CitiMeasure

Using citizen measurements to create smart, sustainable, and inclusive cities

Prototypes of the three (3) instruments

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Acronyms

EC	European Commission
CS	Citizen Science
CSA	Citizen Science Association
D	Deliverable
DG	Directorate General
DOI	Digital Object Identifier System
EU	European Union
GDPR	General Data Protection Regulation
IDE	Integrity, Diversity and Equity
ICTs	Information Communication Technologies
JRC	Joint Research Centre
NGO	Non-Governmental Organization
NILU	Norwegian Institute for Air Research
PGRA	Flood Risk Management Plan (Piano di Gestione del Rischio Alluvioni – in Italian)
PM	Particulate Matter
R&I	Research and Innovation
RIVM	Dutch National Institute for Public Health and the Environment
Scivil	Citizen Science Vlaanderen
SDGs	Sustainable Development Goals
SDI	Spatial Data infrastructure
SDU	South Denmark University
TPB	Theories of Planned Behaviour
TRA	Theories of Reasoned Action
UCD	University College Dublin
UWE	University of Western England
VITO	Flemish Institute for Technological Research
WG	Working Group

1 Executive Summary

This report presents the first prototype of the CitiMeasure instruments, more specifically, the 'CitiMeasure Behaviour & Policy guidelines', the 'CitiMeasure guidelines on Competencies for Digital Inclusion', and the 'CitiMeasure inventory of air quality monitoring initiatives'. In addition to presenting the prototype instruments, this report also provides insights about how the instruments have been developed, including the list of contributors who have provided inputs into the co-creation process, the methodological approach, and the resources that each instrument has been built upon.

2 Introduction

2.1 ABOUT CITIMEASURE

Citizen measurement, or citizen science, initiatives contribute to a sustainable transition in European cities. By using an array of tools and instruments, citizens can play a role in the measurement and monitoring indicators on air quality, temperature, soil moisture, biodiversity, or risk management, among other environmental areas. Citizen measurement initiatives also can foster communications and interactions among stakeholders and contribute to the democratisation of science and policy. The CitiMeasure project (2021-2023) aims to bring together the experiences and expertise of European cities, organisations and networks in implementing citizen science initiatives (in the form of guidelines, toolbox, web-platform, Apps, etc.). The project builds upon the lessons learned from the Dutch City Deal Working Groups, a network of stakeholders working on the broader area of smart cities, including citizen measurement initiatives. The City Deal partners have been working closely with the Dutch Ministry of Interior and Kingdom Relations for over a year.
CitiMeasure builds upon these experiences and will use those to develop and pilot three 'instruments', namely:

1. An instrument that allows the outputs of different city measurement initiatives to be compared.
2. An instrument that safeguards the digital inclusivity of city measurement initiatives (maximising the opportunities for participation of interested individuals and communities).
3. An instrument that connects information to behaviour and policy change.

A 4th (Strategy and Oversight) working group focuses on providing strategic direction and ensuring cohesion of activities across the three Instrument Sub-Groups and the project in general. CitiMeasure will also raise awareness of the importance of citizen measurement initiatives and capitalise on the results and tools of similar citizen science projects by creating an online European Knowledge Centre with a repository of good practices.

2.2 PURPOSE OF THIS REPORT

The current report includes the prototype (text) version of the three instruments. The purpose of this report is to showcase the key elements of each of the instruments. This report includes the co-created work of the three working groups and more than 40 experts, researchers, and local representatives during a period of eight months. Nevertheless, this is not the final version of the CitiMeasure instruments. Lessons learned, as well as further elaborations and improvements during the pilot phase of the project will be used to develop the final version of the CitiMeasure instruments that will be presented in Deliverable 1.12 (Final Instruments) in April 2023.

2.3 PROTOTYPE OF THE THREE CITIMEASURE INSTRUMENTS

The three CitiMeasure instrument working groups worked towards development of their shared vision, objectives and prototype instruments between October 2021 and April 2022 (for details on visions and objectives see CitiMeasure D1.4). Based on the co-created vision and objectives, the Behaviour & Policy and Digital Inclusion working groups focused on developing *guidelines*, and the Comparability working group worked towards developing an *interactive tool and inventory of air quality monitoring initiatives*. The prototype of the guidelines produced by the Behaviour & Policy and Digital Inclusion working groups are presented in sections 3 and 4. These sections present the guidelines in text format. The final version of the guidelines is planned to be delivered in D1.12 (Final instruments), which will include more visual elements and search functionalities based on the current text and the improvements in the pilot phase. Section 5 provides a description of the interactive tool developed by the Comparability working group.

3 CitiMeasure Behaviour & Policy guidelines

3.1 INTRODUCTION

3.1.1 Purpose of the document

Changes in actors' behaviour (at both individual and societal levels) and change in policy processes are among the most desired outcomes of citizen science initiatives. However, such changes are complex to understand, achieve and measure. The CitiMeasure Behaviour & Policy guidelines aim to advance the understanding of the changes in behaviour of different stakeholder groups, as well as decision and policy making processes. This includes changes in trust, participation behaviour, new culture of collaboration, sharing responsibilities, as well as established decision and policy making processes. The current guidelines help unpack the applications of citizen science for policy and behaviour change, understand challenges that citizen science projects face for fostering such changes, and provide practical recommendations on how to tackle such challenges.

3.1.2 Who are these guidelines for?

The CitiMeasure Behaviour & Policy guidelines are primarily developed to guide those who are interested in identifying, understanding, and enhancing policy and behavioural changes resulting from citizen science initiatives. This includes cities, organizations, researchers, and practitioners who are involved in initiating citizen science projects, or those who aim to study or improve current practices in existing citizen science initiatives.

We also hope that these guidelines are informative for those who are interested in the broader topics of policy change and behaviour change in participatory governance processes.

3.1.3 What can you expect to find in these guidelines?

Section 3.2 of the guidelines provides background information about the CitiMeasure project and these guidelines. This includes a description of the project and the CitiMeasure Behaviour & Policy working group, as well as a description of the methodology followed for developing the guidelines.

The main content of the guidelines is summarized in Sections 3.3 and 3.4. These sections start with challenges and needs related to policy and behaviour change. We then explore purpose and applications of citizen science. The main contribution of the guidelines is a set of recommendations on how to systematically think about and enhance policy and behaviour change outcomes of citizen science initiatives.

3.1.4 What these guidelines are not?

There are many things that these guidelines are not, but we would like to emphasize a few:

- These are not step-by-step guidelines to identify and improve policy and behaviour-related impacts of citizen science initiatives.
- The recommendations presented in the current guidelines are built on a wealth of theoretical and empirical insights from several resources and expertise of 35 individual members of the CitiMeasure Behaviour & Policy working group. Nevertheless, this shouldn't be considered as a comprehensive source of recommendations for behaviour and policy change in citizen science. There are certainly more experiences, recommendations and best practices related to behaviour and policy change in citizen science that we couldn't capture and include in these guidelines simply because they were not known to the working group members, and due to the fact that we didn't have the time and resources to conduct a systematic and holistic literature review on the topic.

Lastly, replication is always context-specific, so although many solutions presented in the guidelines may be replicable, we believe applying these solutions should be considered on a case-by-case basis, linked to the aims of the actors or initiatives, and with the local context in mind.

3.1.5 Who to contact for questions or feedback?

For questions, comments, or feedback about these guidelines, please contact the CitiMeasure Project Coordinator Mohammad Gharesifard at Mohammad.Gharesifard@eurocities.eu.

3.1.6 List of contributors

These guidelines are the result of an iterative co-creation process with inputs from members of the CitiMeasure Behaviour & Policy Working group. The members of this working group are affiliated to 19 European cities and 7 (non-)governmental and research organizations (see Figure 1). In particular, 19 out of the 35 individual working group members have contributed to these guidelines by providing resources, and/or critically reviewing those resources. The detailed list of contributors and their affiliations are provided in Table 1. In addition to contributors from the working group, Table 1 also includes the name and affiliations of two Eurocities team members who have been involved in developing the guidelines, as well as one external expert (Margaret Gold) who contributed to the development of these guidelines by reviewing 10 resources.

WG member	Affiliation
Anna Berti Suman	European Commission Joint Research Centre (JRC)
Anna Georgieva	Sofia
Annelies Duerinckx	Scivil
Christina Paci	Milan
Diana Escobar	Barcelona
Emily Daemen	The Green Land
Irene Vivas Lalinde*	Eurocities
Joanna Heyda	Warsaw
Jussi Kulonpalo	Helsinki
Koen Broumels	Sittard-Geleen
Metodiyka Tarlyovska	Sofia
Margaret Gold**	Leiden University
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Sara Spaargaren	The Green Land
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Stella Psarropoulou	Thessaloniki
Valerie De Prycker	Ghent
Velko Velkov	Sofia
Youetta de Jager	ICTU Foundation

**Eurocities team members*

***External Expert*

Table 1 Contributors to the guidelines by providing resources, and/or critically reviewing those resource

3.2 BACKGROUND

3.2.1 About the CitiMeasure Behaviour & Policy working group

The Behaviour & Policy working group is one of the three CitiMeasure working groups developing instruments to create sustainable, inclusive, and smart cities. The group was initially formed through a call for expressions of interest that was shared through the Eurocities and City Deal networks, as well as personal networks of the CitiMeasure team. In September 2021, following an inception meeting, the group started to co-design a shared vision and a number of objectives that helped advance the understanding of behaviour and policy change resulting from citizen science. Since September 2021, and following a co-creation approach, Eurocities has supported the development of the current set of guidelines related to behaviour and policy change outcomes of citizen science. This was done by organizing and facilitating monthly online meetings, as well as communications with the working group members to share knowledge, experience, and resources for creating those guidelines. Currently, the working group has 35 members from cities, governmental, research and other organisations.

Figure 1: Cities and (non-)governmental organizations that are member of the CitiMeasure Behaviour & Policy working group

Here are the co-designed vision and objectives of the working group:

Vision: **"The CitiMeasure Behaviour & Policy WG works towards increased understanding of the changes in behaviour of different stakeholder groups, as well as decision and policy making processes. This includes changes in trust, participation behaviour, new culture of collaboration, sharing responsibilities, as well as established decision and policy making processes."**

Objectives:

1. Share ideas, case studies, best practices related to behaviour and policy change in citizen science initiatives. These best practices are documented with a close attention to their context (e.g., geographic, cultural, legal, and social context).

2. Jointly analyse and document the lessons learned from (un-)successful initiatives in terms of catalysing changes in behaviour of different stakeholders (e.g., trust, participation behaviour, new culture of collaboration, sharing responsibilities), as well as established decision and policy making processes.

3. By April 2022, develop guidelines and principles on behaviour and policy change that help cities and citizen science initiatives foster such changes.

4. Pilot the developed best practice in at least one real life example of citizen science initiatives between May and December 2022.

5. Consolidate the guideline/principles with lessons learned from the pilot phase and further analysis by March 2023.

Besides the Inception Meeting, seven co-creation sessions were organized to work towards development of the prototype guidelines. Throughout the co-creation sessions, the working group developed different elements paving the way to create these guidelines. Development of the shared vision and objectives as described above framed the scope of the work. In November 2021, the working group adopted an implementation plan for the different actions needed to produce their desired outputs. From December 2021 until February 2022, the working group members collected and shared resources such as academic articles, project reports and deliverables, policy documents, and other useful sources of information, such as toolboxes and webinars. The resource collection was conducted in parallel with the resources analysis by members and Eurocities staff. Figure 2 describes the key outputs of all the CitiMeasure co-creation sessions. Further elaboration on the co-creation process of the guidelines is presented in Section 3.2.2.

Inception meeting (Sept)
- Kick-off of working groups
- First version of co-cretated vision and objectives

First co-creation session (Oct)
- Validated vision and objectives

Second co-creation session (Nov)
- Co-created implementation plan

Third co-creation session (Dec)
- Co-created approach and structure for resource collection and analysis
- Roles and responsibilities

Fourth co-creation session (Jan)
- Progress with resources collection and analysis
- Co-created guidelines structure

Fifth co-creation session (Feb)
- Progress with resource collection and analysis
- Shared understanding of reviewed content by discussing reviewed resources

Sixth co-creation session (March)
- Refined content (working session on the content of the guideliens)

Seventh co-creation session (March)
- Refined content (working session on the content of the guidelines)

Figure 2: Key outputs of the CitiMeasure co-creation sessions

3.2.2 Development of the guidelines

The CitiMeasure Behaviour & Policy guidelines were developed using the following methodological steps and approach:

Definition of the scope

With the support of the Eurocities team, the working group members defined a shared vision and five objectives (see Section 3.2.1). Objective 3 specifies that the members found 'guidelines' as the most appropriate format for the outputs of this working group.

Resource collection and initial scanning

Based on the vision, the working group members and the Eurocities team collected and shared resources on behaviour changes, changes in decision and policymaking processes, trust, participation behaviour, a new culture of collaboration, and sharing responsibilities in the context of cities and citizen science initiatives. A shared online workspace (SharePoint) was created so that working group members could easily access and share resources. The working group members and the Eurocities team volunteered to perform an initial scan of the resources and made a suggestion for their inclusion or exclusion for an in-depth review. To standardize the resource collection/suggestion process, the following structure of information (in form of a table) was proposed by Eurocities and validated with the working group members during the third co-creation session.

- Name of the file
- Year of the publication
- Language
- Title of the resource
- Type of resource
- Keywords
- Link
- The person who suggested the resource
- Relevance for the instrument
- Name of the reviewer
- Progress review
- Starting date and review deadline
- Notes
- Should everybody review this resource?
- Is this a difficult resource to review?
- Include or discard?

Analysis of individual resources

The working group members and the Eurocities team volunteered to analyse the collected resources. Similarly, a structure was designed by the CitiMeasure team (in form of a table) and validated by the working group members. This structure included the following information and allowed for a uniform analysis of the shared resources:

- Name of the file
- Type of the resource – Paper, report, audio, deliverable, website, report, etc.
- Name of the reviewer
- Main focus – Policy change, behavioural change or both
- Best practices, approaches and recommendations (policy change, behaviour change and context).
    - Which best practices are identified in relation to policy change?
    - Which best practices are identified in relation to behavioural change?
    - Add the geographic, cultural, legal, and social context.
- Viewpoint (if possible) – Indicate if the resource approaches the topic from a specific viewpoint, perspective, or with certain assumptions or methods.
- Main research question and findings
- Relevance for the instrument
- Limitations
- Notes

Due to the large number of resources and time limit, an external expert was hired to review 10 resources using the same structure.

Peer review and quality control

The Eurocities team checked the individual reviews in terms of completeness and quality, and when necessary either completed the analysis table with missing information from the resource or re-opened the resource for review by the members or the external expert.

Synthesis of the reviews

Synthesizing the insights from individual reviews, was done by adopting an indictive analysis approach. Without prior conceptions in mind, the assessment of individual reviews was done by coding the content and allowing for categories of insights to emerge from the reviews. Coded insights from one resource were checked and compared against coded insights from other resources to create categories of information. The main categories of coded content included applications, expected impacts, challenges, and needs of citizen science initiatives, conceptual elements of behaviour and policy change, and recommendations related to triggering behaviour change and increasing policy uptake of citizen science for cities and citizen science initiatives. Constant comparison of the labelled content resulted in shaping the content that are summarized in Sections 3.3 and 3.4 of these guidelines.

Drafting the guidelines:

The Eurocities team drafted an initial version of the guidelines and organized two working sessions with the working group members to work towards developing the first draft of the guidelines. The two working group sessions took place in March 2022. In the first session, participants were divided into two groups, one working on the Behaviour change, and the other group on Policy change. Participants reviewed the content in terms of structure, formulations, and categories of findings. In the second session, all the participants reviewed together the formulation of the recommendations. Working versions of the guidelines were shared with working group members between March and April 2022 to provide room for reflection outside of the working sessions, and to allow members who could not attend the working sessions to provide their contributions. A section of the content of the guidelines was also presented during the Eurocities Environment Forum 2022 in Grenoble and feedback from that session also contributed to improving the guidelines.

3.3 TRIGGERING BEHAVIOUR CHANGE USING CITIZEN SCIENCE

These guidelines aim to advance the understanding of behavioural change aspects of citizen science. The following sub-sections focus on describing challenges and applications of citizen science for changing actors' behaviour, conceptualising behavioural change, and recommendations for cities and citizen science initiatives on how to foster behaviour change using citizen science.

3.3.1 Challenges of changing actors' behaviour

Change in actors' behaviour such as behaviour towards environment, creating new culture of collaboration and sharing responsibilities are among the aims of many citizen science initiatives. Nevertheless, there are several factors that may hinder such changes. Communities are heterogeneous and each person has certain perceptions, priorities and needs that drive their behaviour. In addition, challenges that citizen science projects address are often complex and existing formal processes and informal norms pretty much define actors' behaviour towards those challenges.

Although several citizen science initiatives aim to, or claim to have, changed actor behaviour, measuring such changes is not easy. Quite often, a baseline situation of actors' behaviour before involvement in a citizen science initiative is missing. Moreover, a significant proportion of citizen science projects' impacts, including changes in actors' behaviour, happens after the lifetime of the projects and their funding period, it is therefore highly difficult to measure such changes (3).

3.3.2 Applications and expected impacts of citizen science for behaviour change

Behaviour change resulting from citizen science interventions can occur at every level from the individual to societal, to the institutional. Applications and expected impacts of citizen science for behaviour change include:

- ***Changes in*** ecological ***perceptions***, sense of place, connections between science, place, ecosystem, and impacts of one's actions on the environment (3, 41, 22).
- ***Increase knowledge and raise awareness:*** participants acquire new knowledge and may be sensitized towards new issues and social challenges, and to act as a bridge to research and knowledge (32, 53).
- ***Shift of attitude*** towards more environmentally sustainable resource management, science, local conservation action, activism, and nature in general (1, 3, 39, 41, 52, 59).
- ***Diffusion of*** participants' acquired ***skills and knowledge*** to peers through social networks (3, 21, 22).
- ***Increased confidence*** to express ideas to natural resource managers and figures of authority, assert their authority e.g., as knowledge brokers, enhance political participation and activism, and foster people's agency for climate action (3, 19, 22, 32, 52, 59)
- ***Changes in relationships and partnerships*** among societal actors, community dynamics (including capacity, wellbeing, and livelihoods) (41, 22).
- ***Triggering (social) innovation***, enhance learning at individual and societal levels and contribute to behaviour change of all actors (3, 22)
- Foster ***social capital***, new forms of participation, mobilisation of people, and community building (15, 37, 39, 41)

Citizen science can serve as a rhetorical resource to ***create new narratives*** around environmental issues (37).

3.3.3 Conceptualising behaviour change

Behaviour change is understood as altering current habits or ways of performing certain tasks. Social psychology theories have long established a link between change in behaviour and change in attitude, intention, and knowledge. For example, the Theories of Reasoned Action (TRA) and Planned Behaviour (TPB) that helps understand actions thought about and 'planned for' suggests that attitudes and behavioural intentions are drivers of behaviour (36). Other scholars have also suggested that knowledge and attitudes are linked (14). An increase in knowledge, however, does not necessarily lead to changes in behaviour. It is thus essential that these changes in behaviour remain even after the intervention or initiative is over (43).

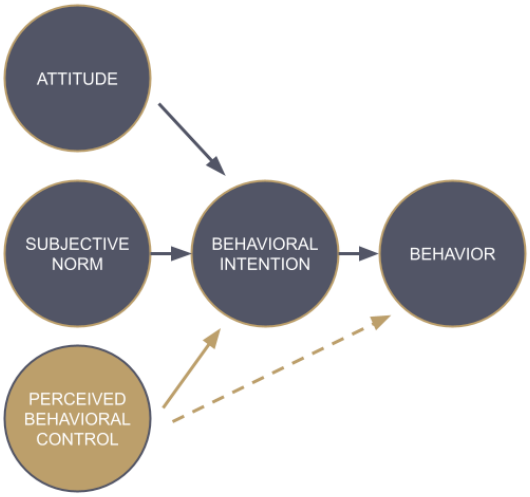


Figure 3 Theories of Planned Behaviour and Reasoned Action[1]

There are several reasons for participation of volunteers in citizen science. E.g., participation may be self-initiated as driven by an environmental concern, as well as scientific curiosity and a sense of fulfilment for being part of finding answers (32)

Citizen science can lead to changes in the participants' behaviour and other stakeholders, i.e., decision makers directly or indirectly involved in an initiative (15, 22). Projects such as iSCAPE, HOPE, CAPTOR, WeSenseIt, Ground Truth 2.0, CitiesHealth, CurieuzenNeuzen and WeCount have attempted to better understand and measure behaviour changes. There are other approaches to behaviour in the context of citizen science. The work of Berti Suman (27), for instance, focuses on understanding the social uptake of citizen science and frames behavioural adaptations as one of its potential consequences.

In the context of these guidelines, behaviour change is defined *as a measurable change in action resulting from engagement in citizen science, that lasts beyond the citizen science project itself*. It can range from a one-off direct action (e.g., installing a low-cost sensor) to incremental changes in attitude and long-term behaviour change (e.g., no longer driving your car within the city) (3, 32).

3.3.4 Recommendations for triggering behaviour change using citizen science

This section summarizes the recommendations on how to trigger behaviour changes using citizen science. The recommendations are organized in two main sections, based on whether they are more relevant for cities or citizen science initiatives. Relevant recommendations are clustered under common themes, and where possible accompanied by empirical insights or examples from existing initiatives.

[1] Source of image: https://positivepsychology.com/behavior-change/

3.3.4.1 Recommendations for cities

- **Institutionalise citizen science at the city level:**
    - Institutionalise citizen science at the local level, e.g., by adding it as an approach in strategic documents and polices (32), or by setting up a citizen science office at the municipality, which works with communities, universities, and projects for co-creating local initiatives, and providing spaces for stakeholder interactions (9).

BOX 1: The Barcelona citizen science office

Established in 2012, the Barcelona Office of Citizen Science's mission is to support citizen science in the city of Barcelona (Spain). Since its creation, the office has advised, accompanied, and promoted citizen science projects active in the city and its Metropolitan Area resulting in the involvement of around 13,000 residents and schoolchildren, who have collected more than 10,000 valuable data for scientific research.

This is one of the few examples of citizen science structures at local level in Europe. The office plays a key role in connecting the public administration and local initiatives, along with researchers, and new civic and cultural agents, while providing services such as dissemination of activities and promotion of spaces for mutual learning.

https://www.barcelona.cat/barcelonaciencia/en/citizen-science

- **<u>Facilitate and promote capacity building and knowledge sharing:</u>**
    - Provide training for city administration staff who are not familiar with the role of behaviour-related aspects of citizen science initiatives (3). Example training may include reaching diverse audiences, public engagement, evaluation, and impact assessment, etc.
    - Set up citizen science working groups to develop a network of cities and organisations that facilitate cross-learning (9).

BOX 2: The Dutch City Deal

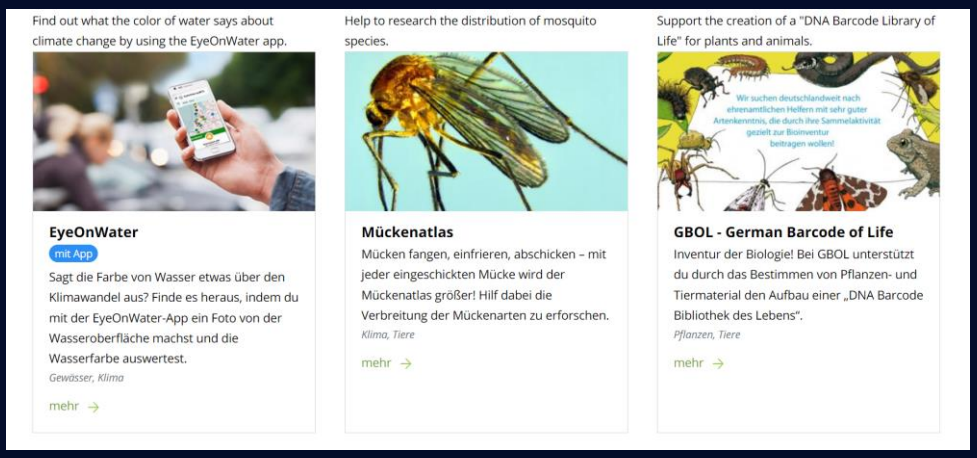
The Dutch City Deal "A smart city, that's how you do it" is an initiative launched by the Dutch Ministry of Interior and Kingdom Relations and the G40 network in 2020. It represents 58 stakeholders working on the broader area of smart cities in the Netherlands, which includes the topic of citizen measurement initiatives. Twelve working groups of the Dutch City Deal are collaborating to co-design optimal future-proof solutions by using digitization and technology. These include the working group "Lokaal meten: betrekken en activeren burgers" which focuses on engagement aspects of citizen science initiatives and "Lokaal meten: Vergelijken van uitkomsten tussen" which focuses on comparability of data produced by citizen science initiatives. The Future City Foundation has been coordinating the efforts towards developing different outputs as well as cross-learning opportunities in online and offline meetings.

<u>https://agendastad.nl/citydeal/een-slimme-stad-zo-doe-je-dat/</u>

- Keep an up-to-date repository of citizen science projects that can be used as a showcase of the activities of each city in this area. This can be a part of a national repository and needs to showcase scientific, educational, social, cultural, economic, political relevance of the initiatives The EU-Citizen.Science platform is a good place to start building this repository (17).

BOX 3: Bürger schaffen Wissen platform

The Bürger schaffen Wissen (citizens create knowledge, in English) is the central national online platform for citizen science in Germany. It was created in November 2013 as a repository of citizen science projects. Its main goal is to present, connect and support these types of projects while further increasing the visibility of the approach within the German public and discourse. Since 2020, it has also been working on the development of quality criteria and the impact of citizen science. The repository includes a search tool based on the project's theme and the region where the project is being implemented. It also includes information about the social, scientific, or cultural impact of the different initiatives.



https://www.buergerschaffenwissen.de/en

- **Strengthen communication efforts:**
  - Citizen science projects can be a good source of information for tailored communications for specific groups, aiming to connect with a group's lived experiences and day-to-day behaviours. This approach helps raise awareness about actions that 'people like me' take to address an issue in their living environment. (20, 22)

- Public environmental communication can be an effective tool to motivate sustainable behaviour, provided that attention is paid to the role of cognitive biases, emotions (e.g., fear and hope), and expectations about the motivations of the communication source and other people's (environmental) behaviours (18).

BOX 4: Changing behaviour through air quality initiatives in the city of Ghent

The city of Ghent (Belgium) has started several local air quality monitoring initiatives to involve citizens and raise awareness. In 2016, 348 Ghent residents and 50 locations were selected to display NO_2 passive samplers. In 2018, the city participated in the regional project Curieuze Neuzen. From 2022, Ghent is planning to use participative monitoring to see changes in circulation of traffic in Ghent's districts. This work will include behavioural research to investigate the effect on awareness of air quality, perception, motivation, thresholds, triggers and expectations, modal shifts, and support base for school streets. The city is also using communication and positive storytelling approaches in their strategy for raising awareness and behaviour change.

https://stad.gent/nl/mobiliteit-openbare-werken/plannen-en-realisaties-mobiliteit/wijkmobiliteitsplan

3.3.4.2 Recommendations for citizen science initiatives

- **<u>Pay attention to the context:</u>**
  - Conduct studies at the early stages of the project to understand the social, institutional, political, cultural context in which you are going to operate (24).
- **<u>Strengthen engagement efforts:</u>**
  - Involve citizens, policy/decision makers and other actors from the very beginning in story finding. This will help with identifying problems for different audiences/target groups, co-create hypotheses, design the research process adapted to those problems, and collect data that contributes to raising awareness and behavioural changes (3, 6, 22, 23, 24, 32, 47, 54).
  - Plan for involving citizens of a wide range of ages is important to achieve a change in behaviour that is effective for awareness-raising from the grassroots of society and for its influence on the family (23, 24).
  - Use co-creation tools and techniques to promote and strengthen shared ownership of the process and its outcomes, and increase trust (24, 38)

BOX 5: The 'Botellon no me deja dormir' project

The 'Botellon no me deja dormir' project is a collaborative initiative co-created by the community of neighbours in Plaça del Sol (Barcelona) and it was one of the pilots of the project Making Sense EU. It builds upon the lessons learnt from previous projects such as Sound Map. Co-design was as the core of the process of installation, sensing and raising awareness about the issue of noise pollution in this area of the city. A series of tools for co-creation and engagement i.e., co-creation assemblies were included in a toolkit available on their website.

http://making-sense.eu/

- Citizens are more likely to engage in initiatives aiming at policy and behavioural change if issues are framed around their values and focus on more local and tangible concerns, and if individuals believe their actions make a difference (3, 6, 22, 38, 57, 59).
- Community building efforts better take place after the scoping stage, but before the start of detailed planning of the initiative (24).

- **Realise stakeholders' needs and work towards fulfilling those:**
  - **To maximise impact, project designers need to understand who their potential participants are, what motivates them, what barriers to participation they face, how these barriers can be overcome, and how their motivations align with the intended project impact (3, 24, 47).**
  - To drive change, make sure that data, motivations, and collaboration opportunities target all involved stakeholder, including e.g., citizens, researchers, government agencies, NGOs, and industry (3, 24).

BOX 6: The STEP CHANGE project

The H2020 project STEP CHANGE, launched in March 2021, is implementing citizen science initiatives, working with energy communities in Germany. The project brings novelty in citizen science research while contributing to broader science aspects. The overall objective is to formulate recommendations and instruments for better mainstream citizen science within research and innovation (R&I) institutions as well as changing researchers' mindsets on its value. In this specific initiative, households will receive a monthly report about their consumptions as well as have real-time access to their energy consumption data which might affect their energy lifestyle.

  - Criteria for citizen science projects that aim to result in successful environmental activism must be 'credible enough' to engage policymakers, must be appealing and inspiring to a wide audience to mobilise action, must be personally relevant to participants, mechanisms must be in place for advocates to be heard by the actors who can action change (3, 59).

- **Enhance communication efforts:**
  - **Invest in developing a good communication and dissemination strategy (3, 6, 24).**
  - **Have dedicated people, ideally community champions (stewards) as the main contact point with the target audiences (24, 38).**
  - Use storytelling as an approach to reach out to a wide range of audiences. In order to achieve the full potential with stories, move away from 'issue-based' towards 'action-based' narratives. Action based stories clarify opportunities for community members to engage in concrete actions and help address specific local challenges (19, 54).
  - Utilise technology to access a broad audience quickly and efficiently (16).
  - Use traditional advertising techniques to reach out to less tech-savvy parts of the population, or those with limited access to technology (16).

BOX 7: CurieuzeNeuzen and Curieuzen Air – innovative ways to communicate and reach out to marginalized communities

The CurieuzeNeuzen project used in its recruitment process both traditional media, including TV, radio, printed media, billboards, as well as online media such as websites, and social media. In addition, citizens were involved in innovative ways, including colourful V-boards as points of recognition of participants; postcards; ads at the Ringland Rock Festival (June 2016); a booth at a science innovation festival (September 2018); video clips with well-known artists as ambassadors; and a large knowledge event with 900 citizen researchers in Antwerp in 2016 (4).

On the other hand, the CurieuzenAir project (involving this time the city of Brussels) also collaborated with local newspapers, used social media, and launched a website in three main languages (French, Dutch and English). To reach more vulnerable communities, they followed an innovative approach by collaborating with a local NGO that engaged the community through air quality city walks, individual calls, and dissemination activities in public places such as medical homes and key stores in the neighbourhood (25).

  - Include tailored communications for specific groups, aiming to connect with a group's lived experiences and day-to-day behaviours. This approach helps raise awareness about actions that 'people like me' take to address an issue. (20)
  - Policies that promote positive environmental behaviour work best, if promotion of 'good behaviour' is combined with measures for discouraging 'bad behaviour' (46). Citizen science projects that try to influence such policies should consider providing examples and recommendations for both encouraging good behaviour and discouraging bad behaviour.
  - Providing 'average user' data may discourage behaviour change. This is especially the case for those who are already performing better than average as they may see no reason to change (50).

- **<u>Develop a robust monitoring and evaluation plan:</u>**
  - Invest in developing a good project monitoring and evaluation plan based on project evaluation principles and best practices (3). Evaluation of citizen science impact (e.g., on behaviour or policy) can be done in collaboration with citizens and by involving them in co-creation of evaluation KPIs and impact assessment instruments. This requires researchers to relinquish control over such processes and increasingly adopt co-evaluation principles such as participant ownership, openness, and reflexivity, [participant] transformation, flexibility, documentation and transparency, time [slow research] (10).
- **<u>Value transparency accountability and responsiveness</u>**

Project leaders should operate ethically and not (inadvertently) mislead participants to endorse a specific agenda. To avoid such situations, projects need to operate transparently, uphold high data, and project design standards, and ensure that the issue or solution they advocate for is evidence based (3).

3.4 FOSTERING POLICY IMPACT OF CITIZEN SCIENCE

This section of the guidelines aims to advance the understanding of policy change aspects of citizen science. The following sub-sections focus on describing challenges and applications of citizen science for changing policies, conceptualizations of policy change, and recommendations for cities and citizen science initiatives on how to foster policy impact of citizen science.

3.4.1 Challenges encountered in influencing policy

The science-policy interface is complex, and many factors contribute to whether findings of a citizen science initiative are adopted by policy stakeholders, and lead to policy change (7). Some of these challenges are listed below:

- There is a lack of alignment between research, community, and policymakers (3, 20). This translates into a mismatch between citizen science data and policy questions, goals and actions on the ground, scientific and political processes in timing and aptness of data to a specific policy process, i.e. public consultation, time cycles, and data infrastructures. Citizen science projects are often short-lived or cease to exist if they don't achieve their desired outcomes; and data can sit on a website and reside there silently without being used by the public or government (23, 30, 53, 55).
- There is a power imbalance so there is need to share power, fear of political biases. Most policy making is still top-down and evidence-based often exclude citizen science (2, 32).
- There are conflicting interests or goals of policymakers, citizen scientists and researchers from citizen science projects (30).
- There is divergent legislation and cultures across science and governance levels that hamper the spread of knowledge and uptake of citizen science (30).
- A common challenge for civil servants who would like to have citizens engaged in data collection practices is that they do not trust the data they collect (15).
- It is difficult to connect citizen science with collaborative policymaking processes such as public consultations and citizen-initiated policy proposals.
- The lack of resources such as funding, time and expertise hinders policy impact.
- There is a high level of distrust and lack of mutual understanding between scientists, politicians, and citizens scientists. Civil servants and public officials who would like to have citizens engaged in data collection practices or citizen science often do not trust the quality (robustness, reliability, safety, and representativeness) of the collected data nor the approach itself as they fear political biases (15, 22, 30, 33, 55).
- There is a lack of awareness about the benefits of citizen science, or even about the breadth and diversity citizen science has to offer (30)
- **A significant proportion of citizen science projects' impacts, including policy change impacts, happens after the lifetime of the projects and their funding period, it is therefore highly difficult to measure such changes (3, 53, 56).**

Funding streams are a key consideration for the success of any project. Some projects are in a "proof-of-concept" phase and therefore depend on external funding to sustain their operations before they are able to generate sufficient income, while other projects face the risk of stopping if the external funding from donors and development agencies runs out. Projects are thus exploring different revenue strategies and diversifying their income streams (23, 53).

3.4.2 Applications and expected impacts of citizen science for policy change

Citizen science initiatives can contribute to problem and policy formulation, policy implementation, policy monitoring, policy evaluation, compliance assurance, awareness rising, anticipation and early warning (3, 37, 41, 52). Citizen science can support knowledge creation, education and communication and climate action at both individual (agency) and decision maker level using evidence collected through citizen science (22, 55). Examples of such contributions include providing complementary evidence for environment policies, helping to monitor and achieve SDGs, and contributing to geospatial intelligence (1, 36, 53). Citizen science initiatives also facilitate multi-level actor interactions and communications, as well as help with balancing power-relationships, and building trust among stakeholders (41).

3.4.3 Conceptualising policy change

Change in policy and governance processes can be interpreted in a variety of ways and can have multiple meanings including changes in institutions, (in)formal procedures, interests, alliances, and ideas. Citizen science can contribute to changes in governance processes in various ways. This includes informing certain steps of the Policy Cycle that include problem definition, policy formation, policy adoption, policy implementation, and policy evaluation. Figure 4 provides an interpretation of the value of citizen science in different steps of the policy cycle (59). Next to actual change in existing policy documents and procedures, policy change can also be interpreted as change in governance processes, such as multi-level actors' interactions and relationships. Specific indicators for such changes include "contributions to management plans and policy", "stakeholder interactions in decision-making processes (e.g., data provision, expressing preferences, deliberation, and negotiation, etc.)" and "change in the level of authority and power of each stakeholder" (35, 37, 41).

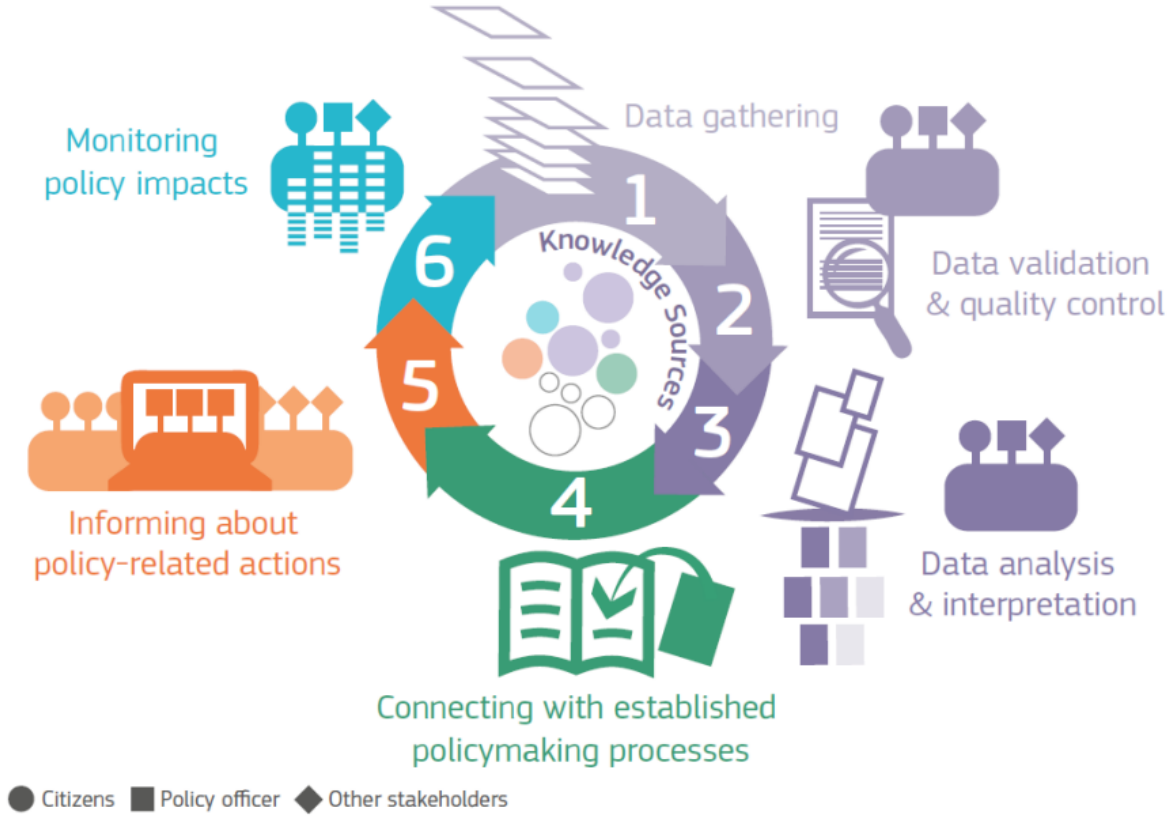


Figure 4 Cyclic value chain of Citizen Science for policy

Citizen science initiatives can be influential at any stage of the policy process. A recent report by the European Commission Joint Research Centre (JRC) that included an inventory of 503 citizen science initiatives, and an in-depth analysis of 45 projects, considers policy impact as one of the main outcomes.

If policies fail, a judicial uptake might be necessary. For instance, on 10 October 2018, in a decision of the Court of First Instance of Brussels in Greenpeace v Flemish Region, the Court found that supplementary information based on data collected via a citizen science project reporting on air quality must be taken seriously and passed on to the European Commission (33). In another example, the project "SensJus" deploys research on the potential of environmental citizen science as a source of evidence for judicial litigation and as a tool to foster mediation[2].

While citizen science's impacts on society, governance and environment belong to different impact domains (41), they are interlinked. For example, Ceccaroni et al. (2021) links policy impacts of citizen science projects with actual environmental impacts (3). Policy change must be meaningful, which means handling, mitigating, or removing a specific (environmental) risk and therefore resulting in a (positive) environmental change (24, 27, 28). The social uptake can facilitate or hinder the policy uptake, even to the point the latter is no longer needed if the environmental risk is eliminated or mitigated. On the contrary, the social and policy uptake can also be in tension. Citizen science initiatives must thus find the right balance between engaging institutions and maintaining social support (27).

In her research, Anna Berti Suman defines **policy uptake of citizen science** as 'the adoption by institutional actors of (some component of) the initiative and/or the performing of policy/regulatory/factual interventions expressly demanded by the initiative or, in any event, stimulated by the initiative'. (27)

These interlinkages acknowledge the existence of power dynamics within a citizen science initiative and outside it, i.e., political context. It also explains why demand-driven initiatives might be more successful than supply-driven (or top-down) ones (35). Top-down, or supply-driven initiatives refer to projects that are initiated by actors with higher influence on policy or decision making, or by scientists, as opposed to bottom-up or demand-driven projects that are initiated by actors such as community groups, individuals, or volunteers (35).

New approaches to citizen science: Environmental justice and the ClairCity project

The term environmental justice acknowledges the unequal effects of environmental policies, the power imbalances within the policymaking process and the lack of representation in environment-related data. While environmental justice is a widely researched topic in the field of social sciences, it is not the higher purpose of many participatory approaches to science. This is changing with projects such as ClairCity, an EU-funded project which aimed to put people at the heart of air pollution management. The project assessed to what extent citizens suffering the worst impacts of air pollution are themselves responsible for the greatest emissions. It also explored the feasibility of performing studies on environmental justice at the city scale and provide six recommendations for other cities when undertaking similar studies (37,44).

[2] https://sensingforjustice.webnode.it/

3.4.4 Recommendations for enhancing policy uptake of citizen science

This section summarizes the recommendations on how to enhance policy uptake of citizen science initiatives. Similar to section 3.3.4, the recommendations are organized in two main sections, based on whether they are more relevant for cities or citizen science initiatives. Relevant recommendations are clustered under common themes, and where possible accompanied by empirical insights or examples from exiting initiatives.

3.4.4.1 Recommendations for cities

- **Facilitate knowledge exchange about and across citizen science initiatives:**
    - Promote best practices for the use of citizen science data and information (1, 30, 53).

BOX 8: Knowledge exchange between governmental organisations and citizen science initiatives – Sensor.Community and RIVM

Sensor.Community is a bottom-up initiative of citizens who seek to contribute to the creation of open environmental data. The community facilitates the access and use of low-cost sensors, and the visualisation of the collected data. The main focus of the initiatives is on air quality (PM 2.5 and PM10) and noise monitoring. So far, its interactive map displays more than 17 billion data points from 14.000 sensors worldwide.

The Dutch National Institute for Public Health and the Environment (RIVM) is a reference in Europe regarding data comparability, and it integrates citizens' science data into its databases. They have developed a data infrastructure in collaboration with other initiatives such as Sensor.Community that has been later used in other projects, i.e., Sniffer bike (or Snuffelfiets in Dutch), or Dutch Skies (Hollandse Luchten in English) (25).

    - Raise awareness of public institutions regarding citizen science (1).
    - Provide training for staff not familiar with policy impacts of citizen science (3, 28).
    - Improve coordination among citizen science initiatives at different governance and thematic levels (1).
    - As much as possible, follow open data principles and establish open data platforms (30, 53).
    - Create networks or communities of practice on different aspects of citizen science initiatives with an urban focus, share their knowledge and experience, and support pilots and practical experimentations (2, 30, 51).
    - Consider developing a central interactive platform or portal where citizen science initiatives can publicise their data and communities interact with the initiatives. The platform should enable exchange between and across initiatives and can also operate as a screening system for purpose-specific search for projects in line with quality standards (28, 31, 51, 53).
    - Develop and maintain an updated repository of citizen science projects that can be used as a showcase of the activities of the city in this area. This can be a part of a national or pan-European repository and needs to showcase scientific, educational, social, cultural, economic, political relevance of the initiatives. The EU-Citizen.Science platform is a good place to start building this repository (17).
    - Use co-creation in citizen science as a mediation tool. Co-created citizen science initiatives have the potential to act as a mediation channel for bridging polarised views about certain policies. They enable new narratives to be explored as different viewpoints are represented and considered within a co-creation setting (35, 57).

- Consider combining citizen science and Urban Living Labs to achieve better policy impact. Such an approach can enable knowledge sharing and exchange between public and private sector actors, create a better picture of problems (e.g., based on citizen-generated data) and solutions, and save resources for cities (58).

- **Pay attention to allocation of roles and responsibilities:**
  - City administrations that proceed in adopting citizen science projects should refrain from (giving the impression that they are) appropriating and controlling the initiative, paying attention to a fair allocation of roles and responsibilities in the process (28).

3.4.4.2 Recommendations for citizen science initiatives

- **Pay attention to the context:**
  - Citizen science projects are most likely to feed into management plans if they are place based and firmly rooted in the local context, carried out over multiple years, deliberately designed for management purposes with scientifically robust protocols, co-created with stakeholders and citizens to identify their needs and decision-making timelines (3).
  - Consider contextual factors (e.g., social, economic, cultural settings, and power dynamics) and the specific political landscape in which the initiative is inserted (27, 42).
  - Recognise and pay attention to diverse interests in data and its application by different actors (47)

- **Realise stakeholders' needs and work towards fulfilling those:**
  - **To maximise impact, project designers need to understand who their potential participants are, what motivates them, what barriers to participation they face, how these barriers can be overcome, and how their motivations align with the intended project impact (3).**
  - **To drive change, make sure that data, motivation, and collaboration opportunities target all involved, including e.g., citizens, researchers, government agencies, NGOs, and industry (3).**

- **Link to policy and decision-making processes:**
  - Identify current policy aims, objectives and concerns, and align projects with ongoing or future policy agendas, processes, debates, and standards (2, 16, 22, 30, 34, 42, 54, 55).
  - Constantly identify evolving policy linkages of the citizen initiative e.g., with bulletins directed to competent authorities and adapting to changing contexts (and scales) (28, 54).
  - When possible, actively seek government support as it favours policy uptake (1). This is also recommended for citizen science initiatives that are established to contrast certain government policies, as they may be able to find allies in the local government level, e.g., the city councils (28).
  - Influence policy processes by linking citizen science and the collected data (empirical evidence) to existing policy agendas, datasets, strategies, and processes, with the aim of complementing existing inputs, processes and outputs (32, 42, 47, 54).

- **Think of ways to improve engagement, acceptability, and credibility:**
    - Engage, and collaborate with, a wide range of actors as this increases policy relevance and adoption (1, 5).
    - Take time to co-create and codesign approaches with strategic partners and networks (1, 24, 30).
    - Invest time and resources on scientific rigour, involvement of NGOs, developing sustainable business models as these encourages policy use (1).

BOX 9: Developing business models in the Ground Truth 2.0 project

The Ground Truth 2.0 project followed a non-profit business model approach to the viability and sustainability of the project's services. It identified their value proposition through a business model canvas and analysed the market characteristics in the different project pilots. More information can be found in the Deliverable D3.2 Updated report on market analysis and market uptake.

https://gt20.eu/wp-content/uploads/2019/10/Deliverable-D3.2-Updated-report-on-market-analysis-and-market-uptake.pdf

    - **Collaboration, and including policymakers, communities and other actors from the outset and aligning to their needs increases the chance of policy uptake (3, 21, 55).**
    - Projects are most likely to influence policy if they received government support, not only in the form of funding, but also through active participation in the design and implementation of the project, and have a straightforward engagement process for participants, requiring limited effort and a priori scientific skills (3).
    - **Citizens are more likely to engage in initiatives aiming at policy and behavioural change if issues are framed around their values and focus on more local and tangible concerns, and if individuals believe their actions make a difference (57).**
    - Data quality is a critical issue in policy context. Citizen science projects that aim for policy uptake need to ensure alignment with monitoring requirements and regulatory standards. In other words, they need to follow a fit for purpose (or fit for use) approach where key aspects like data quality, scale, cost, interoperability, and data format are taken into account. (15, 55)
    - In order to increase trust in citizen science data, it is recommended that where possible, initiatives describe their "data stories"[3] together with representation of official data. (15)
    - Citizen science projects can best engage citizens in science and policy if their activities are playful, simple, visible, personal, and practical (51, 22).
    - It is recommended that citizen science projects create a dedicated work package that focuses on policy implementation, including both the citizen and the cities voice (21).
    - It is important to design engagement activities which appeal to a wide variety of audiences to ensure that a broad cross-section of society can participate in engagement with policymaking (21).
    - Identify and engage governmental 'champions' who are willing to encourage their colleagues and managers to integrate citizen science data in the work inside governmental organisations (22, 24).

[3] Data stories here refer to narratives that are supported by and/or build around collected data and information in a citizen science initiative.

- Have dedicated 'community engagement and outreach' officials with the task of spotting citizen initiatives and leveraging for its adoption (28).
- Foster dialogue through e.g., environmental mediators showing that citizen sensing can be a tool to calm discussions and reward cases of successful adoption with funding (but adopting appropriate safeguards to avoid prevailing of financial interests) (28).
- Clearly define roles and responsibilities in collaborations between policy makers and actors involved in citizen science initiatives at the early stages of the initiative establishment process (30)
- Understand different types of biases and errors issues to enable specialists and decision makers to take into account these potentially misleading factors (54)
- Use metadata to contextualize data and reduce the chance of misinterpretation or misuse of data (54).
- Use established spatial data infrastructure (SDI), standardized approaches and terminology to increase accessibility, acceptability and openness of the results and increase the uptake of data for multiple purposes and end-users (54).
- Provide guidance on how to contribute to data collection, monitoring, analysis and reporting e.g., to responsible authorities (53).

- **Enhance communication efforts:**
  - **Invest in developing a good communication and dissemination strategy (3).**
  - **Utilise technology to access a broad audience quickly and efficiently (16, 24).**
  - **Use traditional advertising techniques to reach out to the less tech-savvy part of the population, or those with limited access to technology (16, 24).**
  - Effective communication about policy and policy change is best done using simple messages that provide action perspective (18).
  - Publish about citizen science initiatives' activities and results in written press and media as it will help change political opinion about the initiatives and their results (5).
  - Storytelling is a recommended approach for capturing and communicating policy impacts of citizen science. (8)
  - Data and stories should thus be used in tandem to affect evidence-based political activism, because data alone may be too abstract, and pictures and stories often elicit a much stronger public response than data alone (3).
  - Local dissemination activities, such as meetings with local decision-makers, newspaper and television reports, and a public exhibition, contributes to wider awareness-raising, and can help increase political pressure towards policy change (6).
  - Provide opportunities for citizens to present their evidence to policy makers (spaces for encounter and mediation) and actively seek out existing opportunities and needs such as desired changes and required resources. Examples for such settings include e.g., citizen assemblies and participatory budgeting (21, 28, 31).

BOX 10: Public advocacy and lobbying in the D-NOSES project

D-NOSES advocated introduction of odour pollution into policy agendas at local, national, and international level. The project managed to provide input for several regulatory processes in Chile, Portugal, and Uganda. In addition, the D-NOSES project attracted the attention of the European Parliament and organized an event with the title "Revisiting Odour Pollution in Europe" hosted by the European Parliament Intergroup on 'Climate Change, Biodiversity and Sustainable Development'. The meeting was planned in October 2021 and aimed at bringing together policy makers, representatives from industries, communities, and scientists to share their perspectives on the issue, discuss the main challenges of regulating odours, and share recommendations for an improved odour management policy framework, based on the lessons learned by D-NOSES (13).

    - Actively try to link to 'trigger events', e.g. emergencies, disasters, or outbreaks such as COVID-19. This will open up both the need and the willingness to utilise alternative sources of data (22).

- **<u>Develop a robust monitoring and evaluation plan:</u>**
    - **Invest in developing a good project monitoring and evaluation plan based on project evaluation principles and best practices (3).**
    - **Evaluation of citizen science impact (e.g., on behaviour or policy) can be done in collaboration with citizens and by involving them in co-creation of evaluation KPIs and impact assessment instruments. This requires researchers to relinquish control over such processes and increasingly adopt co-evaluation principles such as participant ownership, openness and reflexivity, [participant] transformation, flexibility, documentation and transparency, time [slow research] (10).**

- Demonstrate the added value of citizen science for specific environmental issues (e.g., through a mechanism tracking successes; cost-benefit analysis, open discussions on failures; reward mechanisms such as prizes) to involved policy-makers (28).

BOX 11: Measuring success in Brenta-Bacchiglione Citizens Observatory

"Before the pilot case of Brenta-Bacchiglione Citizens Observatory in WeSenseIt, flood risk management practices in the catchment were predominantly structural measures. However, during the WeSenseIt pilot, the value of the initiative for improving early warning systems, models and on-the-ground flood risk management practices was proven. This triggered a change in the official Flood Risk Management Plan (PGRA) of the Brenta-Bacchiglione catchment, which was the inclusion of citizen science initiatives as an official prevention measure to reduce the flood risk in the Brenta-Bacchiglione catchment. A cost-benefit analysis and risk assessments by AAWA showed the substantial monetary benefit from running the Brenta-Bacchiglione Citizens Observatory for flood risk management in the catchment. This is approximately €137 million of damage avoided per year, which equals avoided damage of 45 % as compared to a 'business as usual 'scenario. Both monetary and social benefits of this initiative convinced the Ministry of the Environment to fund the development of a scaled-up citizen science initiative at the district level. The case of Brenta- Bacchiglione Citizens Observatory is among the few cases that has a tangible, and already materialised, policy impact. This case has been identified by the European Commission as a 'good practice' for the implementation of the Floods Directive (2007/60/EC) and specific local measures as a part of the PGRA (13)'.

- Monitor meaningful policy or governance through internal tracking mechanisms and with direct monitoring by the parties involved, including political decision-makers and citizen scientists as they are often the best judges of what counts as meaningful change (42).
- Do not over-standardise impact monitoring and evaluation approaches but keep processes flexible and adapt evaluation strategies to projects based on their unique characteristics (56).

- **<u>Consider post-project needs and actions:</u>**
  - Take time to reflect on how the process went, the ways in which the citizens' efforts can be used post-project and support them to apply for funding or connect them to relevant organisations or follow-on projects (21, 47).
  - Ensure that mid/long-term maintenance for a project can be provided by the organisation in charge of the project (28).
  - Funding shouldn't only be considered for establishing a new citizen science initiative, but also, for supporting the integration of results into established policy processes and for long-term support of initiative infrastructures e.g., website, data platform, and Apps (47, 56).

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4 CitiMeasure guidelines on competencies for Digital Inclusion

4.1 INTRODUCTION

4.1.1 Purpose of the guidelines

The CitiMeasure Digital Inclusion guidelines aim to advance the understanding of the issue of 'competencies' for digital inclusion. This is done by unpacking competencies required by citizens to participate in citizen science initiatives, as well as those of project initiators (including scientists, municipal employees, decision makers, and policy makers) to engage citizens in such initiatives. In the current guidelines competencies are understood as a construct of skills, knowledge, and attitude. Understanding competencies such as skills and knowledge required by citizens to participate in a citizen science initiative and their attitude towards participation e.g., in terms of their ability for, or added value of, getting involved, is a prerequisite for enhancing those competencies. Similarly, understanding competencies of project initiators such as required skills, knowledge for setting up and engaging citizen science initiatives, and attitude towards uptake of citizen-contributed data and information is crucial for realizing the full potential of these initiatives.

4.1.2 Who are these guideline for?

The CitiMeasure Digital Inclusion guidelines are primarily developed to guide those who are interested in identifying, understanding, and enhancing capacities and competencies required for digital inclusion of different actors in citizen science projects. This includes cities, organizations, researchers, and practitioners who are involved in initiating a citizen science project, or those who aim to study or improve current actor inclusion practices in existing citizen science initiatives.

We also hope that these guidelines are informative for those who are interested in the broader topic of competencies for public participation and stakeholder engagement.

4.1.3 What can you expect to find in the guidelines?

Section 4.2 of the guidelines provides background information about the CitiMeasure project and these guidelines. This includes a description of the project and the CitiMeasure Digital Inclusion working group that has developed the guidelines, as well as a description of the methodology followed for developing the guidelines.

The main content of the guidelines is summarized in Section 4.3. This section starts with challenges and needs related to digital inclusion and the link to the issue of competencies. We then use the concept of Changemaking as a point of departure to explore purpose and applications of citizen science. One of the main contributions of the guidelines is unpacking the issue of competencies and identifying categories of skills, knowledge, and attitude for digital inclusion in citizen science, which is summarized in the sub-sections of section 4.3.3. The presented (sub-)categories are informed by a wealth of theoretical and empirical resources and the collective experiments and expertise of the CitiMeasure working group members. Not every (sub-)category of skills, knowledge, and attitude presented in this section may come across as 'technology-focused' or 'digital'. This is because we believe digital inclusion cannot be studied and discussed in isolation, and there are a wide range of more generic skills, knowledge, and attitude categories that come into play when discussing a citizen science initiative. Section 4.3.4 also provides a set of recommendations on how to systematically think about and enhance competencies of actors involved in citizen science initiatives.

4.1.4 What this guideline is not?

There are many things that these guidelines are not, but we would like to emphasize a few:

- This is not a step-by-step guideline to identify and enhance competencies for digital inclusion.
- Although we've built on several resources and expertise of 24 individual members of this working group, this shouldn't be considered as a comprehensive inventory of all possible categories of skills, knowledge, and attitude for inclusion in citizen science.
- Several of the recommendations in Section 4.3.4 are linked to specific categories of skills, knowledge, and attitude, however, there is no one-to-one relation between the identified competence categories and the recommendations.
- Lastly, we also would like to emphasize that absence of certain skills, knowledge, or attitude identified in this guideline shouldn't be considered as a reason for exclusion or discouragement of interested stakeholders and individuals from participation.

4.1.5 Who to contact for questions or feedback?

If you have any questions or would like to give us feedback about these guidelines, please write an email to Mohammad.Gharesifard@eurocities.eu.

4.1.6 List of contributors

These guidelines are the result of an iterative co-creation process with inputs from members of the CitiMeasure Digital Inclusion Working group. The members of this working group are affiliated to 7 European cities and 9 (non-)governmental and research organizations (see Figure 5). In particular, 11 out of the 24 individual working group members have contributed to these guidelines by providing resources, and/or critically reviewing those resources. The detailed list of contributors and their affiliations are provided in Table 2. In addition to contributors from the working group, Table 2 also includes the name and affiliations of two Eurocities team members who have been involved in developing the guidelines, as well as one external expert (Margaret Gold) who contributed to the development of these guidelines by reviewing 10 resources.

WG member	Affiliation
Alena Bartonova	NILU
Anna Berti Suman	JRC
Emily Daemen	The Green Land
Gino Dehullu	Roeselare
Irene Vivas Lalinde*	Eurocities
Kasper Van Hout	Murcia
Margaret Gold**	Leiden University
Metodiyka Tarlyovska	Sofia
Miriam Calvera Isabal	Universidad Pompeu Fabra
Mohammad Gharesifard*	Eurocities
Paolo Palomba	Milan
Peter van Waart	Rotterdam University of Applied Sciences
Tomasz Jaskiewicz	Rotterdam University of Applied Sciences
Youetta de Jager	ICTU

Table 2: Contributors to the guidelines by providing resources, and/or critically reviewing those resources

**Eurocities team members*
***External Expert*

4.2 BACKGROUND

4.2.1 About the CitiMeasure Digital Inclusion working group

The Digital Inclusion working group is one of the three CitiMeasure working groups developing an instrument to create sustainable, inclusive, and smart cities. The group was initially formed through a call for expressions of interest that was shared through the Eurocities and City Deal networks, as well as personal networks of the CitiMeasure team. In September 2021 and following an inception meeting, the group started to co-design a shared vision and a number of objectives that help advance the understanding of the issue of competences for digital inclusion. Since September 2021, and following a co-creation approach, Eurocities has supported the development of the current set of guidelines to unpack competencies required by citizens to participate in citizen science initiatives. This was done by organizing and facilitating monthly online meetings, as well as communications with the working group members to share knowledge, experience, and resources for creating those guidelines. Currently, the working group has 25 members from 7 cities, and 9 governmental, research and other organisations.

Cities	(Non-) governmental and research organizations
• Barcelona • Debrecen • Milan • Murcia • Roeselare • Rumia • Sofia	• ICTU • Joint Research Centre (JRC) • Leiden University • Norwegian Institute for Air Research (NILU) • Rotterdam University of Applied Sciences • Scivil • The Green Land • Universidad Pompeu Fabra • University College Dublin (UCD)

Figure 5: Cities and (non-)governmental organizations that are member of the CitiMeasure Digital Inclusion working group

Here are the co-designed vision and objectives of the working group:

Vision: "The CitiMeasure Digital Inclusion WG works towards advancing the understanding of the issue of 'competencies' for digital inclusion. This includes both unpacking competencies required by citizens to participate in citizen science initiatives, as well as those of policy makers, decision makers and municipal employees to engage citizens in such initiatives."

Objectives:

1. Share ideas, case studies, best practices of digital inclusion in citizen science initiatives, with a close attention to issue of competencies.

2. Jointly analyse and document competencies (knowledge, skills, attitude) required by citizens to participate in citizen science initiatives, as well as those of policy makers, decision makers and municipal employees to engage citizens in such initiatives.

3. Map the identified competencies against specific purposes/applications for citizens, policy makers, decision makers and municipal employees.

4. By April 2022, develop a guideline that helps cities and citizen science initiatives to understand, identify and enhance capacities and competencies required for digital inclusion of different actors.

5. Pilot the developed guideline in at least one real life example of citizen science initiatives between May and December 2022.

6. Consolidate the guidelines with lessons learned from the pilot phase and further analysis by March 2023.

Besides the Inception Meeting, seven co-creation sessions were organized to work towards development of the current guidelines. Throughout the co-creation sessions, the working group developed different elements paving the wave to create these guidelines. Development of the shared vision and objectives as described above framed the scope of the work. In November 2021, the working group adopted an implementation plan for the different actions needed to produce their desired outputs. From December 2021 until February 2022, the working group members collected and shared resources such as academic articles, project reports and deliverables, policy documents, and other useful sources of information, such as toolboxes and webinars. The resource collection was conducted in parallel with the resources analysis by members and Eurocities staff. Figure 6 described the key outputs of all the CitiMeasure co-creation sessions. For further elaboration on the co-creation process of the guidelines is presented in Section 4.2.2.

Inception meeting (Sept)
- Kick-off of working groups
- First version of co-cretated vision and objectives

First co-creation session (Oct)
- Validated vision and objectives

Second co-creation session (Nov)
- Co-created implementation plan

Third co-creation session (Dec)
- Co-created approach and structure for resource collection and analysis
- Roles and responsibilities

Fourth co-creation session (Jan)
- Progress with resources collection and analysis
- Co-created guidelines structure

Fifth co-creation session (Feb)
- Progress with resource collection and analysis
- Shared understanding of reviewed content by discussing reviewed resources

Sixth co-creation session (March)
- Refined content (working session on the content of the guideliens)

Seventh co-creation session (March)
- Refined content (working session on the content of the guidelines)

Figure 6: Key outputs of all the CitiMeasure co-creation sessions

4.2.2 Development of the guidelines

The CitiMeasure Digital Inclusion guidelines were developed using the following methodological steps and approach:

Definition of the scope

With the support of the Eurocities team, the working group members defined a shared vision and six objectives (see Section 4.2.1). Objective 4 specifies that the members found ‘guidelines’ as the most appropriate format for the outputs of this working group.

Resource collection and initial scanning

Based on the vision, the working group members and the Eurocities team collected and shared resources on competences including skills, knowledge and attitudes in the context of cities and citizen science initiatives. A shared online workspace (SharePoint) was created so that working group members can easily access and share resources. The working group members and the Eurocities team volunteered to perform an initial scan of the resources and made a suggestion for their inclusion of exclusion for an in-depth review. To standardize the resource collection/suggestion process, the following structure (in form of a table) was developed and proposed by Eurocities and validated with the working group members during the third co-creation session.

- Name of the file
- Year of the publication
- Language
- Title of the resource
- Type of resource
- Keywords
- Link
- The person who suggested the resource
- Relevance for the instrument
- Name of the reviewer
- Progress review
- Starting date and review deadline
- Notes
- Should everybody review this resource?
- Is this a difficult resource to review?
- Include or discard?

Analysis of individual resources

The working group members and the Eurocities team volunteered to analyse the collected resources. Similarly, a structure was designed by the Eurocities team (in form of a table) and validated by the working group members. This structure included the following information and allowed for a uniform analysis of the shared resources:

- Name of the file
- Type of the resource – Paper, report, audio, deliverable, website, etc.
- Name of the reviewer
- Competences – knowledge, skills, and attitudes described in the resource
- Stakeholders and roles - Does the resource refer to a specific stakeholder group such as citizens, authorities, researchers, etc? Does it refer to specific roles e.g., data generators, end-users of data, etc.?
- Viewpoint (if possible) – Indicate if the resource approaches the topic from a specific viewpoint, perspective, or with certain assumptions or methods.
- Specific purposes/applications - Map the identified competencies against specific purposes/applications for citizens, policy makers, decision makers and municipal employees.
- Main research questions and findings
- Relevance for the instrument
- Limitations.
- Notes

Due to the large number of resources and time limit, an external expert was hired to review 10 resources using the same structure.

Peer review and quality control

The Eurocities team checked the individual reviews in terms of completeness and quality, and when necessary either completed the analysis table with missing information from the resource or re-opened the resource for review by the members or the external expert.

Synthesis of the reviews

Synthesizing the insights from individual reviews, was done by adopting an indictive analysis approach. Without prior conceptions in mind, the assessment of individual reviews was done by coding the content and allowing for categories of insights to emerge from the reviews. Coded insights from one resource were checked and compared against coded insights from other resources to create categories of information. The main categories of coded content included competencies, specific purposes/applications, challenges and needs of citizen science initiatives, empirical insights/evidence, definitions, target group(s), and recommendations for enhancing competencies for digital inclusion. Constant comparison of the labelled content resulted in shaping the content that are summarized in Section 4.3.3 of these guidelines.

Drafting the guidelines:

The Eurocities team drafted an initial version of the guidelines and organized two working sessions with the working group members to work towards developing the first draft of the guidelines. The working group sessions took place in March and April 2022. In the first session, participants were divided into two groups, one working on skills, and the other group on knowledge component of the guidelines. Participants reviewed the content in terms of structure, formulations, and categories of findings. In the second session, all the participants reviewed together the wording and categories of the skills, and attitudes. The working version of the guidelines was shared online with working group members to provide room for reflection outside of the working sessions, and to allow members who could not attend the working sessions to provide their contributions.

4.3 COMPETENCIES FOR DIGITAL INCLUSION IN CITIZEN SCIENCE

These guidelines aim to advance the understanding of the issue of competencies for digital inclusion. The following sub-sections focus on describing purposes, application, challenges, and needs related to digital inclusion in the field of citizen science. We will then discuss categories of skills, knowledge, and attitude required for participation of citizens or project initiators and provide a number of recommendations on how to overcome barriers for inclusion.

4.3.1 Challenges and needs

Citizen science projects increasingly use digital technologies to engage with a wide range of stakeholders and audience. Digital inclusion in the field of citizen science is closely linked to having the right set of skills for inclusion, knowledge of certain topics or processes, and desirable attitude. Lack of balance or inequalities in such competencies sometimes among the main reasons for exclusion of some parts of the society (1). Widespread use of Information and Communication Technologies (ICTs) such as mobile phone applications and low-cost sensor devices in citizen science projects is considered as a powerful enabler of collaboration among many. ICTs make it easy to collect, store, share and discuss data and information in a citizen science project. At the same time, use of new technologies may (unintentionally) exclude parts of the society from participation in citizen science projects, and foster ‘digital divide’ between those who can, or are willing, to use technology, and those who can’t or don’t want to (1, 7, 11).

Enhancement of skills, knowledge, and attitude of the general public for participation in citizen science initiatives, and competencies of project initiators to engage citizens in such processes is needed to increase the chance of inclusion for all. However, it is very difficult to measure change in skills, knowledge, and attitude when participating in citizen science initiatives (10). Without a good understanding of typologies of skills, knowledge and attitude required by citizens to participate in citizen science initiatives, or those of project initiators to engage citizens in such initiatives, it is not possible to systematically measure and consequently enhance those competencies.

4.3.2 Purposes and applications of citizen science

Changemaking is one of the cross-cutting principles and purposes of citizen science initiatives. Changemaking is defined as change in individuals, communities, cultures, and/or institutions, as well as changes in thinking, attitudes, behaviour, and values (22). Citizen science initiatives provide various opportunities for co-production of knowledge, learning, gaining skills, change of attitude and behaviour, and communication with a wide range of audiences (2, 4, 9). ICTs play a key role in such processes and allow fast and widespread interactions between all actors. On the one hand, participation in citizen science initiatives can equip citizens with required knowledge and skills to get involved in science or policy processes, and through that help change the relationship between citizens, scientists, and policy makers (15). On the other hand, policy and decision makers can tap into the collective power of the crowd to better understand and address global or local challenges. This is done through bridging the existing divide between citizens, scientists, and policy/decision makers, through close interactions and information exchange (15).

4.3.3 Categories of competencies for digital inclusion

In the current guidelines competencies are understood as a construct of skills, knowledge, and attitude. This part of the guidelines unpacks different types of skills, knowledge, and attitude that can facilitate participation of citizens in citizen science initiatives, as well as those of project initiators (including scientists, municipal employees, decision makers, and policy makers) to engage citizens in such initiatives. This sub-section of the guidelines also includes boxes with 13 examples that illustrate how different citizen science initiatives can foster participants' skills, knowledge, or attitudes. Where possible, the relevance of skills, knowledge and attitude is indicated for the following target groups:

- ***Citizen scientists***
- ***Project initiators/facilitators***: Those involved in setting up and/ or running the citizen science initiative (including scientists, municipal employees, decision makers, policy makers, and citizens in case they assume that role)
- ***Information professionals***: Those involved with management of data, including librarians and professional data management staff

4.3.3.1 Skills

Seven main cluster of skills were identified as relevant for digital inclusion in citizen science. This includes (I) Scientific research skills, (II) Data management skills, (III) Data science skills, (IV) Digital (software) skills, (V) Technical (hardware) skills, (VI) Co-creation skills, and (VII) Transferable skills. Each skills category is relevant for one or more of the target groups that were defined in the beginning of this section. Furthermore, each cluster includes a number of sub-categories of skills, along with references to resources that mention those, and some examples from real-life citizen science projects (see Box 1 to Box 5).

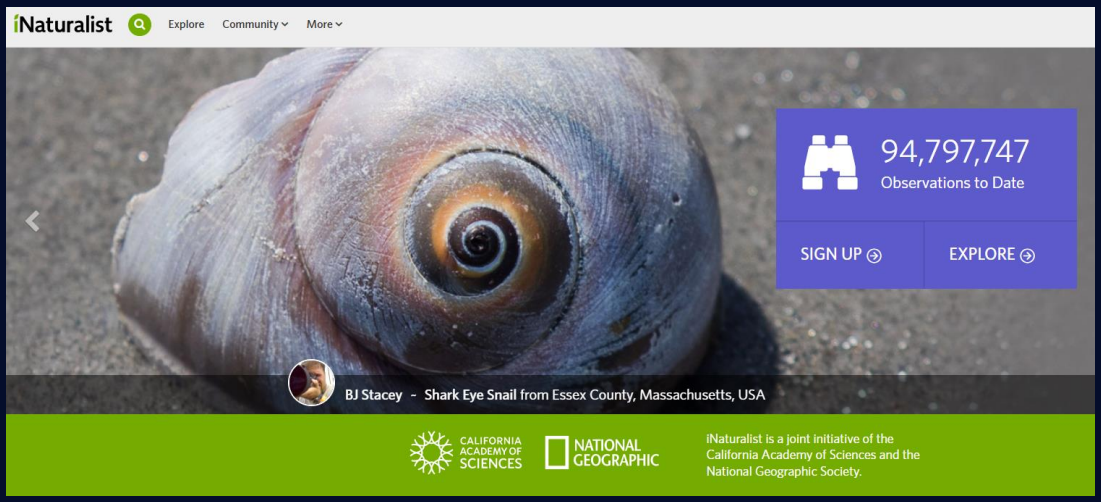
Skills

(I) Scientific research skills	(II) Data management skills	(III) Data science skills	(IV) Digital (software) skills	(V) Technical (hardware) skills	(VI) Co-creation skills	(VII) Transferable skills

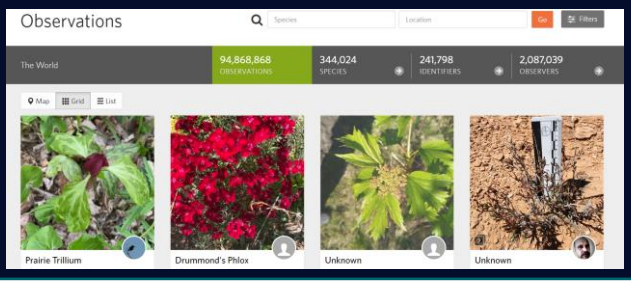
I. **Scientific research skills (2, 9, 26, 36):** ***Citizen scientists, project initiators/facilitators and information professionals***

- Research design and execution (2, 6, 25, 31, 37) - ***Citizen scientists & project initiators/facilitators***
  - Practical and methodological skills for planning and carrying out scientific research (26)
  - The capacity to involve citizens in the collection and analysis of research data (14)
  - Asking research questions (2)
  - Answering research questions (37)
  - Scientific reasoning and argumentation skills (2, 5, 6, 26,31, 37)
- Data collection (2, 37, 34) - ***Citizen scientists***
  - Observing and recording (9, 12, 13, 26, 31)

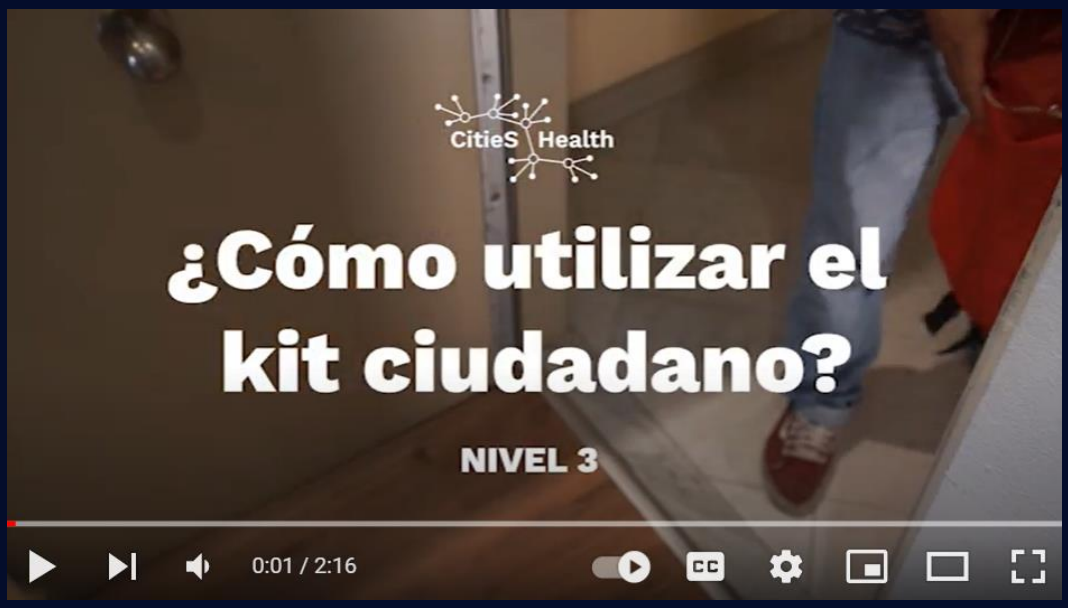
BOX 1: Observing and collecting data about biodiversity



More than 5M people have collected 94M data observations to date. Participants contribute to science by recording observations of different animal and plant species (see picture 2) and sharing them with a wider community of citizen scientists, researchers, and fellow naturalists for further discussion.



BOX 2: Data collection in CitieS-Health



This scientific enquiry was co-created with the citizens of Barcelona to explore how pollution (air, noise, etc.) in cities affect the mental health and stress levels of its inhabitants. CitieS-Health distributed a kit to collect data which was used by 300 participants. Based on the geolocation, the project has estimated how much contamination each participant is exposed to. The team used videos to explain the whole process (including data collection) to future participants.

www.citieshealthbcn.eu

  - Collecting data in a standardized manner
  - Submitting observations to the project database
- Data analysis (2, 34) - ***Citizen scientists & project initiators/facilitators***
  - Data interpretation (making sense of collected data and observation in relation to the context) (2, 9, 12, 13, 23, 31, 35, 37, 38)
  - Data quality control
  - Experimenting with the data
  - Synthesis
- Scientific communication and dissemination - ***Citizen scientists, project initiators/facilitators and information professionals***
  - Scientific communication skills, including publication-related skills and reporting (2, 13, 14, 37)
- Research integrity, ethics, and legal aspects (14) – ***Project leaders/facilitators***
- Integrating concepts of equity (needs-based approach) and equality (absence of discrimination) into the research process (CitiMeasure working group[4]) – ***project initiators/facilitators***
  - Recognizing social power relations and their implications on distributions of skills, knowledge, attitudes, and underlying resources, as well as on procedures (e.g., participation in the citizen science initiative and outcome of decision-making processes),

[4] Based on the experiences of the CitiMeasure working group members

- Identifying sociodemographic characteristics associated with discrimination that might become relevant in the specific research context
- Identifying solutions in discriminatory formal and informal access rules as defined by (semi-)public institutions, (local) economies, and communities.

II. Data management skills (13, 14, 17): Project initiators/facilitators and information professionals

- Handling and storing data
- Data annotation and documentation
- Taxonomy and ontology creation
- Data analysis/use/reuse
- Open data skills
- Respecting legal, and other constraints, e.g., handling sensitive data and complying with GDPR rules
- Knowledge about existing repositories and how to use them

III. Data science skills (14, 39): Project initiators/facilitators, and information professionals

- Collation of relevant scientific data
- Data verification and quality control
- Metadata creation and management
- Use of taxonomies and ontologies
- Data mapping
- Handling big data sets
- Data mining

IV. Digital (software) skills (2, 20, 23, 26, 31, 33, 34, 36, 38): Citizen scientists, project initiators/facilitators and information professionals

- Operational skills (actions required to operate a digital medium such as a computer or smart phone) (1, 10, 21)
- Information skills (browsing, searching, selecting, and evaluating information in digital media e.g., search engines) (1, 10, 11, 17, 18, 30, 21, 34).

- Communication and collaboration skills: mailing, contacting, interacting, creating, and managing online identities, drawing attention, and giving opinions through digital technologies (10, 17, 18, 21, 30).

BOX 3: The Co-Act project

The CoAct for Mental Health is a participatory research project co-designed and led by citizens. The project uses a chatbot as a tool to run the project and investigate the social support networks of adults (+18 people). The chatbot displays micro stories written by co-researchers with experiences on mental health in English, German, Spanish and Catalan.

https://coactproject.eu/

- Strategic skills: using the digital medium as a means to achieve particular professional and personal goals (1, 10, 17, 18, 21)
- Content creation skills: making contributions to the internet with a particular plan or design, developing, integrating, and re-elaborating digital content, copyright and licenses, programming (10, 17, 18, 21, 31).
- Scripting and coding skills (26)
- Developing and using models (37)

- Safety skills: protecting devices, personal data and privacy; protecting health and well-being (17).

BOX 4: The CSI-CO project

This EU-funded project mobilises citizen scientists from across Europe and beyond to investigate the different types of trackers in cookies and apps. The project developed the 'Your Right to Privacy Online' course and delivered it online and in-person where appropriate. Inclusive dissemination activities included: Parent-teacher roundtables and data-privacy stakeholder cafés.

https://csi-cop.eu/

V. Technical (hardware) skills (23,32, 33, 36, 38): Citizen scientists and project initiators/facilitators

- Setting up and maintenance of a device (20, 21)
- Use specific tools or technology provided by the project (34, 22)

VI. Co-creation skills (22, 38): Project initiators/facilitators

- Skills needed by project leaders and facilitators to co-create in a multi-stakeholder setting during the different stages of a citizen science project (e.g., scoping, planning, implementation, evaluation)

- Dialogue and facilitation skills (15,22), Strong dialogue and facilitation skills are required by project leaders to moderate discussions, reach consensus and support the co-existence of different views.

VII. Transferable skills: Citizen scientists, project initiators/facilitators and information professionals

- Problem framing and solving skills (6, 17, 25, 26, 28), formulating and solving problems, identifying needs and potential responses or resources to mitigate and/or adapt, creative use of technology, identify competence gaps, etc.
- Critical thinking (2, 6, 12, 23, 26, 28, 37), to assess information and arguments, identify assumptions, challenge the status quo, and reflect on how our background influences thinking and conclusions, recognizing different viewpoints.
- Analytical skills (23)
- Library and research information skills (13, 14)
- Leadership skills (14, 38)
- Interpersonal skills e.g., building trust (12, 14, 32)
- Stakeholder and community management skills (13, 31, 32)
- Teamwork and collaboration ability (Volunteers need to communicate with project team members in a timely manner, help each other and cooperate to complete tasks; Organization and coordination ability, Harmonious coexistence) (7, 14, 34).
- Generic communication skills (2, 13, 23, 26, 28, 31, 37)
- Generic project management skills (13)
- Creativity (28)
- The skills of how to perform in a certain environment e.g., first aid skills in the wild, using motor vehicles, and the ability to avoid dangerous species (34, 38).
- Skills to provide trainings (9)

BOX 5: Enhance knowledge and skills through trainings

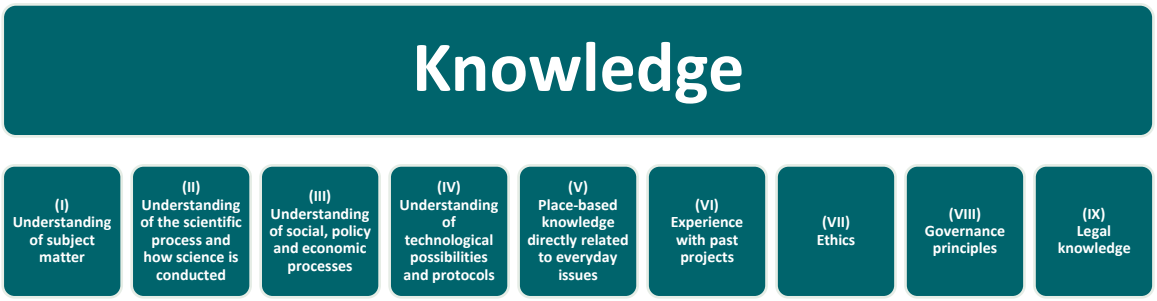
A study researching more than 48 biodiversity citizen science projects in Europe and Australia suggested that participating in training throughout the project was positively associated with participants' perceived gains in knowledge and skills. Other important elements were the information they received from the project, the amount of interaction they had with other project participants and with project staff and scientists, and the feedback and recognition they received from the project (2).

@EU Citizen.science MOOC

- Skills to receive training (Volunteers can be able to seriously participate in the project training, learn the rules and regulations of the project; understand project background and participate in training) (34)
- Geographic (reading a map, or finding a direction) (23)
- Physical fitness (Volunteers need to be physically fit and able to adapt to tough conditions; good health) (34).
- Evaluation skills (28)
- The ability to identify relevant social, political, and economic stakeholders in one's own community and region (28)
- STEM skills (23, 31)
- Literacy and language (Volunteers need to have basic knowledge such as reading, writing, (English) language) (11, 23, 27, 30, 31, 34, 38)
- System thinking (28), i.e., the ability to combine different disciplines, knowledge cultures and divergent views to initiate systemic change.
- Exploratory thinking (28): To adopt a relational way of thinking by exploring and linking different disciplines, using creativity and experimentation with novel ideas or methods

4.3.3.2 Knowledge

There are nine main cluster of knowledge that were identified as relevant for digital inclusion in citizen science. This includes, (I) Understanding of subject matter, (II) Understanding of the scientific process and how science is conducted, (III) Understanding of social, policy and economic processes, (IV) Understanding of technological possibilities and protocols, (V) Place-based knowledge directly related to everyday issues, (VI) Experience with past projects, (VII) Knowledge of ethics, (VIII) Understanding of governance principles, and (IX) Legal knowledge. Each knowledge category is relevant for one or more of the target groups that were defined in the beginning of this section. Descriptions and references are used to elaborate each knowledge category and clarify its source.



I. Understanding of subject matter (2, 5, 6, 9, 12, 23, 24, 28, 31, 32, 34, 35, 37): Citizen scientists and project initiators/facilitators

- e.g., wildlife knowledge, Biodiversity knowledge, environmental knowledge, geographic knowledge, biological knowledge, hydrological, sustainability and future scenarios

BOX 6: Learning outcomes of online citizen science

The impact on participants' learning in citizen science projects and the methods to measure such impacts are under researched. Studies on participation in online citizen science initiatives such as Zooniverse or iSpot have found that increased participation more likely results in enhanced learning gains and leads to learning outcomes such as topic-specific knowledge (31).

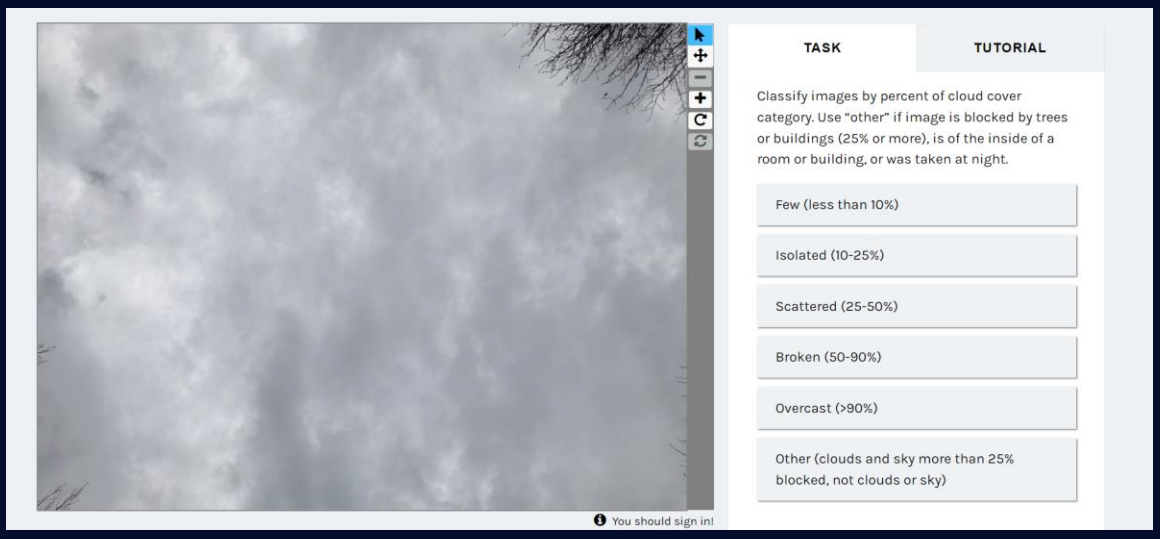


Image: Nasa Globe Cloud Gaze

BOX 7: The project Wildlife Researchers

The project Wildlife Researchers is an urban wildlife ecology project on terrestrial mammals in Berlin (Germany). Participants engaged in an online platform to contribute to research and build a community of citizen scientists and researchers.

https://berlin.stadtwildtiere.de/

Research on the outcomes of the project revealed that participants have developed attitudes toward science but that these were higher in individual participants with prior knowledge on the topic. Future research should thus consider this aspect when evaluating the impact of citizen science initiatives on attitudes toward science (5).

II. **Understanding of the scientific process and how science is conducted (2, 4, 5, 7, 9, 13, 31, 32, 36, 37): Citizen scientists and project initiators/facilitators**

- E.g., knowledge of scientific content, knowledge of scientific methods (i.e., scientific knowledge and scientific reasoning), the ability to discuss and evaluate the origin and quality of scientific results and thus seek answers to scientific questions

III. **Understanding of social, policy and economic processes (CitiMeasure working group): Citizen scientists and project initiators/facilitators**

- E.g., how decisions about wildlife or water resources management are made

IV. **Understanding of technological possibilities and protocols (32): Project initiators/facilitators**

- what are the available tools for a certain type of observation and what are the advantages, limitations, and protocols for use of each tool.

V. **Place-based knowledge directly related to everyday issues (5, 16): Citizen scientists and project initiators/facilitators**

- Local knowledge, e.g., knowledge about species living in a certain area, or how past rainfalls affected a certain neighborhood (3, 8, 20, 28, 32)
- Indigenous and traditional (9, 23, 32 38) including TEK (traditional ecological knowledge) (7, 13, 23, 38)

VI. **Experience with past projects (23, 34): Citizen scientists, project initiators/facilitators and information professionals**

- Volunteers that have some experience in relevant projects will be more efficient in new projects

VII. **Ethics (28): Citizen scientists, project initiators/facilitators and information professionals**

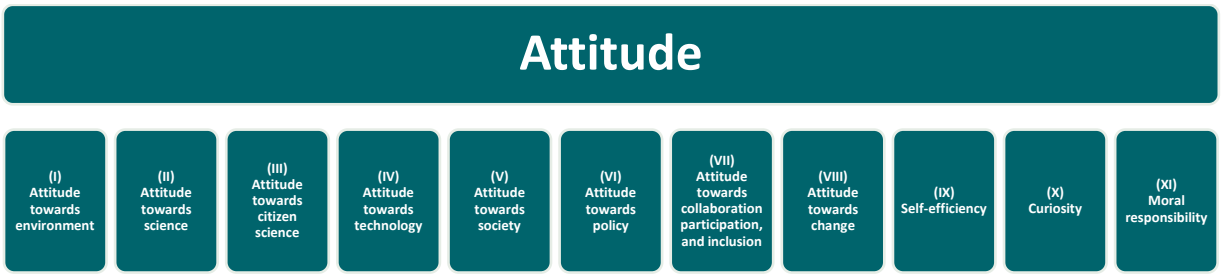
VIII. **Governance principles (28): Project initiators/facilitators**

- understanding of governance principles e.g., fairness, inclusivity, equity, justice

IX. **Legal knowledge (28): Project initiators/facilitators and information professionals**

4.3.3.3 Attitude

Similarly, eleven main cluster of attitude were identified as relevant for digital inclusion in citizen science. This includes (I) Attitude towards environment, (II) Attitude towards science, (III) Attitude towards citizen science, (IV) Attitude towards technology, (V) Attitude towards society, (VI) Attitude towards policy, (VII) Attitude towards collaboration, participation, and inclusion, (VIII) Attitude towards change, (IX) Self-efficiency, (X) Curiosity, (XI) Moral responsibility. Each attitude category is relevant for one or more of the target groups that were defined in the beginning of this section. Descriptions and references are used to elaborate each attitude category and clarify its source.



I. **Attitude towards environment and human life (5,7, 9, 26, 28, 37)**: ***Citizen scientists and project initiators/facilitators***

- One's perception or ideas towards environment, health, inequality e.g., towards natural resources consumption and management that may lead to pro-environmental behaviour and environmental stewardship, or actions that may harm the environment or human health.

II. **Attitude towards science (4, 26, 28, 31, 32, 34, 36, 37): Citizen scientists and project initiators/facilitators**

- One's perception or ideas towards science, including general trust in science and actively searching information about science.

BOX 8: The project iSPEX

The project analysed thousands of measurements made during three days in 2013 and combined them into unique maps of dust particles above the Netherlands. Initially, participants had limited involvement with science in their daily live. Through Likert scales, project questions, and Boolean survey questions scholars identified a shift in the attitudes of participants towards science (31).

http://ispex.nl/en/

III. **Attitude towards citizen science (26): Citizen scientists and project initiators/facilitators**

- One's perception or ideas towards citizen science, e.g., the ability of general public to get involved in scientific research and issues such as quality of the data collected or analysed by citizens.

IV. **Attitude towards technology (1): Citizen scientists and project initiators/facilitators**

- Willingness to learn and use technology

V. **Attitude towards society (34): Citizen scientists and project initiators/facilitators**

- One's perception or ideas about social responsibility.

VI. **Attitude towards policy (28): Citizen scientists and project initiators/facilitators**

- Perceptions or ideas about one's ability to navigate the political system, identify political responsibility and accountability, and trust in policy processes, e.g., for unsustainable behaviour, and demand effective policies for sustainability.

VII. **Attitude towards collaboration, participation, and inclusion (28, 36): Citizen scientists and project initiators/facilitators**

- One's perception, ideas or trust about collaboration, collective action, stakeholder participation, or acting for change in collaboration with others (e.g., people from all gender, age, and income groups within the society).

VIII. **Attitude towards change (28): Citizen scientists and project initiators/facilitators**

- Generic perceptions or ideas about changes in behaviour, act according to values and principles, and willingness to discontinue unsustainable practices and try alternative solutions.

IX. **Self-efficiency (28, 47): Citizen scientists and project initiators/facilitators**

- One's confidence in ability to understand certain concepts and processes or take certain measures

X. **Curiosity (34): Citizen scientists and project initiators/facilitators**

- The spirit of discovery

XI. **Moral responsibility (CitiMeasure working group): Citizen scientists, project initiators/facilitators, and information professionals**

- Perceptions or ideas about upholding common values, norms, and principles

4.3.4 Recommendations

The work of the Digital Inclusion working group resulted in the following recommendations that are relevant for all actors involved in citizen science projects. This includes citizens who (would like to) participate in a citizen science initiative, researchers and information professionals who may initiate, run, or process the results from such initiatives, as well as policy makers, decision makers and municipal employees who engage in these initiatives in different capacities. Everyone has the responsibility to make a CS initiative inclusive.

- **Understand the context** in which a citizen science initiative is being established. Choose appropriate technologies for your participants, based on the social, cultural, economic, and political context (7, 23, 35, 38).
- **Invest time and efforts in the planning phase**:
    - Identify necessary skills for participation, e.g., through brainstorming or mock-up tests (22, 23, 38).
    - Consider privacy, security, legal and ethical concerns from the beginning and work towards resolving those, e.g., by designing appropriate informed consent processes, or anonymizing published data (23, 38).
    - Focus on community gains and make sure participants have the necessary skills and understanding to get the most out of the process (22).
    - Consider the needs for developing new skills in your community, e.g., understanding how sensors work, what data is, and how to interpret it. Spend time and efforts at this stage to train and prepare participants for data collection, interpretation, and resulting actions (22).
- Embed **inclusive thinking from the start** in both project and technology design
    - Aim for diversity and inclusion of marginalized groups including people from different age, race, gender, social orientation, ethnicity, and physical ability strata (6, 7, 23, 25, 27, 29, 32).
    - Carefully consider possibilities for participation of people with different levels of technological savviness by reflecting on how complicated the tasks are, what technical skills are required for participation, and the learning curve of those technological solutions (23).
    - Recognize human values, and emotions (local and global) and shared expectations of inclusion (25).
    - Consider the role, and added value, of traditional knowledge and think about possibilities to capture it. Ensure that this kind of knowledge is likely to feed into decision-making processes. In many situations where citizen-based knowledge and information may open opportunities for achieving a range of ecosystem service safeguards and poverty alleviation outcomes (32).

BOX 9: the Balanngarra Rangers

A collaboration between conservation researchers and indigenous Traditional Owners (the Balanngarra Rangers) enabled the local group to bring their unique skills, experience, and knowledge to the project; an excellent example of the synergy between 'Western science' and Traditional Ecological Knowledge and skills, and the researchers petitioned for more inclusive academic group co-authorship protocols for their resulting research outcomes, with culturally appropriate credit for the contribution of the Rangers (13).

- **Adopt co-creative and participatory design approaches** as this will help identify and overcome end-user challenges from the start (23, 38)
- **Help participants overcome technical challenges** (20)
    - Provide 'easy access' to project information and training. Make sure that 'easy access' is a shared perception by both project initiators and participants (2).
    - Design and run usability tests, for example in form of workshops or surveys (2).
    - Consider different issues related to access to technology (physical, motivational, and actual usage). This includes for example access to internet and smart phone,

motivations to use technology, and restrictions for actual use e.g., due to high usage costs (1, 18, 29, 33, 38).
- Evaluate new technologies with make-versus-buy and cost–benefit analyses, paying particular attention to reliability and ease of use (7, 35, 22).
- When possible, adopt well-established, well-documented, and well-supported technologies (7)
- Consider interoperable, customizable, open-source solutions where possible (7)
- Follow best practices and use standardized data-collection and data-management protocols where available (7)
- Encourage use of open-data standards and open-source software (7, 22)
- Consider support from third parties and organisations to assist with any technology issues, and to keep things running smoothly while sensing is ongoing (22).
- Provide participants with take home manuals, booklets, guides, and troubleshoot instructions. Experience has revealed that problematic sensors are often abandoned, and people may disengage when the technology fails (22).
- Partner with local community representatives and ask their help with e.g., training participants, sharing experiences, and coordinating local action. For example, match participants with environmental interests and those with technical skills (22, 38).

BOX 10: the UrbanAirQ pilot

The Making Sense project (2015-2017) explored how local communities can effectively use open-source software and hardware, digital maker practices and open design to make their own sensors. (22). In the pilot UrbanAirQ in the city of Amsterdam, citizen scientists decided what they wanted to measure and why. In this case, they chose NO_2 as an indicator of air quality. The participants raised diverse questions and concerns about air pollution which helped design the approach of the pilot itself.

Image from the Making Sense toolkit

http://making-sense.eu/urban-airq-citizens-measuring-air-quality-themselves/

- **Recognize efforts and create joint identity**
  - Make sure participants' contributions and achievements are recognized, acknowledged, and celebrated as this highly affects attitude towards (continued) participation (2, 7, 13).

    - If desired, citizen science groups should be readily identifiable by an identity and/or agreed upon collective name (13).
- **Be aware of biases** (23, 32):
    - Self-reported ICT skills of individuals may be subjective and based on specific individual experiences (30). Don't dismiss the need for training based on those subjective judgments.
    - When describing needs, knowledge, attitude, and skills, be as specific as possible and realize unconscious bias and ambiguities hidden in terms such as 'enough' or 'etc.' (19).
- **Support learning and capacity building** within participants
    - Support development of skills, knowledge, and attitude amongst participants e.g., via training or by sharing instructions, so participants can learn to use sensors and devices, judge the quality of collected data, understand its (in)validity, and share data via dedicated platforms (6, 22)
    - The setting for providing training needs to match the purpose. E.g., online training may not be the most suitable method for the use of physical devices such as a flowmeter which may need hands-on field skills developed in practice (33).
    - Where possible, partner with local schools and teachers. Jointly develop educational resources around citizen science linked to educational curricula. This helps strengthen science literacy, raising environmental awareness, and transfer certain skills for the use of observation or measurement tools (16, 36).
- Actively try to **emphasise and foster the value of citizen science**
    - Demonstrate the value of citizen-generated data using scientifically sound methods and communicate this with citizen science sceptics at science and policy domains (35).
- **Think about communication and knowledge sharing strategies**
    - The format of communication needs to match the target audience. E.g., visualizations can ensure scientific content is comprehensible for a large target audience and potentially incentivise further engagement (32)
    - Organise events with the aim of knowledge sharing and peer learning (22).
    - Think of possibilities for providing feedback and interactive communication among actors involved (2).

BOX 11: The NEWSERA project

NEWSERA is a H2020 SwafS-19 funded project which aims to demonstrate that citizen science is the new paradigm of science communication. The focus of the pilot workshops is to define citizen science communication strategies addressed to engage citizens. The project thus showcases the virtues of citizen science as an inclusive, broad, and powerful science communication mechanism. NEWSERA established Labs where 38 citizen science initiatives co-design, implement and validate innovative strategies of science communication addressed to a specific stakeholder group from the quadruple helix model (academics, citizens, policy makers and industry).

https://newsera2020.eu/

BOX 12: Find a Lake

This citizen science project at South Denmark University (SDU) involved kids in science in their free time. The main goal was to recruit and educate citizens in collecting data of water quality and insect life to create a dialogue on future research questions. The project designed a detailed communication plan with specific target groups and communication channels (13).

https://www.sdu.dk/en/forskning/forskningsformidling/citizenscience/soer-i-fritiden/find-en-so

BOX 13: The ClairCity project

The ClairCity project sought to incorporate social psychological theories in air quality and carbon management and involved over 818,000 citizens across Europe in six case studies. The project identified demographic groups and social groups in their visuals and communications. It considers science communication as an essential element for the success of these types of projects, tailored communications are particularly powerful, as they enhance credibility and emotional engagement to ensure the facts reach the desired audience The following picture showcases a social card distributed in Bristol, one of the case studies (40).

http://www.claircity.eu/

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5 CitiMeasure inventory of air quality monitoring initiatives

5.1 BACKGROUND

The CitiMeasure Comparability instrument is an online interactive tool in the form of an inventory of air quality monitoring initiatives. This tool is the result of an iterative co-creation process with inputs from members of the CitiMeasure Comparability Working group. The members of this working group are affiliated to 9 European cities and 15 (non-)governmental and research organizations (see Figure 7). In particular, 18 out of the 27 individual working group members have contributed to the development of the tool. The detailed list of contributors and their affiliations are provided in Table 3. In addition to contributors from the working group, Table 3 also includes the name and affiliations of two Eurocities team members who have been involved in developing the tool, as well as one external expert (David Riallant) who contributed to the refinement and design of the tool.

WG member	Affiliation
Adrien Arfire	Air Parif
Andrea Thornbury	Belfast
David Riallant**	Air Sentinels
Edurne Ibarrola	Kunak
Francesco Cruz Torres	Milan
Heijke Rombaut	Ghent
Hester Volten	RIVM
Irene Vivas Lalinde*	Eurocities
Klemen Risto Bizjak	Maribor
Lukas Mocek	Sensor.Community
Martine Van Poppel	VITO
Michael Lažan	Sensor.Community Prague
Mohammad Gharesifard*	Eurocities
Myriam Lopes	University of Aveiro
Oscar Gonzalez	Fab Lab Barcelona
Paweł Klawiter-Piwowarski	Rumia
Philippe Thomy	Locolabs
Raf Verbruggen	Antwerp
Silvia Moroni	Milan
Vera Rodrigues	University of Aveiro

**Eurocities team members*

***External Expert*

Table 3: Contributors to the development and refinement of the CitiMeasure comparability tool

5.1.1 About the CitiMeasure Comparability working group

The Comparability working group is one of the three CitiMeasure working groups developing an instrument to create sustainable, inclusive, and smart cities. The group was initially formed through a call for expressions of interest that was shared through the Eurocities and City Deal networks, as well as personal networks of the CitiMeasure team. In September 2021, and following an inception meeting, the group started to co-design a shared vision and a number of objectives that help advance the comparability of air quality data collected in citizen science initiatives. Since September 2021, and following a co-creation approach, Eurocities has supported the development of the current online tool

to create an inventory of air quality citizen science initiatives and their approach to air quality measurements. This was done by organizing and facilitating monthly online meetings, as well as communications with the working group members to share knowledge, experience, and resources for creating the tool. Currently, the working group has 27 members from cities, governmental, research and other organisations.

Cities
• Antwerp • Barcelona • Belfast • Debrecen • Ghent • Maribor • Milan • Rumia • Torino

(Non-) governmental and research organizations
• Acoucite • Air Parif • Air Sentinels • ICTU • Civity • Dutch National Institute for Public Health and the Environment (RIVM) • Fab Lab Barcelona • Flemish Institute for Technological Research (VITO) • Kunak • Loco Labs • Norwegian Institute for Air Research (NILU) • Sensor. Community • Sensor2School • University College Dublin (UCD) • University of Aveiro

Figure 7: Cities and (non-)governmental organizations that are member of the CitiMeasure Comparability working group

Here are the co-designed vision and objectives of the working group:

Vision: "The CitiMeasure Comparability WG aims to facilitate information sharing across different cities and organizations involved in air quality monitoring by creating an inventory of air quality monitoring activities and approaches. This inventory will be developed as an interactive tool that can be updated and maintained by the users and will inform citizen science initiatives and city officials on what sensors to use to ensure the comparability with existing observations."

Objectives:

1. Co-design a structure for the inventory of air quality monitoring activities and approaches.

2. Validate the co-designed structure by receiving feedback from the WG members and by testing it for gathering information about at least 5 different cities and organizations.

3. Continuously add to the inventory by completing it for cities and organizations within and outside of the WG.

4.Create online interactive tool(s) for city officials and citizen science initiatives that facilitates information sharing across cities and organizations by clarifying who is involved in what air quality monitoring activities and how.

5. Pilot the developed tool(s) in at least one city between May and December 2022 e.g., to inform the city's decision on finding new approaches, tools, or solutions.

6.Consolidate the tool with lessons learned from the pilot phase and further analysis by March 2023.

Besides the Inception Meeting, seven co-creation sessions were planned to work towards development of the current online tool. However, based on the availability of the working group members, the team Eurocities team decided to merge the second and third sessions. Throughout the co-creation sessions, the working group developed different elements paving the wave to create the instrument. Development of the shared vision and objectives as described above framed the scope of the work. In November 2021, the working group adopted an implementation plan for the different actions needed to produce their desired outputs. From December 2021 until March 2022, the working group members discussed, refined, and tested different approaches to design the online inventory (main sections, steps, and formats) through an iterative process. This was done with the support of Eurocities staff and an external expert. Figure 8 describes the key outputs of all the CitiMeasure co-creation sessions. For further elaboration on the co-creation process of the online tool is presented in Section 5.1.2.

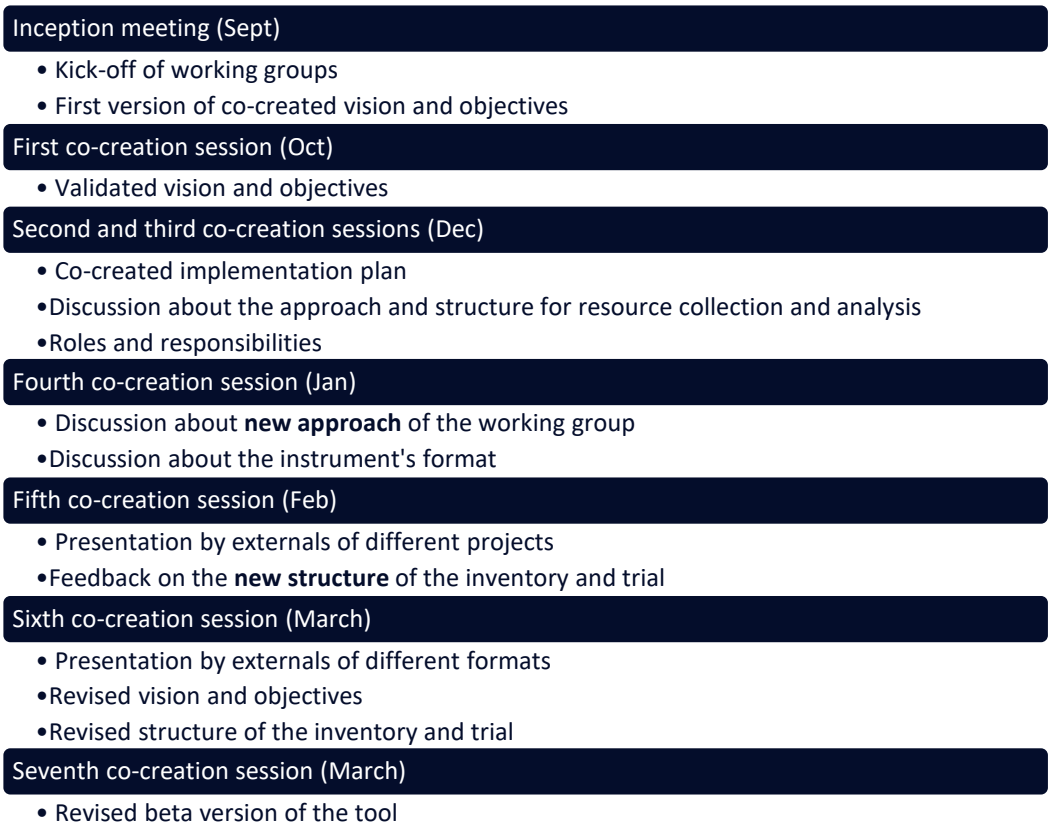

Figure 8: Key outputs of all the CitiMeasure co-creation sessions in the Comparability working group

5.1.2 Development of the online tool

The CitiMeasure Comparability online tool was developed using the following methodological steps and approach:

Definition of the scope

With the support of the Eurocities team, the working group members defined a shared vision and objectives. The initial vision was to "investigate and compare existing technical (data) and interoperability standards that support the gauging of consumer-grade air quality sensors with reference sensors of (regional national, and municipal) authorities. The aim is to develop a basic guideline that informs citizens and city officials on what sensors to use to ensure the comparability of data with other citizen science initiatives, as well as with official observations."

In December 2021, the working group members discussed the approach to collect resources and information about existing standards. However, some of the members were concerned that the WG was duplicating the work of other renowned organisations such as the Joint Research Centre. Therefore, the working group re-defined its approach from January 2022 onwards. The final vision and objectives were revised in the sixth co-creation session following this change in the approach of the working group (see Section 5.1.1). Objective 4 specifies that the members found an interactive online tool as the most appropriate format for the output of this working group. A shared online workspace (SharePoint) was created so that working group members could easily access the working groups' material.

Design of the online interactive tool

The working group worked in an iterative way and adjusted the approach and format of the tool as the work evolved. Based on the new approach, the working group members and the Eurocities team worked together to design the main features, sections, and steps of the online interactive tool. The team used Miro to co-create the main elements, structure and visualisation of the future tool. Due to the complexity of the topic and time limit, an external expert was hired to provide input into the process and refine the structure.

The new structure of the tool was presented at the fifth session. The following figure showcases the Miro board with the old structure (on the left) with comments by members of the working group in post-its and the new structure (on the right) with a four-step approach to provide information about air quality citizen science initiatives. More details about these steps are provided in section 5.2.

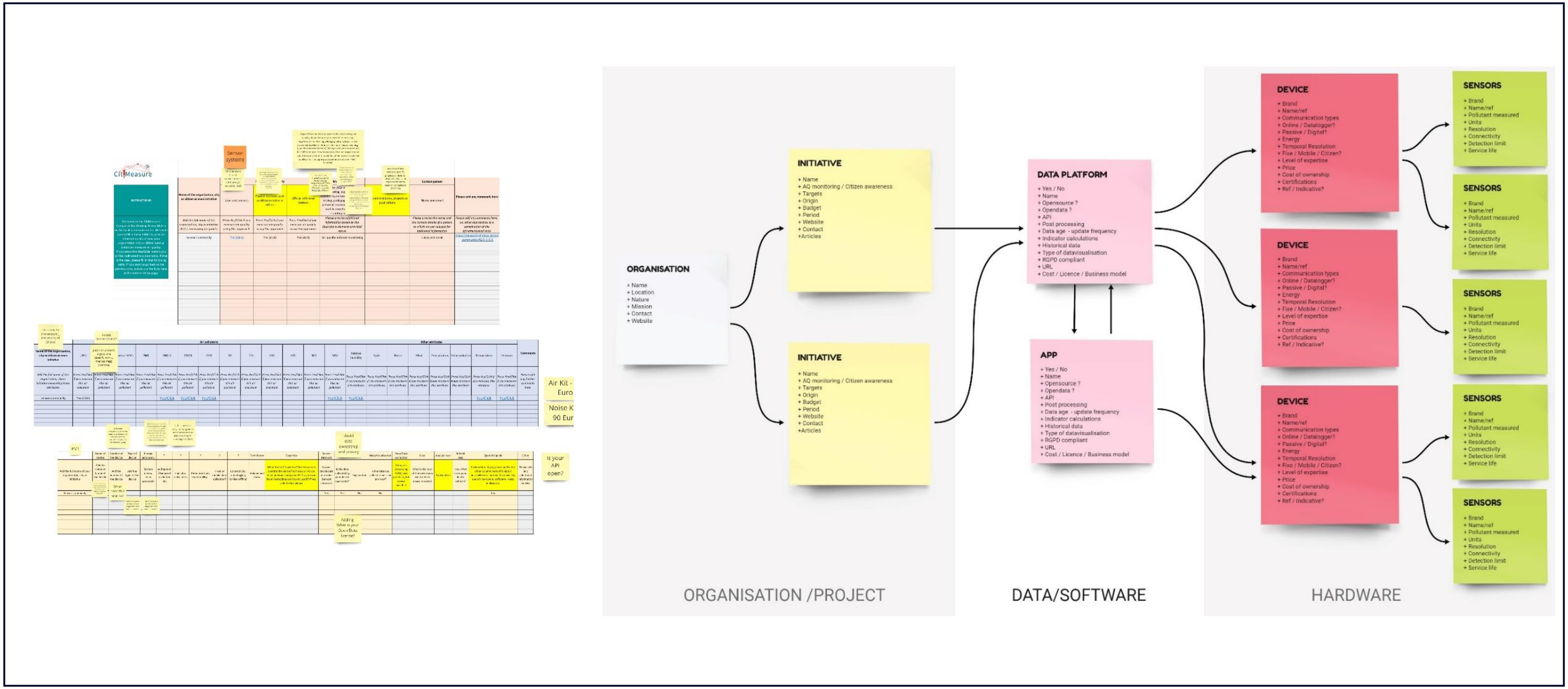

Figure 9: Miro board of the fifth co-creation session (with the old and the new structure of the tool

This project has received funding from the European Union's Technical Support Instrument (TSI) programme under grant agreement 101046124.

5.2 THE BETA VERSION OF THE ONLINE INTERACTIVE TOOL

The **beta version** of the interactive online tool incorporates the requirements, comments and feedback from the working group members. The final prototype of the tool is currently under development and therefore may include slightly different visuals, colours, and minor adjustments in the format, but the main sections and functionalities are expected to remain the same. The following sub-sections include the different elements of the (beta version of the) online tool:

a) Main (landing) page

The landing page of the online tool includes a brief description of the project and its motto. The tool will be accessible from the Instruments page of the CitiMeasure European Knowledge Centre.

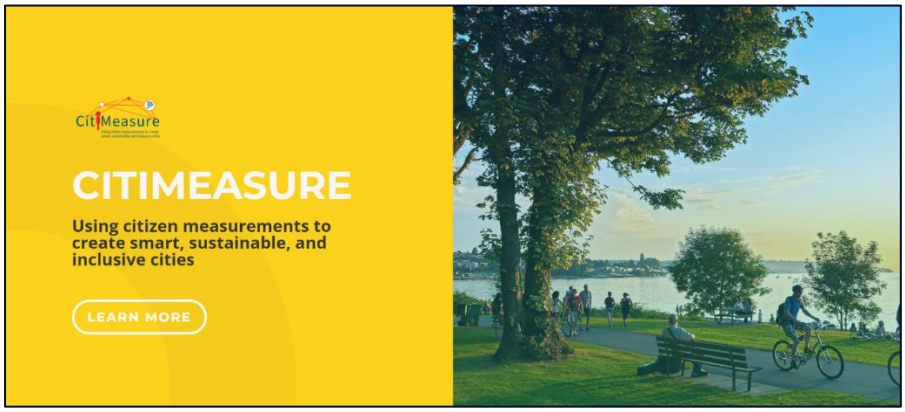

Figure 10: Landing page of the tool

b) Mission of the tool

The CitiMeasure comparability tool has three main goals:

- Identify and co-create an inventory of air quality monitoring activities of different (European) cities and organisations
- Facilitate knowledge sharing between city officials and citizen science initiatives regarding who, what and how they do air quality measurements
- Pilot and consolidate the CitiMeasure tool to facilitate the comparability of air quality data.

This project has received funding from the European Union's Technical Support Instrument (TSI) programme under grant agreement 101046124.

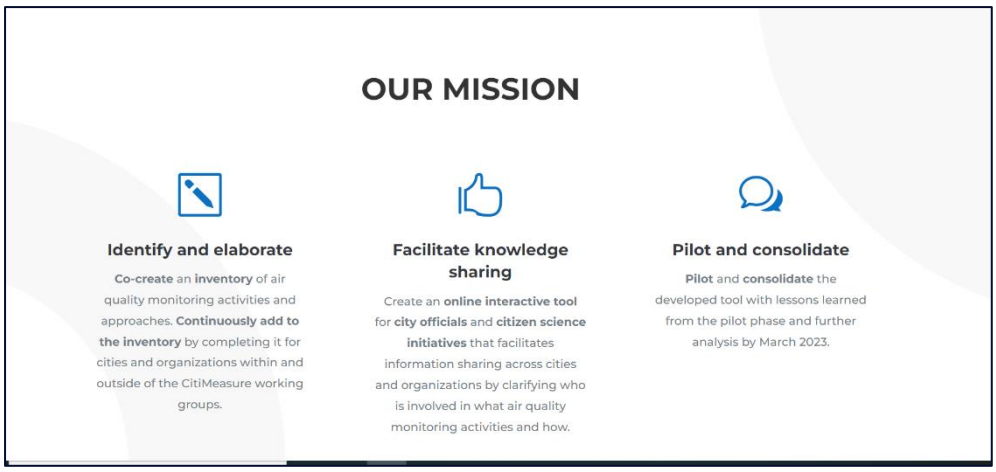

Figure 11: Summary of the CitiMeasure Comparability working group mission

c) Interactive map

The final version of the tool will incorporate interactive elements such as maps where the different initiatives will be represented using a location identifier (e.g., in form of a pin). Users can then click on each initiative to learn more about it. The current version of the map is an example of how other projects have used maps to visualise air quality data (Figure 12). The image is provided by member of our working groups from Sensor.Community. However, the final version will be considerably different to the current design.

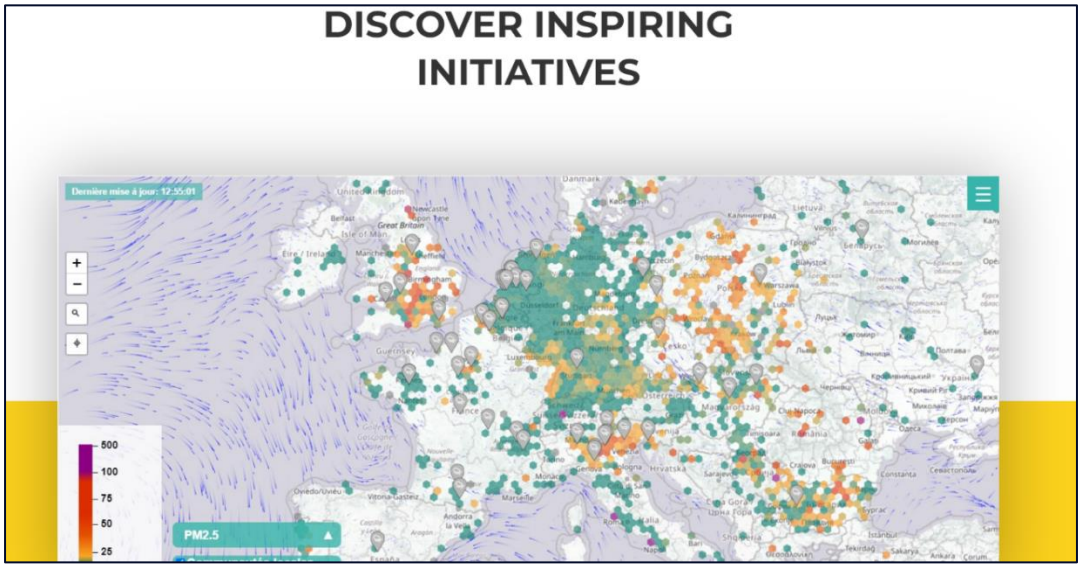

Figure 12: Example of an interactive map

d) Stories and numbers

The final version of the tool will incorporate interactive and automated elements such as 'stories' and quantitative indicators of the different initiatives, including e.g., number of participants and devices, or quantity of measurements collected in different initiatives. Users can then click on the stories to learn more about a certain initiative and its approach.

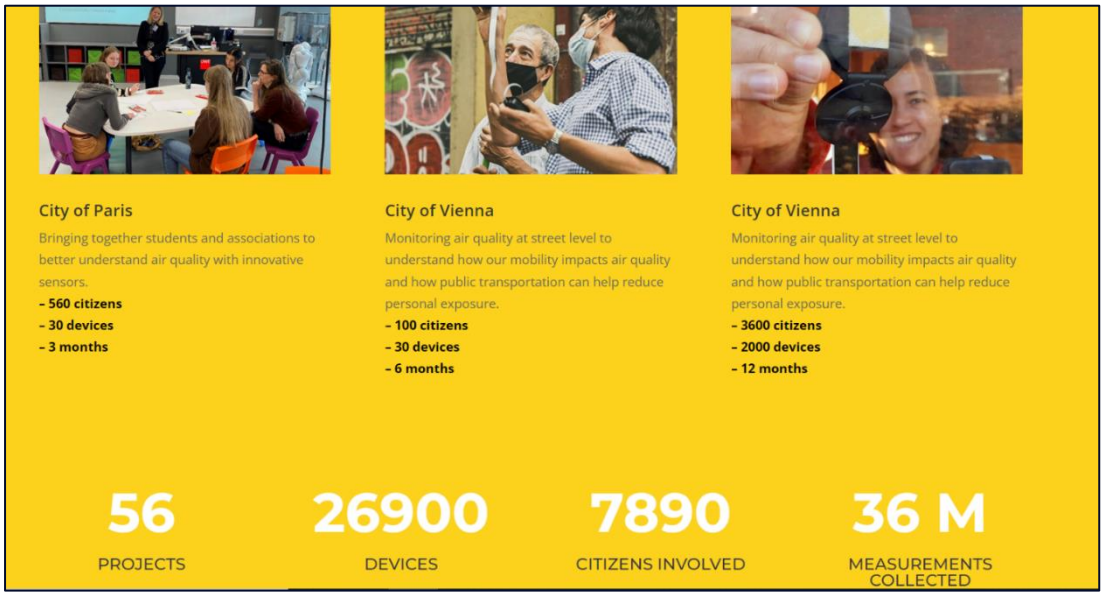

Figure 13: Stories and numbers section in the Comparability tool

e) Add your own story/initiative

This section of the tool will invite the users to share a story on how they conduct air quality measurements. Viewers can click on the button “I want to share my story” to input an initiative.

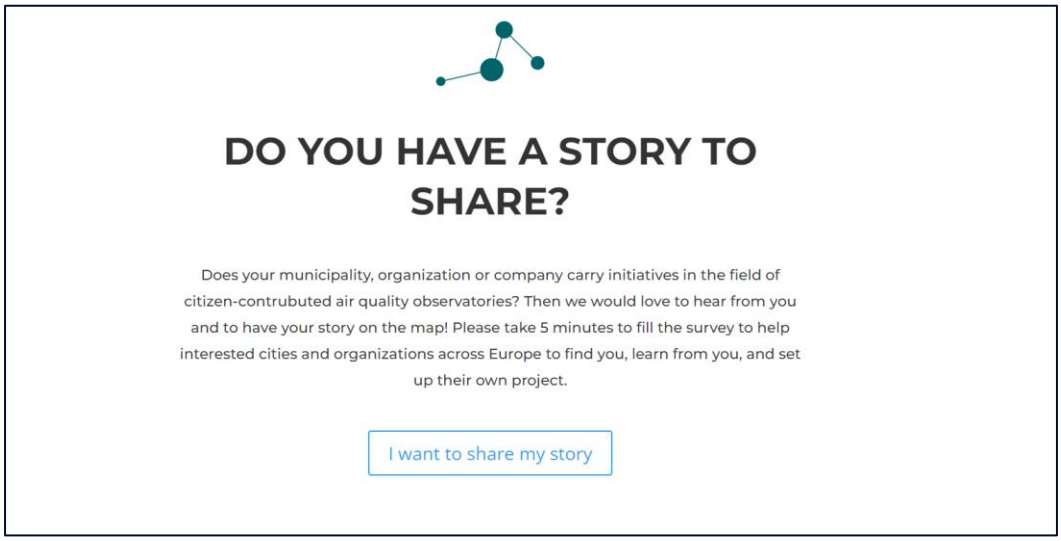

Figure 14: Add your own initiative section of the Comparability tool

By clicking on this button, users will be sent to a new page which showcases a step-by-step approach to fill in a form to provide all the details about your initiative.

Step 1: your organization department

The main aim of this step is to gather information about the organization or the department in charge of the initiative. The user will provide the information presented in Figure 15. The dropdown list under the question “what best describes the type of organization you are representing?”, has the following options:

- City administration
- Government organizations
- National or International Non-Governmental Organizations
- Community-based organization/Civil Society Organization
- Private company
- Academia
- School
- Other

The question ‘ How would you describe your organization’s mission?’ is relevant for understanding the nature and main goal of an organization. The information gathered here may be used as keywords for searching and filtering initiatives and organizations.

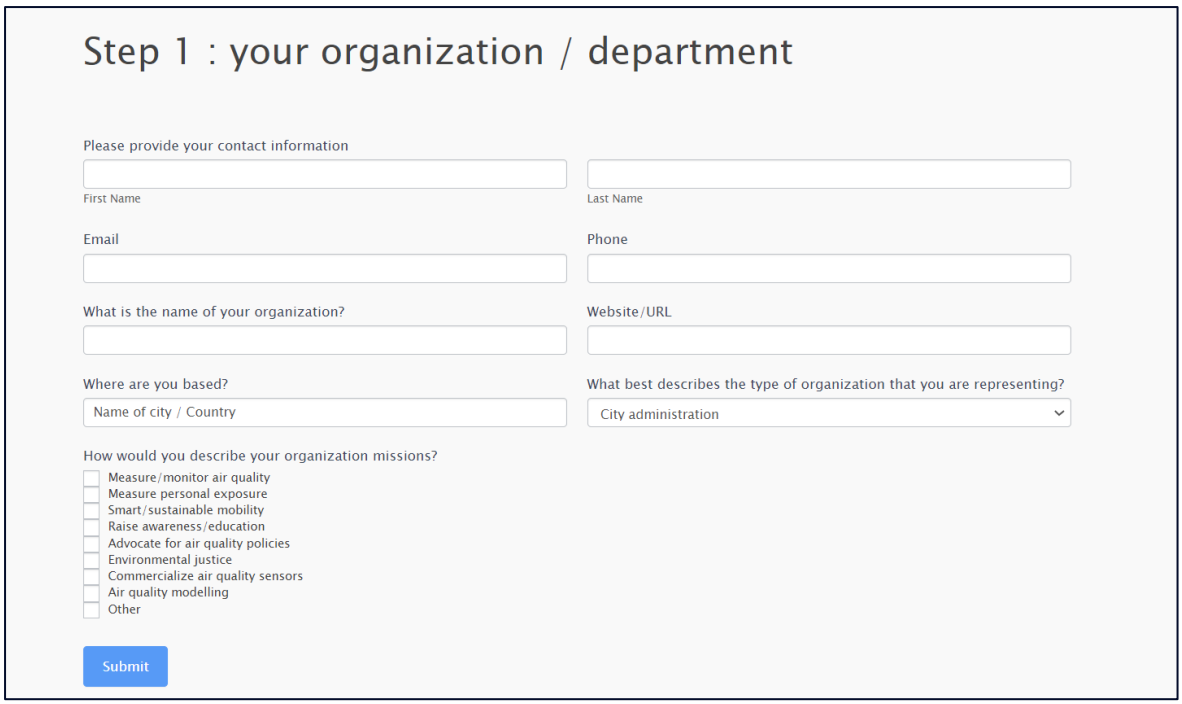

Figure 15: Step 1- Information about organization/department

Step 2: your initiative

The aim of this step is to gather generic information about the initiative, including the main target audience and the context in which the initiative operates (see Figure 16). In the budget question, users will have the option to choose from 'zero to €10,000' (0-10k) to more than a million euros. Under the duration of the programe, users can choose from the range from 'less than a month' to 'more than a year'. In the participants question, user can choose from '0 to 25 participants' to 'over 5000'.

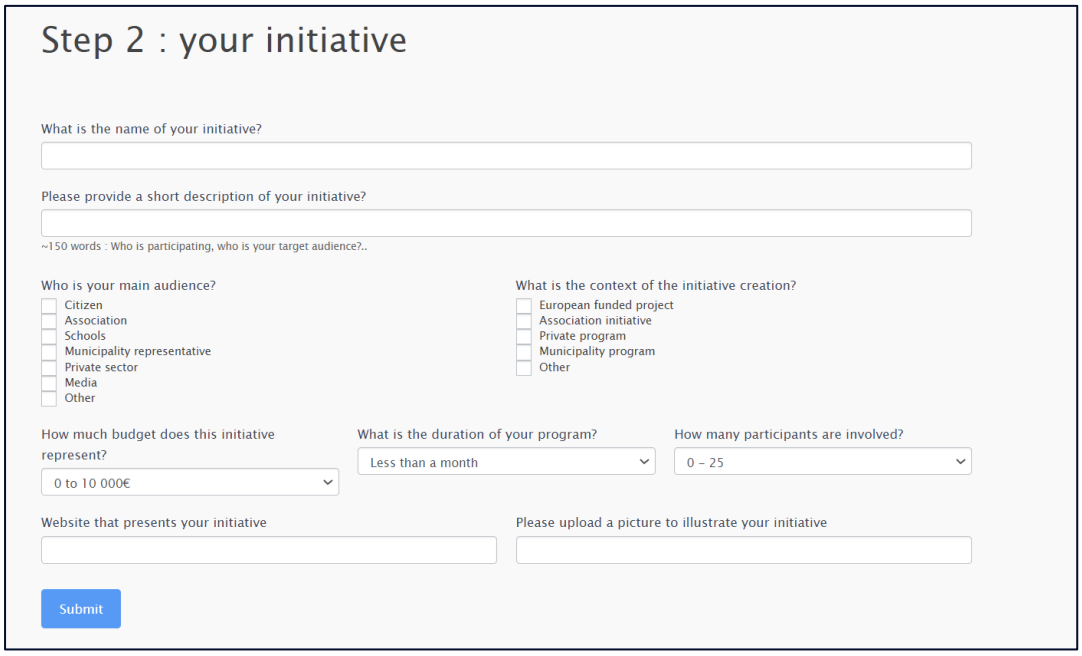

Figure 16: Step 2- Your initiative

Step 3: equipment description

While the first two steps provide contextual and descriptive information about the project and the organization that is providing the information/runs the project, steps 3 and 4 focus on the technical aspects of the air quality measurements. This step focuses on extracting information about the equipment (see Figure 17).

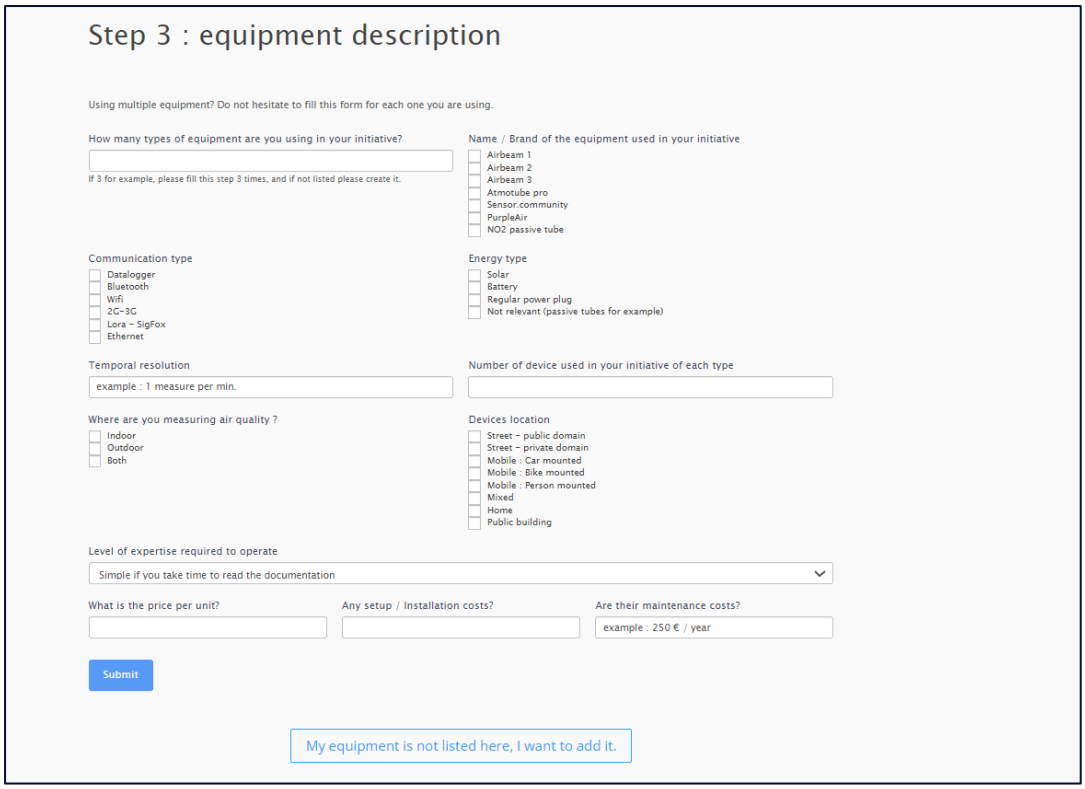

Figure 17: Step 3- equipment description

Many initiatives use the same equipment, and the online tool is designed to avoid users inputting the same information repeatedly. If the equipment is listed, the different questions will be filled in automatically. The level of expertise goes from 'simple if you take time to read the documentation' to 'have to be an expert – requires special training'. If the equipment is not listed, users will need to add it by clicking the button at the bottom (see Figure 18). In this additional form, users will be able to include the name and brand, as well as the origin of the equipment and the parameters which are measured. The new equipment will be thus added together with the information from Step 3. All this information will be automatically incorporated for future users using the same equipment.

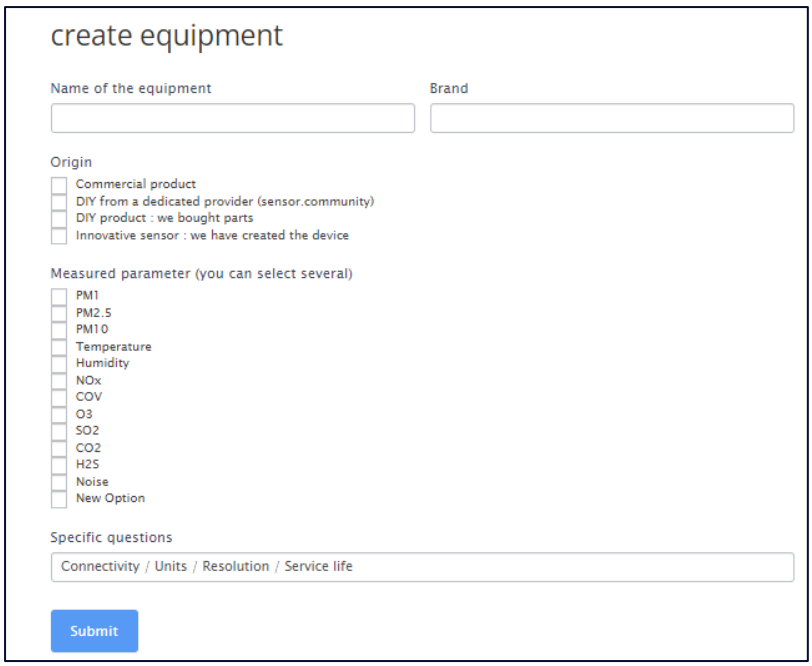

Figure 18: Create equipment form

Step 4: data platform

The main aim of this step is to provide information about the management of the air quality data, more especifically how the data is being used, data visualization, quality control, etc. (see Figure 19).

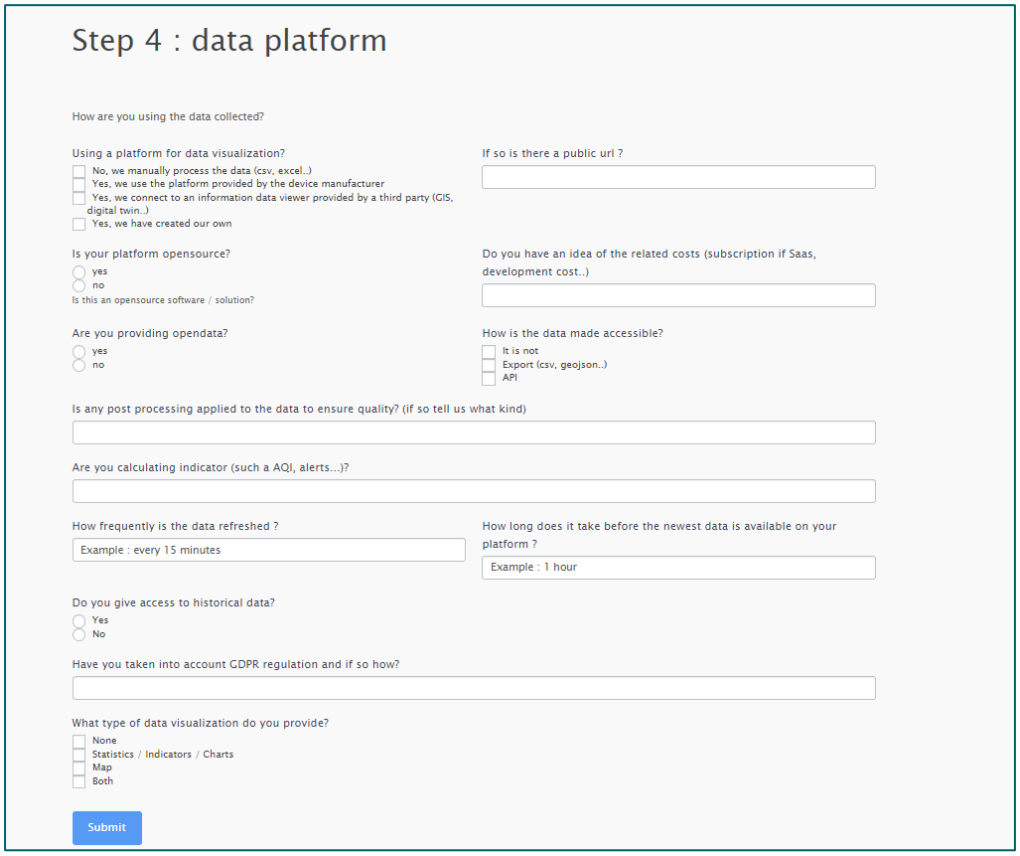

Figure 19: Step 4 - data platform

6 Concluding remarks

The current report presents the prototype (first advanced draft) of the three CitiMeasure instruments. These prototypes are the result of a co-creation exercise during a period of eight months. They are built upon a large number of resources and past experiences in the field of citizen science and reflect the collective knowledge of more than 40 experts, researchers, and city representative. The ambition of CitiMeasure is that these instruments become a valuable source of guidance and information for both existing and future citizen science initiatives, especially those with an urban focus. Consolidation and improvement of the current prototypes will be the focus of the work in the pilot phase of CitiMeasure and the final version of all instruments are planned to be shared publicly by April 2023.