lead to cognitive errors.
- **The possession effect**: People tend to assign a higher value to things they already own than to those they could acquire.
- **Loss aversion**: Losses are psychologically more painful than gains are enjoyable, which affects financial and investment decisions.
- **Overconfidence**: People often overestimate their skills and knowledge, leading to risky decisions.
- **Social influence**: Decisions are often shaped by social norms and other people's behaviour, which can lead to conformity.
- **Emotions**: Emotions, such as fear or excitement, significantly impact the decision-making process, often outweighing rational considerations.

The MOST Model – A Hybrid Model for Building Urban Resilience and Increasing It in Local Communities

Existing models for building resilience illustrate the multidisciplinary interface between the main actors in this process. Many of them emphasise the importance of the social factor in the design and subsequent implementation of solutions aimed at enhancing the resilience of a given administrative unit. At the same time, ongoing research confirms the existence of many barriers to involving stakeholders in participatory processes.

Accordingly, the proposed **MOST model** is based on four pillars of action: **Mapping** (M), **Operationalisation** (O), **Sharing** (S), and **Technology** (T). The model summarises and systematises the activities implemented under the CREST project. Its purpose is to provide a universal prescription—a scheme of conduct that can be applied by local government representatives when implementing other projects and initiatives (Tab. 6).

FIG. 4. MODEL MOST



The model aims to bring three key elements - the concept of citizen science (CC), value-sensitive design (VSD) and the use of digital technologies - to an effective process of building urban resilience. The model is based on stakeholder engagement, with a particular focus on local communities, as it is assumed that this is a key element determining the success of the activities undertaken. With this in mind, stakeholder engagement can be divided into two types by the nature of the process in which they participate:

- Participation in the design process,
- Participation in the education and information process to support the effectiveness of the activities.

The basic premise is that the research methodology must be adapted to its participants' values, expectations, and needs.

Stakeholders - major groups:

- residents and other users of the city,
- municipal authorities,
- executive team - including architects, environmental engineers and other designers, depending on the type of issue,
- city services,
- Project team - a team made up of various stakeholders responsible for the implementation of the project, necessarily with someone responsible for communicating the project externally.

Distinctive features compared to other models:

- Use of citizen science in all stages of project implementation: from diagnosis, design of solutions to their evaluation and implementation,
- Use of value-sensitive-design (VSD) concepts,
- Using the concept of behavioural economics - designing incentives to influence pro-environmental behaviour and the willingness to engage in the processes of implementing the developed solutions (through individual behaviour, but also the education of other members of local communities).

Description of activities by MOST

Phase 1: MAPPING

1. Characteristics of individual threats (threats – according to the problem which is going to be solved) on a local scale and collective threats on a city-wide or regional scale.

Estimating the potential risks arising from the negative effects of climate change should be considered in the context of individual representatives or small groups within local communities. Thus, these activities are concerned with the local scale, i.e. a neighbourhood or city district. On the other hand, since climate challenges often affect larger areas, collective risks covering a broader social and spatial context, referring to the interests and needs of the residents of a given administrative unit or region, are also distinguished.

2. Stakeholder characteristics

Identification of the entire group of stakeholders is a key element of participatory and co-creation processes. It involves preliminary identification of their level of knowledge regarding the issue, as well as their expectations, proposals, and comments on the proposed solutions. It is also essential to analyse their values, i.e., what is important to them and what beliefs guide their lives. This will enable identifying potential conflicts and finding room for possible compromises while also organising and planning methods and forms of cooperation.

Mapping

Why is mapping important?
Just being aware that many types of stakeholders at the stage of preparing a project or other initiative make it possible the following:

- Appropriate adaptation of the forms, methods, tools and manner of organisation and communication in the processes of co-creation and participation,
- Looking at the issue from different perspectives that take into account the various interests, needs, expectations and values represented by each stakeholder group allows for a better understanding of the complexity of the issue,
- Developing an appropriate framework of participatory or co-creation processes for the possibility of potential problems or conflicts

Who participates?

- All parties potentially interested in a given project or initiative (directly affected by the planned solutions),
- Representatives of local activists with experience in conducting or participating in participatory or co-creation processes who can share their knowledge of local communities (their values, needs expectations, possible points of contention, etc.) and experiences in organising/facilitating participatory and co-creation processes,
- Local entrepreneurs,
- Experts dealing with the topic.

How to do it?

- Identify representatives of local communities through, among other things, documents on consultations on similar or other issues concerning the area lists of meeting participants, authors of submitted comments and proposals, etc.),
- Identify local entrepreneurs (through online portals, media, among others),
- Use available databases (e.g., NGO databases, media),
- Perform a search of scientific publications, reports on similar topics or theses of research conducted in the area (including media and scientific articles available in scientific databases).

Phase 2: OPERATIONALISATION and TECHNOLOGY

1. Data collection from stakeholders on problem areas, observed risks and proposed solutions.

Collaboration with stakeholders from the outset is crucial, although it may take a different form. For example, when collaborating on a given research project, the general scope of the topic being developed is defined. However, in the case of city adaptation or mitigation initiatives undertaken by local authorities, cooperation will help identify the areas in a city that are the most vulnerable to key climate risks. It is the residents of an area who possess the knowledge gained through their constant observation of it.

2. Data analysis, development of scenarios, options for action, and design solutions tailored to local specificities.

Stakeholders are also valuable participants in this stage for several reasons. One of the most important factors is their deep understanding of local conditions. This helps accurately interpret data, verify design options, and plan scenarios. When stakeholders help create solutions, these solutions reflect their values, fit local specifics, meet community expectations, and reduce social conflicts. In the long run, shared responsibility for the results increases the chances of successful implementation, effective monitoring, and making necessary adjustments later on.

3. Participation and co-creation using citizen science and digital technologies (e.g., *digital twins*).

The use of digital technologies leads to greater involvement of participants, either out of curiosity or because they have a better understanding of the given issue. It also helps to better illustrate potential risks to a given area and to test solutions.

Operationalisation and technology

Why is this important?

- Recognising the development conditions of an area to identify potential threats and other challenges allows the development of scenarios,
- Stakeholder analysis in terms of their agility, attitude to an issue or motivations for action,
- The efficiency and diversity of information and education channels,
- Greater curiosity of potential participants in participatory and co-creation processes,
- A more illustrative representation of problems, objectives and project solutions.

Who participates?

- Project team,
- Local authorities,
- Experts and technology partners.

How to do it?

- Use planning and strategic documents developed for the administrative unit locally and regionally;
- Organise and conduct interviews, surveys, and workshop meetings;
- Organise and conduct workshops using immersive technologies;
- Use a variety of information channels (social media);
- Use information technology (websites, geo-surveys, online surveys).

Phase 3: SHARING

1. Development of solutions and scope of activities – possible variants

The final stage of project work involves verifying the developed results, evaluating them, and potentially developing additional variants that can be applied in situations with varying external factors. Cooperation with stakeholders at this stage also allows to formulate the scope of activities that local stakeholders can undertake to strengthen the process of implementation of the developed solutions

2. Decisions of local authorities - development of public policies and recommendations to take

A very important part of the project process is implementing the project solutions worked out by the local authorities. The implementation stage of the results can be a simple utilisation in implementing a given project or other activity or initiative of the municipal authorities. However, it is worth emphasising that the project should conclude with recommendations for public action to strengthen resilience, which would have a chance of being translated into the formulation of public policies in a given area, thus having a long-term impact.

3. Publicising results and recommendations

The project's long-term impact is also related to sharing results and recommendations at both local and broader levels. The local level refers to informing all stakeholders, both those actively participating in the project, i.e., the creators, and those with passive participation, who are the recipients of the project's results. The above-local level can refer to both the regional context, which is directly or indirectly related to the participating cities, and the international context, which serves as an inspiration or a case study for other cities facing similar development challenges.

Operationalisation and technology
Sharing
Why is this important**?**

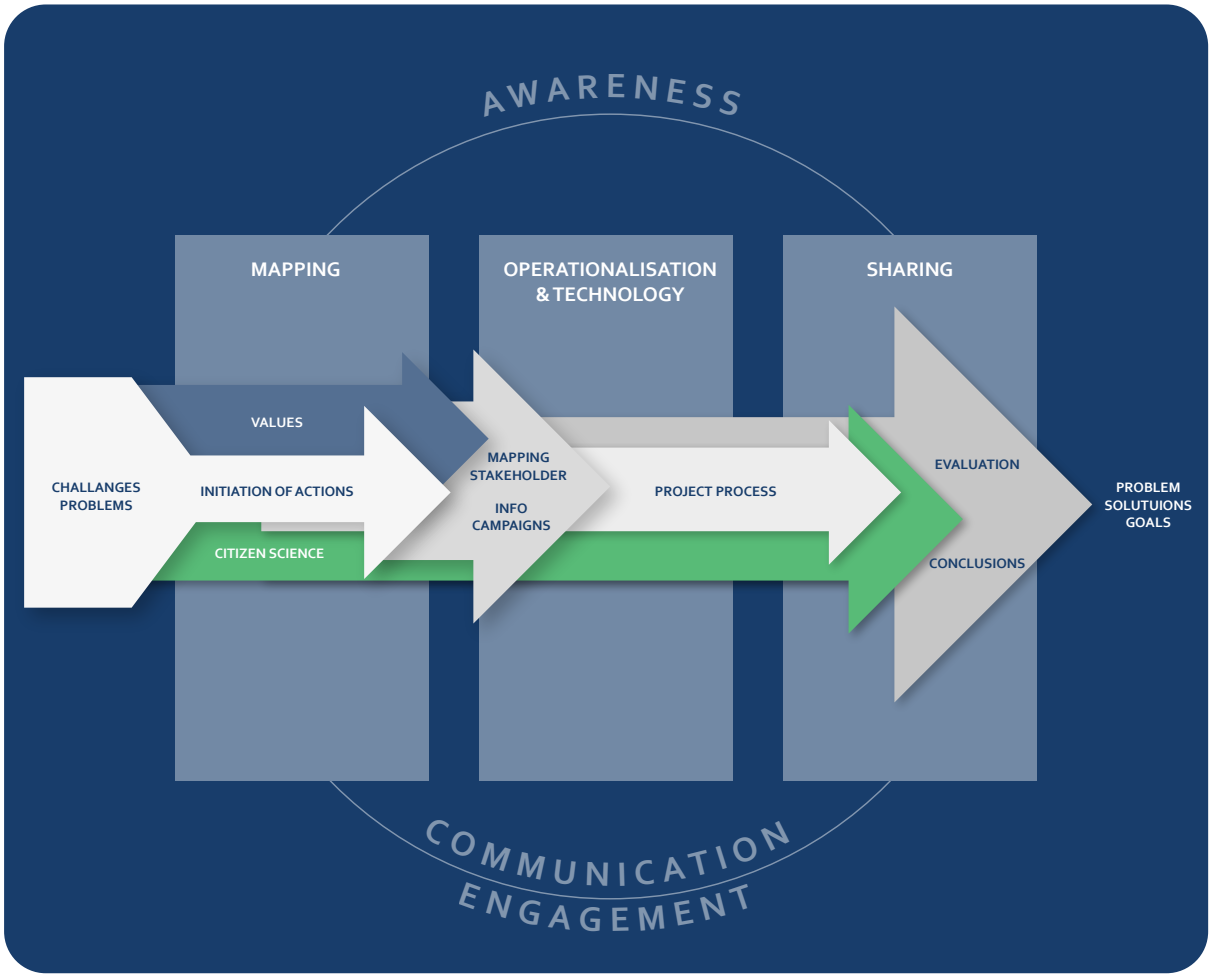
- enables gaining knowledge about the research area, including problem areas, local conflicts, threats and development potentials in spatial terms as well as in the scope of assessing the risk of given phenomena occurring;
- Provides analysis of stakeholder expectations, values and needs by social and age groups.

Who participates?

- Project team,
- Activists, NGO representatives,
- Local authorities.

How to do it?
Organise and conduct interviews, surveys and workshop meetings.

FIG. 5. MOST MODEL



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TAB. 6. OVERVIEW OF PARTICIPATION LEVELS, TYPES, OBJECTIVES AND THE DIGITAL TOOLS THEY INVOLVE.
Source: Authors. Note: The column: Application of methods based on VSD values is based on Friedman B., Hendry D.G. (2019). Value Sensitive Design. Shaping Technology with Moral Imagination, MIT Press.

MAPPING			
What do we do?	How do we do it?	Application of methods based on VSD values*	What do we want to achieve?
Detailed stakeholder mapping	Internal workshops	Value-oriented semi-structured interview Goal: Capture value Partially structured interview questions as a way to find out stakeholders' understanding, views and values on a topic. Questions typically emphasise evaluative assessments of stakeholders (e.g., okay or not okay), as well as reasons (e.g., why?). Additional considerations introduced by the stakeholders are taken into account.	Identification and legitimisation of stakeholders. Identification of individuals, groups, organisations, and institutions, who may be affected by the research being conducted, and how. Two overarching categories of stakeholders: - people who are directly involved in the study (direct stakeholders); - People who are affected by the results of the research (indirect stakeholders) Final decision on the composition of the project team
Information about activities and invitations for submissions if anyone thinks any more stakeholders have been left out	Information on the city hall website, city app, social media		Making sure no one was left out of the internal analysis. Building a community around the project and its external communication channels.

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OPERATIONALISATION and TECHNOLOGY			
What do we do?	How do we do it?	Application of methods based on VSD values*	What do we want to achieve?
Gathering information about the problem within the project team	Workshop meeting	Identification of value systems Goal: Identify value sources Distinguish between the clearly defined values of the project, the personal and professional values of the designers, and the values held by other direct and indirect stakeholders.	Discover how the problem is perceived from various perspectives.
Analysis of financial, social and other costs currently and their trends. The cost of the problem.	Workshop meeting	Value scenario Goal: Representation and value capture Narratives, consisting of stories about the issue under study, are designed to show the social, economic and technical aspects of a given context. Value scenarios emphasise implications for direct and indirect stakeholders, related key values, widespread application, indirect effects, long-term application and similar systemic effects.	As a summary of the surveys and the workshop - obtaining information on various types of costs.
Formulating proposals for solutions	Focus meeting	Prototyping or pilot activities Goal: Representation and value capture. Develop, analyse and co-design mock-ups, prototypes and field deployments to explore the value implications of technologies that have not yet been built or widely adopted. . Mock-ups, prototypes, or field deployments highlight the implications for direct and indirect stakeholders, value tensions, and technology placed in a human context.	Possibly a long list of all potential solutions. Baseline material for further action.

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Gathering information about the problem Residents' understanding of the problem	Survey	Co-creation in conjunction with social aspects Goal: To enlarge the project space Expanding the design space to include social structures integrated into the study topic can yield new solutions that are not feasible without considering social aspects. Social structures can consists of policies, laws, regulations, organisational practices, social norms and other factors.	To find out whether residents perceive the problem, and what is their assessment of the problem, you can ask their opinion on the causes. We get them to take an interest in the problem plus the survey can clarify certain issues and be educational.
Publication of survey results	Publication on the city's website, social media, etc.	The limits of value flexibility Goal: Value analysis An analytical method to reduce the solution space and resolve value tensions between design choices. First, design options that even a small percentage of stakeholders strongly oppose are removed-boundaries/value barriers. Then, of the remaining design options, those that a large percentage of stakeholders find attractive are brought to the forefront - value flows/common values.	Information about the project's results highlights that residents' opinions are taken into account.
Selection of solutions for further analysis	Internal meeting of the project team		Narrowing the lite of possible solutions, rejecting those that are not feasible due to technical issues or other considerations
Prepare solutions/scenarios from the shortlist - digital twins	Necessary cooperation with technology company	Joint design Goal: Long-term thinking and design foresight. Co-design activities and processes that emphasise a long-term anticipatory future with implications for multiple and future generations.	Digitally developed scenarios/solutions

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Analyse information from residents for use in strengthening the effectiveness of the solution used	Working meeting	Value-sensitive stock rebound model Goal: Representation and value capture. Reflective process of incorporating value-sensitive prompts into a collaborative design activity. The prompts can be generated by the designer or the stakeholder.	Prepare a list of conditions/incentives/impulses to make the project work well and be accepted by residents based on all the information collected from residents so far (including posts under previous publications)
Gathering opinions on the various solutions	Co-creation workshops	Values of dams and flows Goal: Value analysis An analytical method to reduce the solution space and resolve value tensions between design choices. First, design options that even a small percentage of stakeholders strongly oppose are removed from the design space - value dams. Then, of the remaining design options, those that a large percentage of stakeholders find attractive are brought to the forefront of the design - value flows. It can be used to design both technology and social structure.	Receive feedback on proposed solutions, possible potential amendments, comments or risks. Discussion on what conditions must be met for the solution to work, what might work, and where the potential risks are - gathering as wide a range of opinions as possible.
Information on the results of the workshop, including a summary of the discussion	Publication on the city's website, social media		Inform about the solution, but also how to implement it and emphasise the role of residents in shaping the solution.

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SHARING			
What do we do?	How do we do it?	Application of methods based on VSD values*	What do we want to achieve?
Evaluation - conclusions and formation of good practices for use in the next project	Internal meeting of the project team	Co-creation in the long term Goal: Long-term thinking and design foresight Co-design activities and processes that emphasise long-term foreseeable scenarios with implications for multiple and future generations.	Record conclusions and recommendations - what worked, what didn't, and advice in each of the earlier phases. Practical, e.g., who worked well with whom, what channels for reaching residents were most effective, what didn't work, Building competencies and knowledge for future project teams based on the model - developing the model and adapting it to local specifics.
Information on how new projects are introduced.	Published on the city's website, social media		Strengthening acceptance of the solution. Increased involvement of residents - they see that their input is real.

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Building the MOST Model Based on The CREST Experience

The main goal of using digital counterpart technologies (*digital twin*) in our project was to create opportunities for ordinary citizens to easily visualise the risks posed by climate change to the places where they live. This is because our project team operated under the assumption that effective visualization of the problems allows for a better understanding, making it easier to accept changes, including infrastructure solutions that enhance local resilience to climate change.

Our project team included scientists, representatives of the three participating cities, namely Kristiansund, Bordeaux and Kołobrzeg, and staff of CREST's coordinator, the company that also developed the technological solution - *digital twins*. Working together, we designed and implemented a number of activities, through which we gained a great deal of valuable experience on how modern technologies can support citizen participation in city decision-making processes.

Kristiansund is a municipality on the west coast of Norway, in Møre og Romsdal County, with a population of 24,013. It is surrounded by a network of islands and fjords in the Norwegian Sea. Its coastal location and proximity to the ocean make the municipality particularly vulnerable to the effects of climate change. Sea storms and rising sea levels threaten coastal infrastructure and shoreline. In addition, melting glaciers and changing precipitation patterns are affecting slope stability and increasing the risk of landslides. At the same time, rising temperatures can disrupt marine ecosystems, affecting the fishing and aquaculture industries, which are the economic pillars of the region.

Bordeaux Métropole is a French metropolitan area located in the Gironde department in the New Aquitaine region. It consists of a total of 28 municipalities and has a population of 814,100. Through its territory flows the Gironde River, which 80 kilometres away flows into the Atlantic Ocean. The influence of the river and the ocean, combined with a high level of urbanisation, promotes the development of flooding in the area, which threatens a total of some 40,000 residents. In the face of these challenges, Bordeaux Métropole has committed to improve the understanding of the impacts of climate change in the region, to develop a long-term strategy for adaptation to these risks, and to protect and strengthen the functions of flood spreading zones, low-lying areas and natural spaces.

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Kołobrzeg is a city located in Kołobrzeg County, West Pomeranian Voivodeship, with a population of 44,737. It is located on the northern coast of Poland on the Baltic Sea, at the mouth of the Parsęta River. Kołobrzeg is a region facing many climatic hazards. The annual rise in the level of the Baltic Sea of 3-5 millimetres indicates a scenario in which the sea level will rise by 45-65 centimetres by 2100. This increases the risk of accelerated coastal erosion, flooding and the frequency and intensity of storms. These outcomes threaten not only key coastal infrastructure such as dykes and quays, but also the safety of residents and the economic viability of coastal areas.

Naturally, as is often the case when undertaking something new and not yet fully understood, we have also made many mistakes that have compelled us to think, reflect, and adopt a critical approach, ultimately leading to the development of the MOST model. We hope that MOST is a universal tool, a ready-made approach that can be applied to many projects. It is flexible enough to adapt to a wide variety of projects, locations and needs. We had the opportunity to test its flexibility while working in different geographical, cultural and socio-economic areas within the CREST project.

The basic premise of our CREST project was to empirically verify the advantages and disadvantages of *digital twining* as a tool to support citizen engagement processes. We did not know in advance which problems the residents of each city would consider crucial in terms of the climate risks typical for their area. We only knew that these would be the problems faced by coastal cities and that they would be set in the context of building their resilience. Although all the cities participating in the project are struggling with the effects of climate change, the main threats to each city varied, for example due to their geographical location. Therefore, the approaches we adopted in the project had to be - from the very beginning - both flexible and universal.

The desire to meet the requirement for simultaneous flexibility and universalisation led us to adopt the following main directions for co-creation activities:

1. Designing and conducting a survey
2. Organising and conducting focus meetings,
3. Development of digital equivalents for selected use-cases,
4. Organising and conducting co-creation workshops.

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Mapping

Mapping was included within the fundamental pillars of the MOST model, primarily due to our experience in the CREST project. Although we made a concerted effort to ensure effective communication, it became apparent during the project that our efforts were insufficient. One of our conclusions is that communicating information about the project and building channels of communication with stakeholders, but especially with citizens, should start at the very beginning of the project when it is still in outline. Our lack of extensive project communication activities was reflected in the difficulties in completing and selecting participants for the workshop groups, but also, in one city, it jeopardised the achievement of the stated goals of organising a focus group at all. Hence, our concern is to place 'mapping' as the first important duty of good participatory practices. An accurate reflection of a community's richness, diversity, and specificity defines successful mapping. The group of people involved should include those whose competencies complement each other. It is a grave mistake to under-represent or over-represent in favour of any of the stakeholder groups - for example, by succumbing to the temptation to reach out more easily to the city government or some larger organisation.

Effectively inviting other key stakeholders will make for a more multifaceted view of a given project and open and streamline communication channels from the outset. Hence, in our opinion, it is so important from the very beginning to determine who is interested in a particular initiative, who is affected by it and whose life it affects, and who is necessary or even indispensable (including whose favour will facilitate the implementation of a given project) for smooth implementation. It is also necessary to think already at this stage that the composition of the people involved should be such that the absence of one person will not paralyse the work and the lack of any activity during someone's absence

Of course, the larger the group, the more difficult it is to agree, reach a compromise or even find a date for a meeting. It seems that the solution here may be to establish a broader and narrower composition - one working in a more working mode and the other of a more consultative nature.

At the same time, during the mapping phase, necessary outreach activities on social media are already underway, for example. Of course, it is important for the local community to know what the upcoming plans are. Still, we would like to point out something else here - communication, especially on social media, allows for building a wider group of people from the very beginning, including lay citizens who are interested in the project in some way. Since, as we have found out, the task of recruiting citizens to meetings is enormous, we have experienced particular difficulties in Poland (this is described in more detail in the description of the next phase). Building contact and relations with citizens is worth starting from the very beginning.

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Operationalisation and Technology

At the beginning of this phase, we aimed to gather as much information as possible about how various stakeholders perceive the risks associated with climate change. We began our efforts by designing a survey with the same set of questions in all three regions, targeting a broad audience. Information about the survey was posted on the cities' websites, city apps and social media. Despite somewhat similar outreach efforts in all three cities, the greatest success - measured in the number of responses collected relative to the size of the city and in the speed of collection - was achieved in Kristiansund. It appears that the most significant factor contributing to such a high response in Norway was the exceptionally high level of personal involvement among city decision-makers. Knowledge of the local context and strong identification with the goals of the participatory activities, combined with an intensive, well-designed information campaign (e.g., hanging posters in various parts of the city) passed the test here.

Posting surveys on social media on project profiles also seems like a good solution. This way, interested people can easily find more information about the project, share it, and write comments, which builds a community around the project and facilitates later contact, especially since the surveys themselves are anonymous.

This experience was the source of some of the project's most important observations - for any project activity to succeed, there needs to be a real commitment from those working for the city and, so to speak, "corporate ownership" of the project by them.

The results we obtained from the surveys served as the basis for conducting focus meetings with groups consisting of a variety of city stakeholders, including professionals such as representatives of city services, local entrepreneurs, people involved in water supply, emergency management, etc., and representatives of local authorities. The primary purpose of these meetings was to identify key risks and specific locations that could serve as case studies (use cases).

Here, the mistake that taught us the most was insufficient communication of the project context itself, including the construction of the consortium. One of the partners in the project was a private technology company responsible for implementing the digital twins component; the project was funded by European funds and was in no way commercial. During the workshop, the participants were introduced to the project's goals, and we also wanted them to learn about the digital twins technology itself. In our understanding, the knowledge of this technology was to help them better understand what we want to achieve with this technology and thus better select use-cases - locations for further research. These locations were to - on the one hand - be a good exemplification of the climate challenges for a given city, and on the other hand - meet the criterion of availability of data necessary to describe these locations digitally using the new "twinning" technology. For us, these goals, after more than a year of the CREST project - were well realised, even obvious. On the other hand - apparently due to poor communication - participants at the French meeting got the impression that our technological partner presenting digital solutions - were doing so mainly for commercial purposes. A lot of extra time had to be spent at that meeting for thorough explanations and corrections, proceeding in an atmosphere of tension, mutual distrust and misunderstanding. It seems that equally important in this context was the fact that part of our French team happened to lack representatives from the city of Bordeaux. Also, not a very successful decision was the hiring of

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external experts to lead the focus meeting in France, whose connection to the project's goals and thus knowledge of the project itself turned out to be too small to avoid communication errors.

„For the focus group, the goals have been partially achieved, since no specific area in Bordeaux Metropole has been identified by experts. They were disappointed, or more precisely, destabilised because they wanted to be part of "public research" and thought to be "manipulated" by the Norwegian private partner".

Jeanne Dachary-Bernard, INRAE

For the case studies that emerged from the focus group results, data were collected, and their digital twins were developed, along with scenarios for the development of climate change threat situations. It turned out that in most cases, the fact that we were using modern technology was an element that interested people and helped decisively to engage. In a few cases in Norway and France, we received requests from individuals who had been selected to work in teams without technology support, asking to be moved to digital groups.

„The only incident that occurred during the workshop was that too many people came to the workshop, which we did not expect".

Lina Essafi, INRAE

The final step was to conduct co-creation workshops, where groups made up of ordinary citizens and professionals worked together to find specific solutions using new and existing infrastructure to increase the resilience of selected locations to climate change risks.

„Recruitment challenges - recruiting participants representing all target groups (e.g., vulnerable populations) was a bit challenging in Kristiansund due to its smaller size".

Rosmary Aghedo, Kristiansund Municipality

The biggest problems occurred in Poland, despite a previously conducted, extensive recruitment campaign that included sharing information on social media, posting posters in the city, making phone calls to representatives of various NGOs and other city organisations, as well as personal visits and invitations to meetings. Ultimately, only a few individuals were recruited. Already during the meeting, it turned out that for some of the participants (who left the meeting and eventually did not attend), it turned out to be a problem that the project is financed with EU funds and that at the beginning of the project, we asked people to sign relevant documents - under RODO. Although these

measures, as we know, are intended to protect personal data, in this case, they aroused distrust and adverse reactions. This came as a big surprise to us. Especially since every email and piece of information about the project was clearly described, along with the source of funding, it seemed to us that by now, we were all accustomed to consenting to sharing an image or processing personal data.

These experiences further reinforced the conviction that effective action in any project to involve people requires a great deal of communication effort and a good understanding of the local context and the characteristics of the local community.

"Lack of consistency in contacting the people involved in this activity and priority to select experts instead of local associations, citizens and communities. The focus group failed because WP1 leaders had decided to choose high-profile professionals from public institutions and the army instead of involving lay citizens and local communities and leaving these professionals in the hands of an external consultant who didn't know CREST. There was a lot of scepticism; their expertise was way above on the topic, and they were questioning the scientific methodology of CREST".

Silvia Cibien, Accent Sud

Sharing

An essential pillar of our MOST model and an important phase of the project is to summarise, formulate conclusions, and describe and systematise good practices - thus building a helpful message for the future. We aim to achieve this on a broader level by writing a guide and constructing a model, with the hope that our experiences will make it easier for many people to work and demonstrate, step-by-step, how to do what we did more effectively.

It is worth noting that the municipal decision-makers from Kristiansund involved in CREST have also created a project summary document for internal use, which identifies good practices and tips of a very local nature. Such a project evaluation is not only formal but also very practical – advice that is strongly rooted in the local context will make life easier for subsequent project teams.

The above-described course of action made it possible to achieve a synergistic effect by looking at the problem from two perspectives - the perspective of ordinary citizens, residents of the regions concerned and other users of cities, and the perspectives of people who are directly involved in various decision-making processes in cities due to their professional duties. In turn, the co-creation workshop provided an opportunity for these two perspectives to meet.

The processes of involving ordinary citizens in any decisions or creating proposals for solutions are demanding for both sides. During the focus meetings, when we showed the results of the surveys to

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a group of professionals, we were met with criticism of the results. The basis of the criticism was that ordinary citizens do not have enough knowledge regarding the problem being studied, hence what they have to say should not necessarily be taken into account. However, it is the people who will later be the recipients of the solution developed in the project that will benefit from understanding their perspective and taking it into account, allowing for a better solution to be developed.

This experience describes very well why it is so important to apply citizen science and people's participation at each stage of the project. Learning about their values and basing the project on those values yields better solutions and allows for more targeted outreach, which in turn influences public acceptance of the solutions developed. On the other hand, the professionals participating in the meetings shared their knowledge and experience while setting the framework for discussions on aspects such as the state of the municipality's budget, legal solutions or certain technological possibilities.

Our observations prove that cooperation between ordinary citizens and professionals is much more effective when supported by new technologies. In our case, the use of digital twinning for the areas that were selected in the focus groups and showing scenarios with them, e.g. for flooding as was the case in Kołobrzeg, definitely raised the level of understanding of the risks and the effects of the proposed solutions, improved the discussion and made it easier to reach an agreement.

Benefits of Using Technology in The CREST Project

The dynamic development of digital technologies is having an increasing impact on all areas of our lives, both work and leisure. Hence, the use of technological solutions in design and research processes is becoming an increasingly common method. The assumptions of the CREST project, which included the use of technology, fit into this trend. Thus, technological tools were not only an essential element of the dialogue, but also a helpful tool in demonstrating challenges and solutions related to climate change. The project's groundbreaking digital twins enabled analysis and visualisation of data and "what if" scenarios in an interactive and immersive visualisation tool that can be used by policymakers, researchers, businesses and citizens. This made them more understandable and tangible for stakeholders, especially local communities, who were more actively involved in the co-creation of solutions and decision-making in three European urban areas, focusing on the adaptation of resilient urban infrastructure to climate change.

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TAB. 7. PROS AND CONS OF USING TECHNOLOGY IN THE CREST PROJECT
Source: Authors

Pros	Stakeholders: Local communities, entrepreneurs	• Interesting and engaging informational and educational methods that allow easier and faster assimilation of basic issues related to the project topic • Effective methods of communication and conveying comments and suggestions • Opportunity to "see and experience" the proposed solutions and thus better understand all the nuances of the proposed solutions
	Local authorities	• Increasing the level of knowledge among residents related to climate change and the need to strengthen the level of urban resilience, • Greater involvement in environmental activities • increased engagement of local communities
	Project team	• Greater interest in the project and, through this, greater involvement of stakeholders in co-creation processes, • Effective methods of communication and collection of data and feedback among stakeholders, • achieve better project results
Cons	Stakeholders: local communities, entrepreneurs	• Difficulties in technology that is too advanced - especially for the elderly or those with limitations that exclude them from using VR technology
	Local authorities	• Difficulties in implementing complex and innovative design solutions
	Project team	• Technical difficulties in organising participatory processes • Exclusion (e.g., medical) of certain stakeholders from participation in digital activities

Summary and recommendations

Building urban resilience is becoming one of the most important challenges facing modern cities and other urbanised areas. Due to the great diversity of individual administrative units and their unique spatial, social, economic, environmental or infrastructural conditions, there is no universal recipe for building or increasing the level of resilience in individual units. Local resources build the capacity to adapt to hazards, disasters and climate challenges, which is why it is so important to start every project with a good and detailed diagnose of existing conditions, resources and challenges relating to specific cases. One of its stages is the analysis of social capital in terms of its self-organisation to create mechanisms for interaction in climate change adaptation, mitigation of its negative effects and self-organisation in situations of threat or emergency.

The experiences of other cities in building urban resilience, as well as research projects exploring this topic, can provide valuable lessons and guidance. They are not directly applicable to the experiences of other urban centres. Still, the lessons learned from them allow the formulation of more universal recommendations that can serve as a starting point for designing similar activities in the design and implementation of solutions to strengthen the city's ability to regenerate to unexpected events and set the course of action in this regard.

Building a city's resilience helps prepare it for more or less predictable risks resulting from the negative effects of climate change. The result will be to reduce the city's vulnerability to sudden emergencies, reduce potential damage, shorten the duration of the crisis and use it as experience in the long-term process of strengthening and improving the city's level of resilience.

CREST project Climate Resilient Coastal Urban Infrastructures Through Digital Twinning was concerned a specific group, cities such as coastal cities, the solutions developed, the experience gained, and the conclusions of the participatory co-creation processes carried out became the basis for formulating a universal MOST model. This model, so to speak, is a prescription, a scheme of activities supplemented with tools that enable the effective implementation of initiatives taken by local authorities to strengthen the resilience of urban areas.

The work within the CREST project and already formulating the MOST model's assumptions has produced a list of recommendations aimed at local authorities, which are the most important actor in the process of building urban resilience.

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Key components of building or strengthening urban resilience:

- Preparation at the institutional level,
- Competent, municipal administrative units, interdisciplinary and interdepartmental working teams,
- Bringing the city into compliance with European and international climate law,
- Expert and social potential (UrbanLabs, NGOs, etc.),
- Open and properly aggregated data,
- Identification of climate risks and the introduction of a system for monitoring the level of residuals using appropriately selected indicators,
- Securing funding,
- Experience in co-creation processes,
- Existing, effective information channels with stakeholders,
- Implementation of new policies, programs or projects aimed at strengthening the resilience and flexibility of the city, implementing the assumptions of the adopted local action strategy for adapting cities to climate change and overcoming its negative effects,
- Identification and optimal prioritisation of current, long-term and strategic challenges.

Recommendations

Systemic thinking, planning and action. It is necessary to think systematically about building a city's resilience because a given area is part of a whole, not only in the context of a single urban centre but also in the context of a given region. This is particularly important in the context of building climate resilience, where administrative boundaries do not limit the threats and challenges that occur.

Integrating perspectives and a holistic approach. A city is a complex system, so its development planning and resilience enhancement must be a process that integrates all its areas of functioning. Actions in the environmental sphere have their translation into economic or social aspects, so a correct understanding of these interrelationships makes it possible to optimise actions and their subsequent consequences, both positive and negative. It should be emphasised that city resilience cannot be treated as just another activity or project but requires a change in the perspective of thinking about city management. It should be coverage for all actions planned and implemented by the city government. This implies the need to assess potential climate and environmental impacts on a regular basis. Integrated resilience-enhancing activities can achieve better results while reducing financial resources. Systems thinking in this regard greatly minimises the danger of duplication of activities by different municipal entities, but also proper coordination and synchronisation of these activities.

Innovation and technology. The use of digital technologies in co-creation processes allows conditions for experimentation, scenario planning and testing of alternatives, as a result of which it

is possible to develop optimal solutions and make decisions under the uncertainty of unpredictable climate conditions.

Inspiration and cooperation. Collaborate with other cities to share experiences, knowledge, and joint efforts in building regional resilience. The term resilience itself is increasingly present in the public debate. It is very important, but it is crucial to examine levels of resilience and consciously manage cities to strengthen them. The experience of cities can become an inspiration and motivation but also set a pattern of action for other urban centres.

Education and increased awareness. Increasing the level of knowledge of the local community in the field of urban resilience contributes to a better understanding of the issue in all its complexity and thus increases the chances of accepting the actions taken, developing compromise on contentious issues, spreading knowledge in one's surroundings, more pro-environmental individual behaviour, etc. Attention should be paid to educating children and young people, informing them about local government actions taken in favour of climate and ecology, and promoting ecological content and actions.

Broad stakeholder group. Identifying all stakeholder groups is a key element in the success of all activities. On the one hand, they allow for a broader cognitive perspective, which brings a different understanding of an issue and often provides new insights.

Nudges. Incentive design. Involving the correct number of participants in participatory and co-creation processes and actively engaging with them can be quite a challenge in some cities. A similar situation may apply to encouraging residents and other stakeholders to adopt environmentally friendly daily habits and attitudes. One solution may turn out to be well-chosen incentives—incentives that will encourage these less socially engaged groups to participate in the processes of strengthening resilience in their cities.

Monitoring effects and their evaluation. Even the best project solutions need to be monitored at the implementation stage, allowing for possible modifications due to implementation difficulties, changes in conditions (e.g., economic or social), or other unforeseen factors.

Co-creation and co-responsibility. Involving the local community and other stakeholders (local entrepreneurs, experts, researchers, NGOs, etc.) in the co-creation of projects at every stage allows for better results of individual activities or projects. This applies to both the diagnosis of the existing situation in terms of threat assessment and potential, as well as to the designed solutions and their evaluation and conclusions. In addition, involvement in project work and decision-making processes often results in a sense of agency, which in turn translates into an increase in shared responsibility for the city by all who shape it. This has very beneficial consequences in the long term, as public involvement makes it easier to monitor the effects of individual actions and their possible modifications. Another advantage is the increase in ecological awareness among residents, which provides an opportunity to foster pro-environmental attitudes and behaviours.

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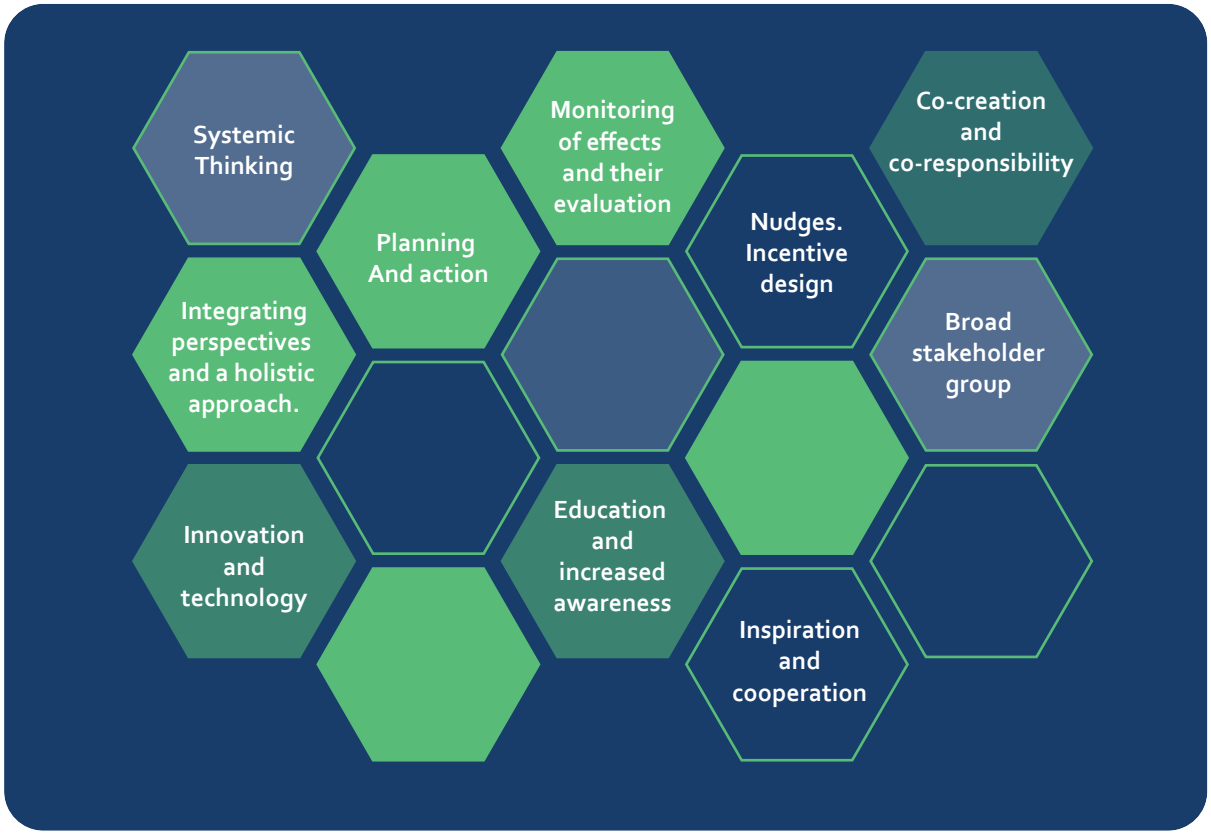
FIG. 6. RECOMMENDATIONS
Sources: Authors.



How to use the findings and recommendations?

This study is a handbook that presents issues related to increasing urban resilience in a clear and accessible manner. Its conclusions and recommendations are based on the experience in this regard, which was carried out on three selected administrative units in European cities within the framework of the CREST project. Three distinct case studies and varied contexts of spatial, social, economic, or environmental conditions facilitated the development of a universal model of action, which can serve as a guiding principle and inspiration for other local governments.

The conclusions and recommendations formulated can be implemented not only by the authorities of the three selected cities but also by the authorities of other administrative units. The most important thing is that they should be translated into practical decisions and actions - including the formulation of relevant policies and programs. Conclusions and recommendations should become the subject of reflection and analysis by interdisciplinary and interdepartmental city teams, which will analyse them already in the context of local conditions.

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IRMiR INSTITUTE OF URBAN AND REGIONAL DEVELOPMENT

INRAE science for people, life & earth

BxSE Bordeaux Sciences Economiques Bordeaux School of Economics

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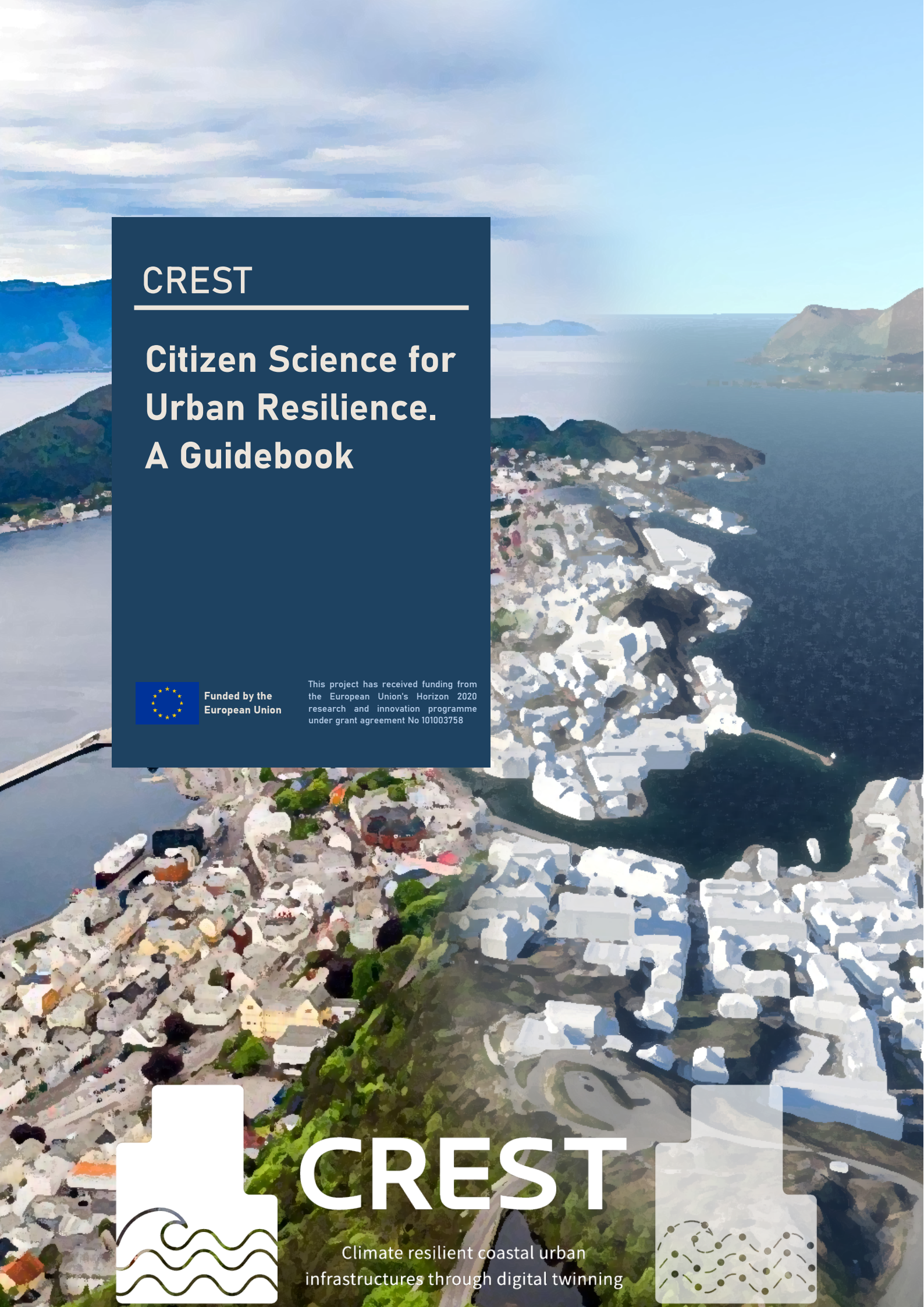

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