An Ecosystem of Citizen Observatories for Environmental Monitoring

WeObserve D.3.1: Develop infrastructure and WeObserve toolkits for scaling up citizen engagement in citizen observatories

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Task	Task 3.1: Develop infrastructure and WeObserve toolkits for scaling up citizen engagement in citizen observatories
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Table of contents

Index of figures

N/A

Index of tables

Glossary of terms

Term	Description
Toolkit	Widely understood as a collection of methods and objects which help facilitate the execution of activities towards a specific purpose. For COs, toolkits support and improve best practices, encompass a range of methods for collective inquiry, and provide digital and analogue tools which can facilitate a progressive approach in environmental monitoring.
Infrastructure	A way for COs to increase citizen engagement in data observation, data use and decision making
Communities of Practice	'Groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis.' (Wenger *et al*., 2002:4).

List of abbreviations and acronyms

Abbreviation	Meaning
CO	Citizen Observation
COs	Citizen Observatories
EO	Earth Observation
CoP	Community of Practice
CS	Citizen Science
F2F	Face-to-face
GDPR	General Data Protection Regulation
GWO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
ECSA	European Citizen Science Association
CSA	Citizen Science Association
GEO	Global Earth Observation
CREAF	Ecological and Forestry Applications Research Centre
AAWA	Alto Adriatic Water Authority
EU	European Union
CLO	Cornell Lab of Ornithology

Executive Summary

WeObserve is a H2020 Coordination and Support Action (CSA) which tackles three key challenges that Citizen Observation (CO) / Citizen Observatories (COs) face: awareness, acceptability and sustainability. Its mission is to create a sustainable ecosystem of COs that can systematically address these identified challenges and help to move Citizen Science (CS) into the mainstream. The project aims to achieve this by improving coordination between existing COs and effectively linking regional, European and International activities.

The specific WeObserve objectives can be summarized as follows:

- Develop Communities of Practice (CoPs) around key topics to assess the current CO knowledge base and strengthen it to tackle future environmental challenges using CO-driven science;
- Extend the geographical coverage of the CO knowledge base to new communities and support the implementation of best practices and standards across multiple sectors;
- Demonstrate the added value of COs in environmental monitoring mechanisms within regional and global initiatives, such as GEOSS, Copernicus and the UN Sustainable Development Goals;
- Promote the uptake of information from CO-powered activities across various sectors and foster new opportunities and innovation in the business of in-situ earth observation.

Pathways to achieve these objectives include diverse activities which engage the CO landscape including, but not limited to, landscape mapping, the development of CoPs, public-facing events such as roadshows, publications and academic literature on the subject, and the creation and dissemination of publicly accessible toolkits.

This report tends to the creation and dissemination of toolkits. We look at toolkits in the CO landscape, focusing on what is already in existence, as well as at some of the pertinent discussions on this subject. We also present findings from several scoping activities, including a survey which sought input from the WeObserve Engage CoP, and other key networks, such as the European Citizen Science Association (ECSA) and the Citizen Science Association (CSA).

This report is the part of a longer process of building a sustainable CO infrastructure, with specific, replicable tools and processes that will allow individuals, groups, agencies and COs to devise, promote and evaluate their own projects.

1 Introduction

The WeObserve (WO) consortium brings together four currently funded H2020 COs (LandSense, GROW Observatory, Ground Truth 2.0, and Scent) with a strong range of networks through the active COs as well as WO partner organisations such as ECSA, users and stakeholders, including GEO and Copernicus (CREAF), and organisations that represent cases of best practice in previously funded COs (AAWA). A main objective of WeObserve is to bring these different kinds of stakeholders together at a range of awareness-raising events to create welcoming spirit and proliferate the ecosystem of COs. WeObserve anticipates that this long-term collaborative approach will drive a step-change in EO innovation and participatory environmental monitoring.

WeObserve advocates that COs are an integral way to tackle environmental challenges by empowering communities in addressing pressing issues, and there are different models and approaches to achieve this. However, there are currently three key challenges that must be tended to in order to realize this intention specifically the awareness, acceptability, and sustainability of COs among the wider scientific, society and other decision-making communities.

Awareness: Citizens are generally not aware of Citizen Science (CS) opportunities that exist to address environmental issues affecting them. They often lack the awareness of what it means to volunteer their time or energy and how it contributes to environmental stewardship. Furthermore, other stakeholders such as public authorities, SMEs and NGOs are also not aware of the potential of COs to support their decision-making and create business opportunities.

Acceptability: Citizen-based observations are often scrutinized for not meeting the required quality standards for informed decision making and environmental governance. Public authorities in decision-making positions do not generally trust or do not accept “scientific” data from citizen-science experiments to complement authoritative data. Equally there can be issues in mainstreaming practices and data for uptake within scientific and environmental disciplines.

Sustainability: Although localized CS projects within the European Union (EU) have shown great promise, the infrastructure, measures and legislation in place are insufficient to sustain and scale-up these projects across various sectors, especially the private sector. Furthermore, deficiencies in systems and standards of data preservation and data interoperability across initiatives are limiting the long-term potential of CS and COs.

The aim of WeObserve is to create the conditions for a sustainable ecosystem of COs that can tackle these identified challenges by improving coordination between existing COs and effectively linking past, present and future projects at national, regional, European and International scales. This approach underpins the action-oriented mission of WeObserve, which is to:

> *Move citizen science into the mainstream by building a sustainable ecosystem of citizen observatories and related activities*

To achieve this project mission, we have detailed specific objectives as follows:

Objective 1: Develop Communities of Practice around key topics to assess the current CO knowledge base and strengthen it to tackle future environmental challenges using CO-driven science.

Objective 2: Extend the geographical coverage of the CO knowledge base to new communities and support the implementation of best practices and standards across multiple sectors.

Objective 3: Demonstrate the added value of COs in environmental monitoring mechanisms within regional and global initiatives such as GEOSS, Copernicus and the UN Sustainable Development Goals.

Objective 4: Promote the uptake of information from CO-powered activities across various sectors and foster new opportunities and innovation in the business of in-situ earth observation.

1.1 Purpose and scope – Aims and objectives of WP3 and D3.1

The WeObserve Work Package on toolkits (WP3) is aligned with the plans to extend the geographical reach of the CO knowledge base to new communities and support the implementation of best practices across various sectors.

Objectives of this work package, which are also aligned to what is presented in this report (D3.1) are:

- To accelerate the uptake of the CO knowledge base and facilitate democratization and significant scaling and replication of CO and citizen science for future environmental challenges (Objective 1)
- To synchronize the results and outcomes from the WP2 Community of Practice (CoP) activities and employ this network for designing the WeObserve WP3 toolkits for extension of geographic knowledge (Objective 2)
- To identify pathways for infrastructuring and delivering toolkits which drive citizen observatories into mainstream science to support the added value of CO's (Objective 3)

Infrastructuring is a term which has helped to define development in technology that is both socially engaging and also can be used by those not included in the original design process (LeDantec & DiSalvo, 2013). Others have described it as way to capitalize on skills and relationships within a community that allows innovation to flourish (Björgvinsson et al. 2010). In the context of WeObserve, we understand infrastructuring as a way for COs to increase citizen engagement in all aspects of earth observation including (in-situ) data collection, data observation, data use and decision making.

We focus on how to enable sustainable interventions at a large scale. This approach to infrastructuring would support communities to deliver sustained activity in citizen observation. The resources required for this development are drawn from lessons learned from the WeObserve consortium and the CoPs which have been organized by WeObserve partners. The

WeObserve consortium employs the Wenger *et al*. (2002) definition of "communities of practice", which is 'groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis' (p.4).

This report considers how to infrastructure with specific replicable toolkits for individuals, groups, agencies and COs to devise, promote, and evaluate their own campaigns. It explores how we lay the groundwork for this, and what short- and long-terms actions can be set in place to achieve this.

During the funded period of operation, WeObserve will provide a short-term solution for knowledge exchange within the CO ecosystem and scoping of toolkits. The longer-term aim of building 'WeObserve Toolkits' will be published as both printed hard copy and downloadable pdfs. These will be flexible for different stakeholders (e.g. grassroots communities, science museums or universities) and will support various users in understanding personas, project types and decision making. The main aim will be to support different users in navigating content, which will also set the toolkits apart from the WeObserve cookbook, and its more linear format. The long-term aim will be to support and sustain continued engagement and self-organised CO activities beyond the end of the formal period for WeObserve.

1.2 Approach – Research Methods

Toolkits are an increasingly common output of practice. They can be developed from diverse domains and by different practitioners and might support a range of stakeholders across communities of practice and interest. The research methods used to develop this report are listed and described below:

1.2.1 Contextual Review

We have provided an overview of what exists in terms of tools, toolkits and current provision of instruments to support the activities of citizen observation. As citizen observation is a relatively new field, we offer a summary of activities in areas such as citizen science, citizen sensing and environmental monitoring, to name a few.

1.2.2 WeObserve Toolkit Workshop

To understand and hone the expertise which was coming from within WeObserve, an in-house workshop sought to identify both where existing knowledge is and where gaps in provision and knowledge are. This was achieved through a workshop which examined the premise behind toolkits in CO and collated existing tools and materials that draw on best practice from the field.

1.2.3 MozFest Workshop

Mozilla Festival (MozFest) is a yearly event in London organised by Mozilla, the company behind the Firefox browser. The festival brings together people interested in social innovation enabled by the advancements in technology and co-creative activities. WeObserve led a session (26 October 2018) over the duration of a few hours, which brought together 17 people from diverse backgrounds (designers, developers, activist for the Open Web, people who were

interested in running their own COs, and experts in sensing, open data, and service innovation) to discuss the processes, tools, networks and challenges found frequently in CO.

1.2.4 Toolkit Survey

Developed collectively by WeObserve and its CoP-Engage group, the toolkit survey gathered specific information on the tools and methods that are used and developed within COs. This approach is used as the premise for discussing existing toolkits found in current COs.

1.3 Structure of this Report

This report is designed to give a concise and comprehensive review of the work done to date in this area, both within WeObserve consortium and also the wider landscape of COs and associated areas, such as CS, environmental sensing and participatory sensing.

Section 1: Background and review of toolkits in CS and other associated areas, highlighting gaps and where WeObserve aims to address these.
Section 2: A description of the tools used by members of the WeObserve consortium.
Section 3: Next steps in the project. A description of how WeObserve will use this curation of tools and plans for further scoping and dissemination of information to the field.
Annex 1. Making Sense D5.3 Report on Toolkit Resources, Methods for Actionability and Evaluation of Findings from Data
Annex 2. WeObserve Toolkit Survey - Questions

2 Background

WeObserve is building an ecosystem of COs for environmental monitoring. COs are community-based environmental monitoring and information systems, that invite individuals to share observations, typically *via* mobile phone or the web. CO is a relatively new area to describe ways in which citizens collect information and are empowered by this data to participate in environmental management (Grainger, 2017). The full concept emerged from the European Commission, and is defined as:

> New *in-situ* observatories ('Citizen Observatories') based on citizens' own devices (e.g. smart phone, tablets, laptops and other social media) used together with innovative technologies can strengthen environmental monitoring capabilities, have the potential to generate new and original applications to reduce investment and running cost of in-situ observations and monitoring applications and solutions, and involve novel partnerships between the private sector, public bodies, NGOs and citizens.[1]

COs build on, and merge elements from CS and environmental monitoring. The concept is also part of a new wave of terms which seek to define the democratization of collecting information for the use and benefit of concerned citizens (i.e. citizen sensing, participatory sensing, crowdsensing, public participation, etc.). The role which technology has in facilitating and enhancing activities in CO is an important one. The advancements of technology, in regard both to devices for collecting information, and to ways in which citizens connect and share information, have an impact on how toolkits are understood in this field.

[1] https://cordis.europa.eu/programme/rcn/664594/en

Toolkits are widely understood as a collection of methods and objects which help facilitate the execution of activities towards a specific purpose. The concept of toolkits can be applied in many diverse fields, within which understanding of the term can vary. For COs, toolkits support and improve best practices, encompass a range of methods for collective inquiry, and provide digital and analogue tools which can facilitate a progressive approach in environmental monitoring. There is a limited amount of information on toolkits in this area, in fact most of the literature comes from adjacent fields, such as CS.

In this section, we present existing toolkits and literature that are relevant to the growing ecosystem of COs. We examine how toolkits have been discussed in previous literature, namely, through pinpointing the stages in the process when certain tools can be applied. With the overall goal of building a database and network of organisations and tools, we also highlight the gaps in provision and a need for continued scoping in this area.

2.1 Tools and Toolkits in Use

There are a number of sources, both online and in print, which provide toolkits for those interested in running their own citizen engaged, environmental monitoring project. CS being the most established field, has the greatest number of resources which aim to demonstrate both the process of the scientific inquiry and the tools which can be used to support that enquiry.

C.C. Wilderman (2007) defined a model of 'community science' through a series of questions, which were intended as a pathway for those wished to undertake their own study. Correspondingly, the "CLO Model" which defined 'steps' for CS (Bonney, 2007) and the Bonney et al. (2009) paper, *Citizen Science: A developing tool for expanding science knowledge and scientific literacy*, have since been refined and developed as the Cornell Lab of Ornithology[2] Citizen Science Toolkit. This toolkit is available online and is organized into steps including: choose a question; form a team; refine protocols; recruit participants; train participants; accept data; analyze data; disseminate results; measure effects. For each stage there is a page with an overview of that step. The toolkit also includes information on how to keep various stakeholders engaged and a 'reality check' which serves as a guidance to manage expectations and overcome common challenges. However, this online resource is far from comprehensive. Many of the pages are lacking in content, particularly the page on tools, which invites readers to get provide information on their own tools but has yet to feature any such crowdsourced content.

In the US, there are several federal online resources in relation to CS, including CitizenScience.gov which aims at providing federal agencies with support in public participatory projects.[3] The site has guidelines in areas such as; choosing a citizen science project, community engagement, project design, project evaluation, templates and other guidance. The toolkit resource gathers information into a series of steps, similar to the process models above, which include: Step 1. Scope Your Problem; Step 2. Design a Project; Step 3. Build a Community; Step 4. Manage Your Data; Step 5. Sustain and Improve.

[2] http://www.birds.cornell.edu/citscitoolkit/toolkit/manual
[3] http://citizenscience.gov

Further analysis of toolkits can be found in the Making Sense D5.3 Report on Toolkit Resources, Methods for Actionability and Evaluation of Findings from Data.[4] This report [see Annex 1] examines the H2020-funded project, Making Sense, and the tools that were used in each of the nine pilots delivered. Further to this, Making Sense (2017) published *Citizen Sensing: A Toolkit.* This publication demonstrates a reflective process of citizen sensing, a means of employing low-cost sensors to evidence local environmental issues and empower citizens to use the data they collect. The Making Sense process model and cross-cutting principles demonstrates the philosophy that underpins citizen sensing projects. These cross-cutting principles are: empowerment, co-creation, changemaking, and openness. Furthermore, the model is comprised of framework steps: scoping, community building, planning, sensing, awareness, action, reflection, and legacy. In this toolkit, each step is given a chapter and three to four tools are provided for each step. Tools are given a description, a 'how-to' guide, and support materials (worksheets, sensing equipment, online platforms). The publication also provides a series of case studies and personal records of people who have participated in the project to demonstrate some of the challenges and opportunities this way of working can provide.

2.2 Existing Tools in Environmental Monitoring

The literature is helpful for providing the CO ecosystem with a foundation of resources and existing toolkits. However, desk-based research also found many tools that exist in relation to a specific project. These tools are listed below alongside steps found in CO projects. The steps were developed through the existing literature and through reflective feedback from the WeObserve CoP-Engage community. The literature as described in the section above helped to form initial lists of steps, which were then presented and discussed during three consecutive remote CoP-Engage meetings. These discussions helped to develop and refine a collection of steps that encapsulate activities found in diverse CO projects.

In Table 1 below, the steps identified through CoP-Engage are listed in the left-hand column. Desk-based research has been used to identify tools assign a step (or several steps) according to the description of the tool. This list is not exhaustive and in several cases tools discovered in this way led to deadlinks and projects, rather than tools. However, this database can continue to grow, something that will be covered in the final section in this report, Next Steps.

TABLE 1: GENERALISED USER-FOCUSED STEPS FOR SUPPORTING BEST PRACTICE IN COS WITH EXAMPLES

Steps	Tools
Understanding the issue of problem (e.g. environmental, ecological, etc.)	
Forming a team	
Creating a community	
Choosing a question	
Deciding what data to collect	

[4] http://making-sense.eu/toolkit

Steps	Tools
Developing protocols for data collection	
Training for data collection	
Capturing or generating the data	• NoiseTube Application[5] • Wide Noise Application • NoiseSPY Application (Kanjo, 2010) • NoiseWatch 2.0 Application • Ear-phone (Kumar Rana *et al*., 2010) • Laermometer Application (Bilandzic *et al*., 2008)
Managing the data	• Ear-phone (Rana *et al*., 2010) • NoizCrowd (Wisniewski *et al*., 2010) • Laermometer Application (Bilandzic *et al*., 2008) • GeoNetwork[6] • SenseLog[7]
Understanding the data	• NoiseSPY Aoolication (Kanjo, 2010)
Analysing the data	• DISCOPAR (Zaman *et al*., 2018)
Visualising the data	• NoizCrowd platform (Wisniesweki *et al*., 2013) • Sound of the City[8] • Laermometer Application (Bilandzic *et al*., 2008) • DISCOPAR (Zaman *et al*., 2018) • GeoNetwork
Disseminating results	• Ear-phone (Rana *et al*., 2010)
Informs decision making	• SUDPLAN online platform[9]
Change-making / planning action	• SUDPLAN online platform
Measuring impacts	

What can be deduced from this table is that there are many tools in existence which focus on data collection, data management and visualising data. Further to the desk-based research on existing tools, a survey was distributed to the CS and environmental monitoring communities to capture the expertise from the practioners/researchers themselves. This was distributed through ECSA, CSA and listserves such as citizen science on jiscmail. The survey is presented in Annex 2. WeObserve Toolkits Survey Questions.

[5] http://www.noisetube.net/index.html#&panel1-1
[6] https://geonetwork-opensource.org
[7] http://www.senslog.org
[8] http://citysound.itm.uni-luebeck.de
[9] http://sudplan.eu/about-sudplan

Many of the responses came from within the WeObserve consortium, which will be discussed in the following section. Five other respondents gave information about existing tools in CS activities, which were described in detail. The results of these surveys are presented in the tables below. Each table below presents a single tool, containing summarised version of the response, with focus on the description of the tool, the steps that are support by the tool.

TABLE 2: COMMUNITY LEVEL INDICATORS

Name of Tool	Community Level Indicators
Description of Tool	CLIs make the invisible visible. CLIs are objective measurements collected by the community so as to complement the sensor data. These criteria are chosen by the community, and reflect the collective goals of the project.
Steps Supported	• Understanding the issue or problem • Choosing a question • Deciding what data to collect • Developing protocols for data collection • Understanding the data • Disseminating results • Informs decision making • Change-making / planning action • Measuring impacts
Description on how the tool supports the above steps	People sometimes struggle to understand how data is relevant to their day-to-day lives, or how it is connected to the challenges they face. This is especially true when decision about what constitutes an important barometer of change are taken in a non-transparent way and do not relate to the community's concern. CLIs are a good way to connect the dots between sensor data and real life. They also help those involved see the impact of their actions by tracking and measuring real change. This process encourages participants to choose collaboratively what information will be collect, and how. Ideally, this is also a tool that people can continue to use after the campaign ends to see how their actions have made a difference.
Intended user of the tool	• Citizens
References and links	DOI: 10.20933/100001112

TABLE 3: BIRDATA

Name of Tool	Birdata
Description of Tool	BirdLife is Australia's new Birdata web portal. Birdata was formerly the online tool for entering data into the 'Atlas of Australian Birds'. Birdata has been redesigned to expand and take in data from the Atlas project and also from various dedicated monitoring projects such as Powerful Owl Project.
Steps Supported	• Capturing or generating the data • Managing the data • Analyzing the data • Visualizing the data • Informs decision making
Description on how the tool supports the above steps	Individuals or groups enter count data for birds generated through planned or ad hoc surveys from anywhere in Australia. It allows you to see the data that has been progressively collected and submitted. It identifies formal Birdlife Australia projects. Allows for a visual review of data via map of survey points for species, regional groups, season, etc. Data is periodically assessed and reported on by Birdlife Australia which is a highly valued source of trend data and emerging issues in bird conservation
Intended user of the tool	• Citizens • Policy makers • NGOs • Scientists / Researchers
References and links	https://birdata.birdlife.org.au/

TABLE 4: ACRONET PARADIGM

Name of Tool	Acronet Paradigm
Description of Tool	An open hardware station compliant with the Acronet Paradigm project. It is enabled for measuring precipitation, temperature, pressure, wind (speed and direction) and can be autonomously managed by students and teacher.
Steps Supported	• Understanding the issue or problem • Creating a community • Deciding what data to collect • Training for data collection • Managing the data • Understanding the data • Analysing the data • Visualizing the data

Name of Tool	Acronet Paradigm
Description on how the tool supports the above steps	Through a training program delivered in three different steps based on Open Schooling philosophy aiming at collaboration between formal, non-formal and informal science education providers, enterprises and civil to ensure relevant and meaningful engagement of all societal actors with science and increase the uptake of science studies, citizen science initiatives and science-based careers, employability and competitiveness.
Intended user of the tool	• Citizens • NGOs • Scientists / Researchers
References and links	www.acronet.cc

TABLE 5: SENSOR ASSEMBLING TOOLKIT

Name of Tool	Sensor Assembling Toolkit
Description of Tool	A toolkit for assembling noise and dust sensors.
Steps Supported	• Understanding the issue or problem • Forming a team • Deciding what data to collect • Developing protocols for data collection • Training for data collection • Capturing or generating the data • Managing the data • Understanding the data • Analysing the data • Visualizing the data • Change-making / planning action
Description on how the tool supports the above steps	This tool can be used individually or during an assembly workshop.
Intended user of the tool	• Citizens • NGOs • Educators • Scientists / Researchers
References and links	http://www.diysciencelab.com/

TABLE 6: RAINDROP COUNTER BY DISDRONMETRICS

Name of Tool	Raindrop Counter by Disdrometrics
Description of Tool	A DIY toolkit for measuring rainfall intensity.

Name of Tool	Raindrop Counter by Disdrometrics
Steps Supported	• Creating a community • Capturing or generating the data • Understanding the data • Visualising the data
Description on how the tool supports the above steps	Using urban living labs to build a community, and in areas where the lost-cost rainfall sensors are built. The sensors are placed in backyards and then the data are uploaded to the database. Currently in the process of building a website and mobile application so users can view their data.
Intended user of the tool	• Citizens • Scientists / Researchers
References and links	http://www.disdro.com/

TABLE 7: NEAR REAL TIME QUALITY ASSURANCE TOOL

Name of Tool	Near Real Time Quality Assurance Tool
Description of Tool	FotoQuest Go is a project designed to collect an updated comprehensive data on land use and land cover in Europe. Participants are asked to go to specific locations and take photographs using the FotoQuest GO app, also identifying the land use and land cover at the location.
Steps Supported	• Creating a community • Training for data collection • Managing the data • Understanding the data • Analysing the data • Visualising the data • Change-making / planning action • Measuring impacts
Description on how the tool supports the above steps	The near real-time quality assurance tool was built as one branch within Geo-Wiki (geo-wiki.org – a platform for engaging citizens in environmental monitoring). The tool shows the results of the expert, who visited the same point, as well as the results of the FotoQuest Go participant next to each other, which allows us to compare them immediately.
Intended user of the tool	• Scientists / Researchers
References and links	[left blank by respondent]

TABLE 8: NATUSFERA

Name of Tool	Natusfera
Description of Tool	Natusfera is an adaptation of iNaturalist developed by CREAF and Bineo Consulting. One of the world's most popular nature apps, iNaturalist helps to identify local plants and animals. It connects users with a community of over 750,000 scientists and naturalists. By recording and sharing observations, Natustea creates research quality data for scientists working to better understand and protect nature.
Steps Supported	• Forming a team • Creating a community • Choosing a question • Deciding what data to collect • Developing protocols for data collection • Training for data collection • Capturing or generating the data • Visualizing the data
Description on how the tool supports the above steps	The platform allows to create projects and subprojects with different characteristics and purposes and then integrate data collected under these projects. Both the platform and the app are designed to easily collect data and show it on lists or on a map. No more functionalities with data are available, except exporting. People can create and participate in several projects and a community is created around each one. Each project decides what data to collect. Guides and protocols can be created and uploaded for training.
Intended user of the tool	• Citizens • Educators • Scientists / Researchers
References and links	https://natusfera.gbif.es/

TABLE 9: BWK-BCN TOOLKIT

Name of Tool	BWK-BCN Toolkit
Description of Tool	The BWK-BCN Toolkit uses a fictionalised town created as an adaptation to climate change to engage participants in better understanding the relationships between climate change, place and culture, and encourage them to find entry points to make change in their local communities.
Steps Supported	• Understanding the issue or problem • Creating a community • Choosing a question • Informs decision making • Change-making / planning action

Name of Tool	BWK-BCN Toolkit
Description on how the tool supports the above steps	The toolkit consists of a pack of custom cards and a pamphlet that function much like a game. Participants are invited to design all elements of a new town that merges elements of Barcelona and Berwick-upon-Tweed (a market town near the Scottish border) that has been created as an adaptation to climate change. Whereas most citizen science tools are based on data collection, this toolkit provides the opportunity to imagine the world we want to see, and through a holistic approach, discover which questions we need to be asking.
Intended user of the tool	• Citizens • Policy makers • NGOs • Educators • Scientists / Researchers • Industry / Business / Technologist
References and links	http://bwk-bcn.systems/

TABLE 10: CIVICFLOW

Name of Tool	CivicFlow
Description of Tool	A multi-channel platform for the creation and management of questionnaires for collecting data from citizen in a structured way.
Steps Supported	• Capturing or generating the data • Analysing the data
Description on how the tool supports the above steps	[left blank by respondent]
Intended user of the tool	• Citizens • Policy makers • Scientists / Researchers
References and links	http://civicflow.com

WeObserve activity in WP3 will continue to gather tools and processes, these will be compiled, compared and will help information forthcoming deliverables and the WO Toolkit.

3 Infrastructure - Toolkits in Development (WO)

3.1 WeObserve CO – tools in development

The following tables present the tools currently under development from the WeObserve partners. However, tools from GroundTruth2.0 are currently under development and not yet ready to share.

3.1.1 LandSense

TABLE 11: CROPSUPPORT

Name of Tool	CropSupport
Description of Tool	The CropSupport tool is a web and mobile based application. It has been primarily (but not exclusively) designed for farmer community to collect data related to crop type and farm. The CropSupport application offers several added value services to its users – such as NDVI maps, parcel-based weather forecast, and a farm activity diary. The application offers a management service for measuring and monitoring of the users' contributions via the CropSupport web-based Administrator Panel. Besides monitoring of user performance, the administrator panel allows for checking validity and reliability of collected data.
Steps Supported	• Deciding what data to collect • Capturing or generating the data • Understanding the data • Visualizing the data • Informs decision making
Description on how the tool supports the above steps	[left blank by respondent]
Intended user of the tool	• Citizens (specifically Farmers) • Scientists / Researchers
References and links	Web app: https://landsense.inosens.rs/ Mob app: https://play.google.com/store/apps/details?id=rs.inosense.landsense&hl=en

TABLE 12: LANDSENSE CAMPAIGNER

Name of Tool	LandSense Campaigner
Description of Tool	The LandSense Campaigner tool is a web-based application that allows interested practitioners to plan and launch their own citizen science campaign within the LandSense Engagement Platform. They can take advantage of the established LandSense community and services and use the project to promote their campaign to their respective communities.
Steps Supported	• Understanding the issue or problem • Forming a team • Creating a community • Choosing a question • Deciding what data to collect • Developing protocols for data collection • Training for data collection • Capturing or generating the data • Understanding the data • Analysing the data • Visualising the data • Disseminating results
Description on how the tool supports the above steps	[left blank by respondent]
Intended user of the tool	• Citizens • Policy makers • NGOs • Educators • Scientists / Researchers • Industry / Business / Technologist
References and links	Currently in development

TABLE 13: CITY OASES MOBILE APPLICATION

Name of Tool	City Oases mobile application
Description of Tool	Mobile application for urban landscape dynamics monitoring
Steps Supported	• Creating a community • Deciding what data to collect • Training for data collection • Capturing or generating the data • Understanding the data • Visualising the data • Disseminating results • Informs decision making • Change-making / planning action
Description on how the tool supports the above steps	Users of the City Oases mobile application can share their perception of various locations in Vienna (i.e. parks). This information feeds into local authorities (i.e. urban planning department) for improving access to the green and open spaces. Users also have the ability to search for locations to participate in certain activities (i.e. spots to stay cool on hot days, walks in nature). Data is visualized directly on a map in the mobile application.
Intended user of the tool	• Citizens
References and links	Currently in development

TABLE 14: NATURA ALERT MOBILE APPLICATION

Name of Tool	Natura Alert mobile application
Description of Tool	Mobile application for marking locations and classifying various threats to biodiversity across Spain
Steps Supported	• Creating a community • Deciding what data to collect • Developing protocols for data collection • Training for data collection • Capturing or generating the data • Understanding the data • Visualising the data • Informs decision making • Change-making / planning action • Measuring impacts

Name of Tool	Natura Alert mobile application
Description on how the tool supports the above steps	Volunteers and/or contributors can identify and validate potential threats to biodiversity and habitat changes within Important Bird Areas (IBA) and protected areas. They can also submit reports about the state of your IBA every year. Lastly, they can check out the ongoing threats on a map, provided by other community members.
Intended user of the tool	• Citizens • Scientists / Researchers • Other: BirdLife Important Biodiversity Area (IBA) Caretakers and volunteer community
References and links	Beta/Unreleased Version: https://play.google.com/store/apps/details?id=at.ac.iiasa.naturaalert

3.1.2 Scent

TABLE 15: CROWD BACKEND

Name of Tool	Crowd backend
Description of Tool	A digital platform for the collection and qualification of crowdsourced data (including orchestration of the whole data lifecycle).
Steps Supported	• Capturing or generating the data • Managing the data
Description on how the tool supports the above steps	[left blank by respondent]
Intended user of the tool	• Industry / Businesses / Technologist
References and links	https://scent-project.eu/scent-toolbox-details

TABLE 16: SCENT EXPLORE

Name of Tool	Scent Explore
Description of Tool	For Scent Explore, end users are invited to go to specific geographic areas, walk around, take pictures and tag these pictures (or write short texts and fill questionnaires). Like in the case of the basic gaming app, there will two gamification mechanisms (points and badges). Differently than on the crowdsourcing platform, the points can here be obtained in three ways: (1) by taking pictures of specific objects (e.g., cars and vehicles along the river bank, etc.); (2) by going to a very specific location and finding the 'Little Spirits and Animals' (in this case, the camera will automatically take a picture or a video of the area where the Little Animal is and the user has to tag it); (3) by filling questionnaires and/or sending texts.
Steps Supported	• Creating a community • Deciding what data to collect • Capturing or generating the data
Description on how the tool supports the above steps	Through the gamification techniques, Scent Explore engage the citizens. The app generates some AR fictitious characters appearing on the phone screen. The user will simply tap and catch it, automatically taking a picture. The user collects points and badges trough walking a capturing the animals, and he is engaged thanks also to the narrative behind them. Deciding what data to collect, the campaign manager generates the Point of Interest, which users should reach. People select a campaign and automatically the map appears on the screen giving direction towards the POIs. Capturing or generating the data Once the user captures an animal, Explore automatically takes a picture. In addition to the that a user is allowed to send picture and tag them or send video (to measure the water velocity). Explore is integrated to measuring app, to detect the water level measure and also the water velocity trough the videos. Moreover, the metadata generated relates to time stamp and geolocation.
Intended user of the tool	• Citizens
References and links	https://scent-project.eu/

TABLE 17: SCENT MEASURE

Name of Tool	Scent Measure
Description of Tool	Scent Measure is an innovative application developed by ICCS for the Scent project to measure changes in soil conditions. The app uses portable sensors to measure and report the soil moisture and air temperature to the user smartphone or tablet.
Steps Supported	• Capturing or generating the data • Managing the data • Visualising the data
Description on how the tool supports the above steps	Users can simply insert the sensor into the ground and, select whether to measure and report soil moisture levels and/or air temperature and receive the measurements directly to the app.
Intended user of the tool	• Citizens • NGOs • Scientists / Researchers
References and links	https://scent-project.eu/scent-toolbox

TABLE 18: SCENT CAMPAIGN MANAGER

Name of Tool	Scent Campaign Manager
Description of Tool	The Scent Campaign Manager is a web-based application developed by ICCS for the Scent project, which allows public administrators, policy makers and other interested users to create and manage citizen science campaigns for monitoring and streamlining the collection of environmental information.
Steps Supported	• Creating a community • Choosing a question • Deciding what data to collect • Managing the data • Visualising the data • Informs decision making • Change-making / planning action
Description on how the tool supports the above steps	Users are able to design citizen campaigns and define points of interest, where data on LC/LU, soil conditions and river parameters are needed and, thus, mobilize the use of the relevant components of Scent toolbox. Interested users and/or stakeholders may contact ICCS via email at: ScentCampaignManager@lists.scent-project.eu.
Intended user of the tool	• Policy makers

Name of Tool	Scent Campaign Manager
References and links	https://scent-project.eu/scent-toolbox

3.1.3 GROW Observatory

TABLE 19: GROW OBSERVATORY APP

Name of Tool	GROW Observatory App
Description of Tool	The GROW Observatory app is available on Android and IoS, is it a service of the GROW Observatory, a European project on soil moisture sensing and land monitoring. The GROW App provides three services to growers: local growing, planting and harvesting advice for small scale growers, gives practical information on specific growing approaches that will also improve soils and ecosystems, and it allows the submission of site descriptions for the GROW citizen sensing activity. Information for users on suitable crops is derived from GROW's Edible Plant Database and is interrogated based on the phone's GPS to show crops that are suitable to plant for the location and time of query. Each crop has detailed information on site requirements and cultivation. The practice-based information highlights the value of specific regenerative practices as well as guidance on how to implement them. The site information data gives step-by-step guidance for a consistent land-survey for the placement of each sensor including categorization of side position, slope, canopy cover and aspect-oriented site photos to enable a consistent comparison of sites.
Steps Supported	• Understanding the issue or problem • Training for data collection • Capturing or generating the data • Understanding the data • Informs decision making • Change-making / planning action
Description on how the tool supports the above steps	Citizens can gain access to a location specific Edible Plant Database for information about plants to grow "right now". They can also get detailed, science based information on regenerative growing practices. This includes practices that help improve your soil and support the wider ecosystem. Participants in the GROW Changing Climate Mission, in 9 geographic GROW Places, can also use the app to record and share data about landscape features, soil properties and land management activities such as irrigating, fertilizing, mulching, and others.
Intended user of the tool	• Citizens • Educators • Other: Community Champions

Name of Tool	GROW Observatory App
References and links	https://play.google.com/store/apps/details?id=at.ac.iiasa.grow&hl=en_US

TABLE 20: GROW MOOC1

Name of Tool	GROW MOOC1 – Citizen Research: From Soil to Sky
Description of Tool	Free Massive Open Online Course (MOOC) on FutureLearn platform that trains thousands of people who are wish to learn independently yet in a social peer to peer environment. The course covering topics and protocols relevant to the GROW CO including: • Citizen Science and Fieldwork Soils • Growing Sites and Plant Health Climate • Temperature and Moisture • Landscape representivity and Cover Soil Components • Global Challenges for Soil Regenerative Techniques Landscape Ecosystems • The GROW Observatory
Steps Supported	• Understanding the issue or problem • Creating a community • Developing protocols for data collection • Training for data collection • Capturing or generating the data • Measuring impacts
Description on how the tool supports the above steps	By offering training, including data submission steps, testing protocols and getting feedback from learners, and by learners interacting with each other (creating a community – online and in some occasions, locally as some learners realise they are based in the same geographical area).
Intended user of the tool	• Citizens • NGOs
References and links	https://www.futurelearn.com/courses/grow-from-soil-to-sky

TABLE 21: GROW MOOC2

Name of Tool	GROW MOOC2 – Citizen Research: Sensing the world
Description of Tool	Free online open course on FutureLearn covering topics and protocols GROW is working on including: • Earth Observation • Citizen science • Climate monitoring • Climate and moisture • Satellites • Soil sensors • Remote sensing • The GROW Observatory
Steps Supported	• Understanding the issue or problem • Creating a community • Change-making / planning action
Description on how the tool supports the above steps	Introducing learners to citizen science and sensing while creating communities of learning.
Intended user of the tool	• Citizens • Scientists / Researchers
References and links	https://www.futurelearn.com/courses/grow-earth-sensor

TABLE 22: GROW MOOC3

Name of Tool	GROW MOOC3 – Citizen Research: Living soils, Growing food
Description of Tool	Free online open course on FutureLearn covering topics and protocols GROW is working on including: Challenges facing food and farming systems Citizen Science and Fieldwork The GROW Observatory Regenerative practices for food growers - exploring the effectiveness of approaches like mulching, no dig, cover crops, creating wildlife friendly areas and more Designing a robust research experiment to investigate the effectiveness of regenerative practices Finding a three-sisters crop combination (polycultures) to improve the productivity of your plot and the health of your soil

Name of Tool	GROW MOOC3 – Citizen Research: Living soils, Growing food
Steps Supported	• Understanding the issue or problem • Creating a community • Choosing a question • Deciding what data to collect • Developing protocols for data collection • Training for data collection • Capturing or generating the data • Change-making / planning action
Description on how the tool supports the above steps	By offering training on how growers can design their own experiments; the course includes data submission steps, testing protocols and getting feedback from learners; learners interact with each other (creating a community - online and in some occasions, locally as some learners find out they are based in the same geographical area).
Intended user of the tool	• Citizens • NGOs • Educators
References and links	https://www.futurelearn.com/courses/grow-soil-to-food

TABLE 23: GROW MOOC4

Name of Tool	GROW MOOC4 – Citizen Research: From data to action
Description of Tool	Free online open course on FutureLearn covering topics and protocols GROW is working on including: Overview of different sources of citizen science generated datasets in the GROW Observatory including soil sensor data. Analysis of results submitted by GROW participants over the growing season to investigate the effectiveness of a polyculture vs monoculture experiment. Identifying trends and patterns in datasets as well as reflecting on the different insights you can gain from individual and collective experiment results. The role and potential of art in communicating complex scientific concepts and data. Creating positive change through citizen science: from the local to the global.

Name of Tool	GROW MOOC4 – Citizen Research: From data to action
Steps Supported	• Understanding the issue or problem • Creating a community • Training for data collection • Managing the data • Understanding the data • Analysing the data • Visualising the data • Disseminating results • Informs decision making • Change-making / planning action • Measuring impacts
Description on how the tool supports the above steps	By offering training on how growers can design their own experiments; the course includes hands on steps for users to interact with citizen-generated data as well as on Community Level Indicators to measure change; learners interact with each other (creating a community - online and in some occasions, locally as some learners find out they are based in the same geographical area).
Intended user of the tool	• Citizens • NGOs • Educators
References and links	https://www.futurelearn.com/courses/grow-from-soil-to-data/1

TABLE 24: GROW HUB

Name of Tool	GROW Hub
Description of Tool	A forum for GROW participants and GROW team to communicate, ask questions and share resources
Steps Supported	• Creating a community • Disseminating results
Description on how the tool supports the above steps	Facilitating conversations with citizen scientists and other people interested and/or involved in GROW activities.
Intended user of the tool	• Citizens
References and links	https://hub.growobservatory.org/discussions

TABLE 25: BY THE CODE OF SOIL

Name Tool	By the code of soil
Description of Tool	Artwork

Name Tool	By the code of soil
Steps Supported	• Understanding the issue or problem • Visualising the data • Disseminating results
Description on how the tool supports the above steps	By The Code Of Soil is an online networked digital artwork, created by Kasia Molga and Scanner which invites you to experience soil through a uniquely data-driven generated audio-visual representation on your laptop or desktop computer. Simply download the By the Code of Soil web application to connect. The soil will manifest itself to you when it is ready.
Intended user of the tool	• Citizens • NGOs • Educators
References and links	https://hub.growobservatory.org/discussions

TABLE 26: KNOWLEDGE HUB PROTOCOL AND MATERIALS

Name of Tool	Knowledge Hub Protocol and Materials
Description of Tool	An online repository of protocols and materials including: Sensing Manual: PDF Manual introducing participants in GROW Places to a citizen science mission with detailed instructions on how to carry out a Land & Soil survey and install and connect a soil sensor. PDF Field Handbook for GROW Places with summarised instructions to carry out a Land & Soil survey + install and connect a soil sensor. Land & Soil survey multimedia materials, including videos on how to carry out a Land & Soil survey + install and connect a soil sensor. Protocols for a setting up a polyculture vs monoculture growing experiment - Protocol for testing Acidity and Alkalinity of Soil (while making lemonade!) Protocol for making an Earthworm Hotel
Steps Supported	• Understanding the issue or problem • Training for data collection • Capturing or generating the data • Understanding the data
Description on how the tool supports the above steps	Training participants on how soil sensors work Training participants to carry out a Land & Soil survey to better understand and monitor scientific parameters in their growing site.
Intended user of the tool	• Citizens • Other: Food growers / farmers / gardeners
References and links	https://knowledge.growobservatory.org/

TABLE 27: GROW VIDEOS

Name of Tool	GROW videos
Description of Tool	GROW Youtube channel with a variety of videos including: - Instructional videos on various topics such as how to carry out a Land & Soil Survey, install and connect a soil sensor, and assessing soil texture by hand. - Trailers to GROW MOOCs - Recordings of GROW Webinars - Introduction to GROW videos The Land and Soil Survey + soil sensor videos are available with subtitles in Greek, Hungarian and soon, in German as well.
Steps Supported	• Understanding the issue or problem • Training for data collection • Visualising the data
Description on how the tool supports the above steps	By providing training to participants and raising awareness of the topics covered by the GROW Observatory
Intended user of the tool	• Citizens • NGOs • Educators
References and links	https://www.youtube.com/channel/UCNBezWJ_KQx0l-Kjb63_G3A

4 Next Steps

To further the work in this area the Dundee team will continue with desk-based research and further build the database of existing tools to provide a comprehensive review to WeObserve project end. The approach will replicate the existing online search methodology using key terms in the definition of steps. Within in this work there is scope to synchronize work on to the D2.4 Landscape of the COs in Europe report.

Another way to generate further knowledge in this area is by gathering information into an online repository. Possible further research conducted through having the toolkits survey on the WeObserve knowledge platform for further accumulation on existing tools. In addition, this could promote tools and projects through the WeObserve knowledge platform.

Lastly, the aim is to developing a set of WeObserve toolkits through existing tried and tested tools. This can enable citizens and stakeholders who wish to take up CO's to select the most appropriate tools for their purpose, we envisage a flexible approach to WeObserve toolkits. As potential CO teams have differing skills and capabilities, technology requirements, numbers of participants and other variables it is often difficult to recommend a fixed approach, yet teams

are often not equipped to select tools and approaches with relatively scant information. The WeObserve Toolkit will therefore present a navigable and useable decision-support process for differing stakeholder groups. The next step is to devise a strategic design pathway to curate bespoke recommendations for suites of tools. This will be done through further analysis of the existing tools and toolkits of the field and further collaborative work between the WeObserve partners and communities, such as CoP-Engage.

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Annex 1: Making Sense D5.3 Report on toolkit resources, methods for actionability and evaluation of finding from data

Report on toolkit resources, methods for actionability and evaluation of findings from data. This document will provide early results of the development, design process, application, uptake and sustainable use of the toolkit resources, specifically for campaign generation and delivery.

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Introduction

Making Sense is a two year European Commission funded project, based around utilising open source hardware, software, maker practices and open design towards local environmental issues such as air and noise pollution. It ran nine pilots in three European cities, co-creating campaigns with citizens to work on issues important to them. Making Sense is geared towards collective awareness in communities encouraging movement towards collective action. A key part of Making Sense was to develop and achieve impact through a toolkit to enable citizen-led approaches that can be used to create awareness and change in communities.

The four principles of Making Sense are co-creation, openness, empowerment and change-making. These principles are fundamental to the toolkit and the tools have been designed with these principles in mind. More details regarding these values are shown in Table 1 below.

The Making Sense consortium is multidisciplinary, including IAAC in Barcelona (Architecture and city planning), University of Dundee, UK (Duncan of Jordanstone College of Art and Design/DJCAD & Centre of Environmental Change and Human Resilience/CECHR), Waag Society in Amsterdam (Institute for Arts, Science and Social Innovation), JRC in Brussels (Foresight and Behavioural Insights Unit), the Peer Educators Network (Kosovo) and the European Fab Lab Network. Two key members of the European Fab Lab network were Fab Lab Barcelona (part of IAAC) and Fab Lab Amsterdam (part of Waag Society). Fab Labs are spaces that provide access to various maker tools and materials allowing for personal digital fabrication. Next to these, we have a large network of supporting partners, from academia to governments and arts organisations, including health, pollution and technology experts.

This document will present all the tools used within the Making Sense pilots, however not every tool used in the project will be covered in depth here. There are tools which have already been described in great detail in prior outputs and deliverables, this will be signposted in relevant places in the text. In addition, a Making Sense toolkit publication that covers several tools has been attached as Appendix 1 to this document. This document will be structured as follows:

Section 1: Background and review of other toolkits, highlighting gaps and where Making Sense attempts to fill these gaps. A summary of the Making Sense Framework.

Section 2: Includes a subsection for each pilot city describing tools across the phases of the Framework.

Section 3: Details on the sustainability and uptake of any tools so far.

Section 4: Development of Citizen Sensing: A Toolkit.

Appendix 1: Citizen Sensing: A Toolkit

1. Background

Making Sense is situated in the field of citizen sensing. This field democratises the use of open technology for collective awareness and action. It typically focuses on monitoring aspects of the environment that are of interest to citizens, to facilitate collective awareness and action in social and environmental issues. Citizen sensing merges elements from participatory sensing, with which it is closely aligned, and citizen science. Since both citizen sensing and participatory sensing are relatively new fields, there are few existing toolkits to review and make comparisons with. Therefore, this section will focus mainly on citizen science toolkits, of which there are several.

Citizen science is an expanding field, with five current definitions of degrees of participation. These are: contractual, contributional, collaborative, co-created and collegial (Shirk et al, 2012). Contractual and contributional are more traditional top-down, expert-led citizen science. The main difference between the two is that in the former, citizens ask scientists to collect data, whereas in the latter, citizens are asked by scientists. In both, the questions and experimental design are created by experts with citizens only collecting data and the data is used for scientific knowledge. A step closer to a bottom-up design is collaborative citizen science where the project is still designed by experts but citizens may be involved in data analysis or dissemination as well as collection. In co-created citizen science, experts and citizens work together across most, if not all the stages of the project. In collegial projects, citizens independently conduct their own research. In both co-created and collegial citizen science, the citizens create and use the data or outcomes. Making Sense has aimed for co-created citizen science at a minimum level of participation and collegial levels where possible.

There are many benefits to co-created citizen science, including utilising the role of local knowledge in research, greater engagement of citizens and being able to use any findings to create real change. One example of this is a co-created study concerning gardening in a polluted area next to an old mine (Ramirez-Andreotta, 2015). Citizens together with experts worked to create questions, collect samples and understand the data. The community understood the outcomes of the study and stated they would modify their gardening practices to reduce arsenic in their vegetables.

Toolkits

There are several toolkits from various sources available online or in print, to help people create and design their own citizen science projects. These toolkits tend to be designed to form a set of resources to assist in the various steps a citizen science project must take. One example is from The Cornell Lab of Ornithology[10], this lab is based around bird ecology and as a result, although the toolkit is stated to be aimed at an interdisciplinary field, the resources tend to be pulled from ecology and conservation. This toolkit is available online and it is broken down into several steps: choose a question, form a team, refine protocols, recruit participants, train participants, accept data, analyse data, disseminate results and measure effects. Each step consists of a 'reality check' where expectations of this step are managed and challenges are outlined. The steps also include a how-to guide, resources, tools, questions and cases. Not all categories within each step have content and many of the resources lead to broken links. The tools are also all external links, again many of which are broken or lead to homepages.

[10] http://www.birds.cornell.edu/citscitoolkit/toolkit/manual

Although there is a section for data analysis, there are no resources or tools to promote data literacy other than general high level tips on data and analysis.

Another example is the Federal Crowdsourcing and Citizen Science Toolkit[11], this is hosted by the US government and is aimed at helping federal employees use crowdsourcing and citizen science in their work. This toolkit is set up in a similar way to the Cornell toolkit, with a step by step guide, a case study overview and a resource library. Their steps are: scope out your problem, design a project, build a community, manage your data and sustain and improve. Each step has a detailed how-to guide within it, for example, their scoping step consists of the following: know your tools, engage your stakeholders and participants, know where your project fits and get approval from your supervisors. Each step includes links to external resources. These resources are diverse, including journal articles, reports, videos, homepages of websites and a few practical immediately usable tools. As with the Cornell toolkit, several links are broken. These external resources are more clearly organised within the resource library by type. Actual usable tools are more easily found in this section under Toolkits and Guides. This toolkit is more focused on data management than sensemaking and data literacy.

A different example is the California Academy of Sciences citizen science toolkit[12]. This toolkit is presented in a different way compared to the two above, as a downloadable pdf. The audience for this toolkit is educators and as such it is focused on teaching the value of citizen science in the classroom as opposed to creating citizen science projects outside of education. It includes worksheets, ready to be printed out and used in the classroom by educators as well as external links for further information and tools. Within this toolkit there is a focus on helping pupils to understand the data they are collecting. This includes tools such as scientist's notebooks where pupils can keep track of their data as well as annotate it with any observations, and a tool for constructing a scientific explanation using evidence from data gathered.

A toolkit based around social innovation within the design domain, rather than citizen science, is the Development Impact & You (DIY) toolkit[13]. It was designed for development practitioners to help them invent, adapt or adopt ideas from the toolkit to assist them in their work. This toolkit is available as a printed book as well as a digital pdf download. It is organised into sections: look ahead, develop a clear plan, clarify my priorities, collect input from others, know the people I'm working with, generate new ideas, test & improve, and sustain & implement. Each section has a set of tools within it, these tools include descriptions of what they are and how to use them, as well as a blank printable example of each tool. Some tools have accompanying case studies or exemplars where they have been filled in. The toolkit as a whole is designed to be as practical as possible. Due to the design of the toolkit, there is no real focus on collecting or understanding data.

A more specific citizen sensing example is that of the Air Sensor Toolbox for Citizen Scientists, Researchers and Developers[14], the audience for this toolbox is citizen scientists and

[11] https://crowdsourcing-toolkit.sites.usa.gov/

[12] https://www.calacademy.org/educators/citizen-science-toolkit

[13] http://diytoolkit.org/

[14] https://www.epa.gov/air-sensor-toolbox

the public who are interested in air quality monitoring. This toolbox is separated into the following sections: how to use air sensors, what do my sensor readings mean, what is the Environment Protection Agency (EPA) doing, and resources and funding. Each section contains highly detailed information about various considerations of using sensors such as what to look for in a sensor and how to collect useful data from air sensors. Within the resources section there are various tools linked including a full guidebook, how-to videos, technical reports and standard operating procedures for various low-cost sensors that are currently on the market. However, there is little focus on how to help citizens understand the data that sensors collect, the section on understanding only links to other air quality projects and one sensor scale that shows very basic information.

The toolkits summarised above tend to link to external sources for their tools which makes them vulnerable to moved or broken links. There is a large gap in the tools available for data sensemaking and data literacy. There are also a lot of links to technical reports or academic papers which are not useful for non-experts. In the air sensing example, there is a focus on how to use sensing hardware, but not necessarily how to build your own sensors. There is also a lack of practical, usable tools, other than in the social innovation toolkit which focuses on this exclusively.

Making Sense Toolkit

The Making Sense toolkit is designed to fill the gaps outlined above, it includes many different types of tools and approaches that can be applied in many domains of citizen science. In particular, the Making Sense toolkit includes several tools for understanding and interpreting data. The audience for the making Sense toolkit is first and foremost community activists who are motivated to take action on an issue. It is also designed to help professionals in organisations that support community activists as well as researchers, government officials and other public policy actors. The tools in this project are presented across the different phases of a citizen science project similar to some of the toolkits above. The Making Sense Framework phases are: scoping, community building, planning, sensing, awareness, action, reflection and legacy (see Table 1). By placing tools within these phases, this will help citizens to find appropriate tools.

Making Sense Framework		
Stage	What happens at this stage?	Cross-cutting Principles
Scoping	Scoping is the first step and the stage when the important issues are discovered, mapped, and discussed by the key participants. Information is gathered by internet searches, collecting articles, news reports and academic literature or by conducting surveys and interviews. This is the stage when existing communities are found and new ones start to form. There is no time limit on scoping; it can take only a few weeks or can be something that is in the works for years.	

	Key Participants: community organisers, project team, community members and the public.
Community Building	Community building brings together everyone around an issue. The aim is for all participants to come to a shared understanding of the issue and decide on the goals of the campaign. It is when the skills of the participants are identified and new skills are developed, and it is also when others are brought on board if there are any skills or expertise missing. Participants collectively agree on the organisation of the project and how to document activities.
	Key Participants: community organisers, project teams and community members.
Planning	Planning entails participants collectively deciding on the goals for the project, sensing strategies and protocols for collecting data. This includes a plan for collecting other types of indicators. It is when the sensing tools are created or developed from existing resources. Sensors are tested and calibrated. Participants learn about sensors and are introduced to approaches for understanding data.
	Key Participants: community organisers, project teams and community members.
Sensing	Sensing is the phase in which everyone collects data on the issue, i.e. environmental pollution. The data can be uploaded to a publically accessible online platform. Participants can also record observations about their lives and how they are affected by the issue. Note taking and collecting indicators is important as this information can support the findings of the sensor data and be used to show the impacts of the issue to other people and government officials.
	Key Participants: community organisers, project teams and community members.
Awareness	Using the information gathered during the sensing phase, the data is analysed and discussed amongst the community. The analysis stage can include optional activities of data visualisation; professional science or academic support. The aim is to build a collective awareness from the data. This includes an assessment of the personal observations and the other indicators collected as part of the project. Bringing together all this information is important for identifying potential areas for action and change.
	Key Participants: community organisers, project teams, community members, data visualizers and external experts.
Action	Once there is a collective awareness on the issue at hand, participants work together to propose possible courses of action. The aim is to devise, organise and deliver a single or series of actions as a group that may generate a wider recognition of the issue. Actions can

Co-Creation

The practice of collaborative development and a way to describe an approach in a project using methods and tools for people to work together on a level playing field. Co-creation is a process of jointly using a wide range of resources and ideas for creating new actions and objects.

Empowerment

The feeling of control or responsibility towards yourself and your environment. This can be encouraged with a combination of collaborative approaches and openness in technologies and data that address individual and community issues. This can lead to improved quality of life and greater power for change-making relative to corporations and governments.

Openness

This is about the transparency of the organisation of the campaign, as well as the data and the actions. This extends to strategic priorities of:

- Open Design
- Open Science
- Open Tech and Data
- Open to the World

Change-making

We aim at change making beyond creating awareness of developing purely technological solutions. This involves change in individuals, communities, institutions, and/or cultures, and in thinking, attitudes, values and consciousness. We embrace change led by the community.

	range from behavioral change of an individual, to public facing activities (e.g. a protest) aimed a creating further awareness or even policy change. The aim is to have impact and make change for the better.	
	Key Participants: community organisers, project teams, community members, media outlets and government officials.	
Reflection	Participants reflect on the process to date and consider what worked and what did not. This can include looking at the data and seeing if there was change as a result of the action. This might require the participants to repeat or go back to previous phases, such as sensing.	
	Key Participants: community organisers, project teams and community members.	
Legacy	Legacy is created by looking towards the future of the project and making a plan for lasting impact. It should also include planning for sharing information and news to make sure there is sustainability and reuse of the project tools and the uptake for others. For those community organisations, it is a phase of writing reports and publications and for sharing the project assets that might be useful for other initiatives.	
	Key Participants: community organisers, project teams, community members, academics, and external experts.	

Table 1: The Making Sense Framework

The Making Sense toolkit covers soft tools such as mapping communities and issues, assisting with data awareness, and creating sensing strategies. It also covers tools that assist in building and adapting sensors, such as open source information on the Smart Citizen Kit[15], which has been developed and delivered by associated Fab Labs. The tools have all been used in one or more of the Making Sense pilot campaigns. One of the main goals of the toolkit is to be a sustainable, open resource that can be modified and used by a wide range of communities.

2. Making Sense Tools

This section will cover the tools used across the Making Sense project, split into subsections for each pilot city. There is one table of tools for each pilot city. All tools used in each pilot city are shown in the tables by the phase of the Framework that the tool was used in. Some of the tools are described in deliverables and in Appendix 1 and this will be signposted in the text. Each tool not described elsewhere will be discussed in the sections below.

Amsterdam

The table below (Table 2) shows the tools that were used in the Amsterdam Making Sense campaigns by the Framework phase they were used in. Each pilot campaign has one column.

[15] https://smartcitizen.me/

For more information on the application of the tools within the pilots, please see D3.1 Documentation on Activities in Amsterdam.

All of the tools that are not starred in Table 2 are described in detail in Appendix 1 (p16-95), starred tools are described below.

Framework Phase	**Tools used in pilots**		
	Amsterdam Urban Air Quality	**Amsterdam Smart Kids Lab (SKL)**	**Amsterdam Gamma Sense**
Scoping	Geographical mapping		Geographical mapping
Community building	DIY kit (air/water/noise)*		
Planning	Sensing strategy Sensor calibration	Prototype instructables* Installation* (scream-o-metre, prototype instructables)	A4 sheet alternative measuring tools* Sensing strategy
Sensing	Open hardware Questionnaire Sensing guides/notes	SKL instructables* Open hardware Digital presence	Open hardware (black tape) Gamma Sense beta app* Questionnaire Digital presence
Awareness			Awareness sheet Future newspaper
Action			Media strategy*
Reflection	Questionnaire	Questionnaire Pilot appraisal	Pilot appraisal (Proposal for Gamma Sense 2.0)
Legacy			

Table 2: A list of tools used across the Amsterdam pilots, shown by Framework phase, starred tools are discussed below

Urban Air Quality

This pilot aimed to empower citizens who live in streets with poor air quality in Amsterdam, with knowledge and experience in understanding air quality. It aimed to enable citizens to come up with questions about air quality around their homes, to have those questions answered and to be able to change their behaviour or routines depending on the air quality around their homes.

As part of three Smart Citizen crash courses, led by Waag Society, the citizens made their own air, noise and water sensors (Figure 1). These DIY kits contained low-cost sensor materials and DIY instructions on how to build a sensor.

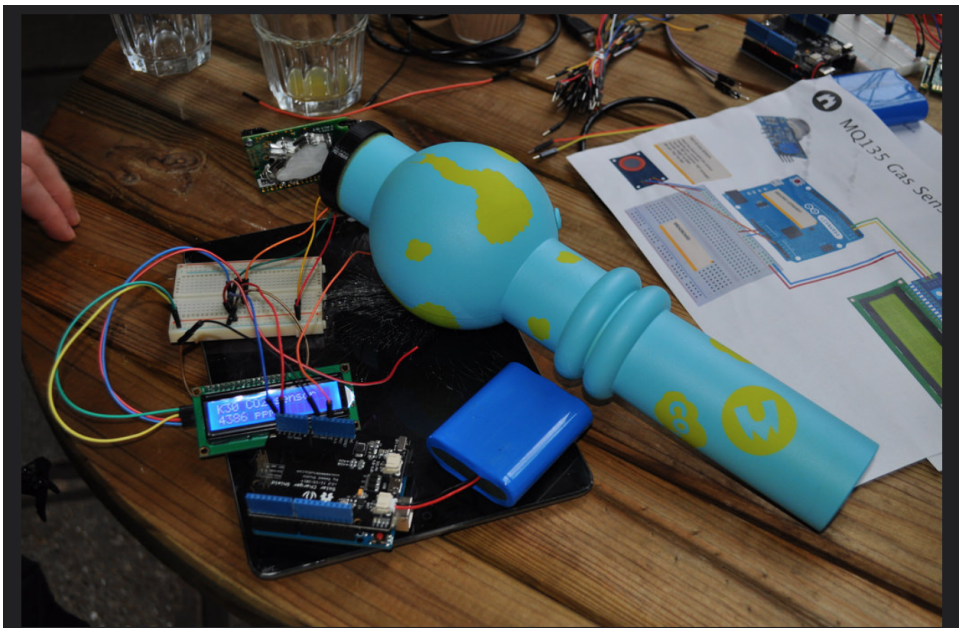


Figure 1: A DIY air quality sensor

Smart Kids Lab

The Smart Kids Lab was first conceived as an installation at the Dutch Cinekid Festival 2016. Waag society created an interactive installation where children could measure different aspects of their environment with easy to make sensors. The idea was to create environmental awareness with children and make 'making a sensor' fun. Initially, the instructable sensors were designed to be made at home by children on their own. After the Cinekids installation, the plan changed to focus on schools with a structured environment and a teacher to help. Waag decided to test the school method more thoroughly and the activities were adapted to be better suited to the classroom with the cooperation of teachers and schools. Three schools were chosen to test the Smart Kids Lab instructables in Amsterdam to cover different geographical and socio-demographic contexts.

The Smart Kids Lab instructables were initially designed, sketched and prototyped by an interdisciplinary team. The instructables were low-tech sensors that covered a range of sensing, including air, water, noise, soil and light. These were illustrated and laid out to be usable in both online downloadable and printed formats.

These prototype instructables were taken to the Cinekid Festival as part of Waag Society's installation at the festival. Kids, parents and teachers were able to use the low-tech sensing instructables. A large 'scream-o-metre' was also built and taken to the festival, this metre allowed children to scream into it and captured their noise levels. It also kept track of high scores (Figure 2).


Figure 2: Smart kids lab instructables (left) and scream-o-metre (right) at Cinekids Festival

The prototype instructables were iterated on and sent to three schools in Amsterdam to be tested. The Smart Kids Lab activities including descriptions of materials are all listed on http://smartkidslab.nl/. A full list of the Smart Kids activities follows:

1. An acidity metre that measures the acidity of liquids by using blended red cabbage (Figure 3). The red cabbage is mixed with various liquids and the difference in colours shows the acidity of the liquid.
2. A simple particulate matter metre where Vaseline is smeared on a piece of cardboard. The cardboard is then hung up with double sided sticky tape and placed where the pupils want to measure the particulate matter in the air.
3. A microbe metre which measures the acidity of soil. This instructable is more complex than the previous two and requires soldering. Soil is placed in containers, wires are connected to a voltage metre and the voltage shows the acidity of the soil. This activity requires an adult to assist the pupils with soldering.
4. A sound metre that measures decibels using a smartphone app. This sensor involves downloading a free decibel app, taking measurements of sounds and comparing the difference in sounds in different places and at different times. It also asks the pupils to report when they find sounds irritating.
5. Described as a fart metre that pupils can use to measure farts. This sensor actually measures methane gas using a MQ4 sensor module. Similar to the microbe metre, this activity requires wire stripping and soldering.
6. This sensor measures UV radiation from the sun. This instructable also requires an adult due to the chemicals that are used in the creation of the sensor. The chemicals are mixed with water and sprayed on paper. The paper is then placed for 2 minutes where UV radiation is to be measured. After rinsing the paper, the shades of blue left on the paper show the levels of UV radiation measured.
7. This instructable measures the brightness and clearness of water. It requires an LP, paint, tape and rope. It involves covering two quarters of the record with tape and paint, then a rope is pulled through the record with a button attached every 10cm on the rope. Lowering the record into the water until you cannot distinguish between the light and dark quarters shows the depth of the clarity of the water.

8. This instructable involves attaching a camera to a kite to take photos to measure how much green space, e.g. trees, parks, there is in the local area.
9. The final instructable is a mineral metre, this measures how many minerals there are in water by letting it flow through a battery, the higher the reading, the more minerals in the water.

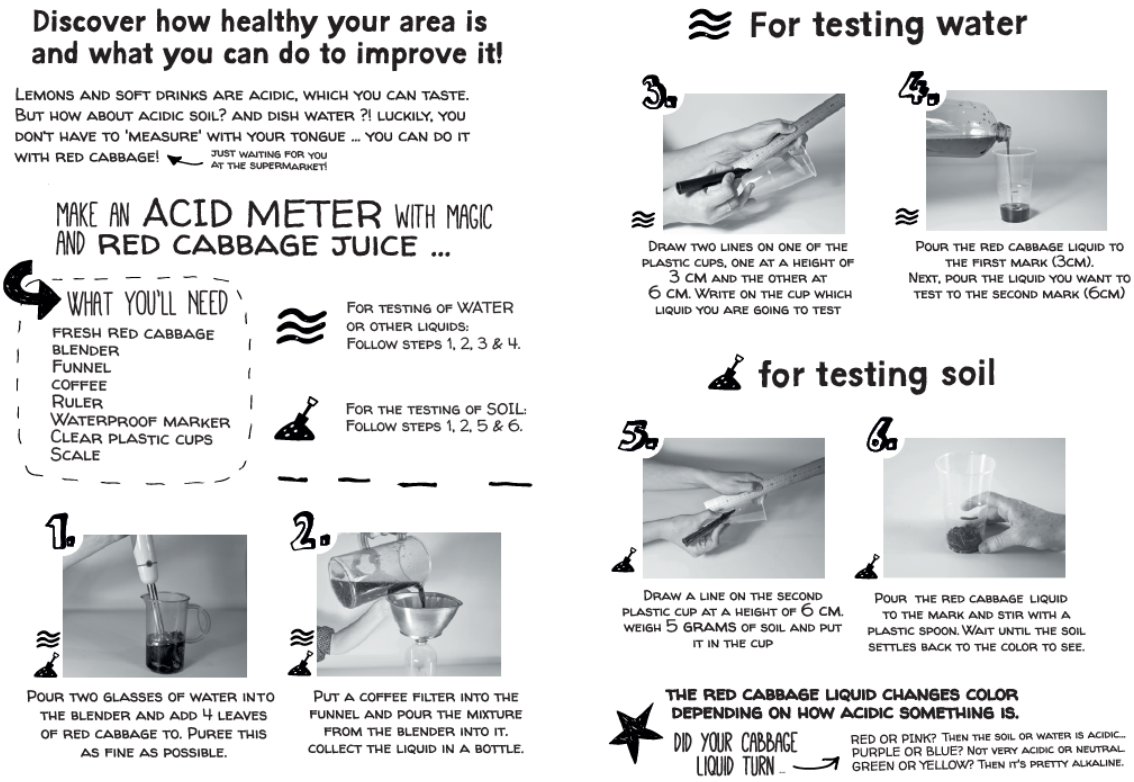


Figure 3: The how-to section of the Smart Kids Lab acid metre

Gamma Sense

The Dutch Environmental Protection Authority (RIVM) currently has around 150 official measuring stations for gamma radiation in the Netherlands, where every 10 minutes accurate and reliable values are determined and uploaded. According to RIVM's own reports, this number is actually quite low should a disaster result in a radioactive cloud over the Netherlands and the government wants to learn where and how radioactivity is spreading in order to advise the public. This pilot aimed to empower citizens in this area by showing them how they can turn their smartphones, laptops and tablets into gamma radiation measuring units by simply covering the camera of the device with a piece of black tape. To be able to do so, an internet application was built that converts stills from the video-stream to values (specifically: Counts per Minutes) that are commonly used in the field of gamma-radiation monitoring.

As part of one of the workshops based around developing the Gamma Sense mobile app, citizens were given A4 sheets of other radiation measurement tools and asked to imagine how their community would use these alternative tools (Figure 4).

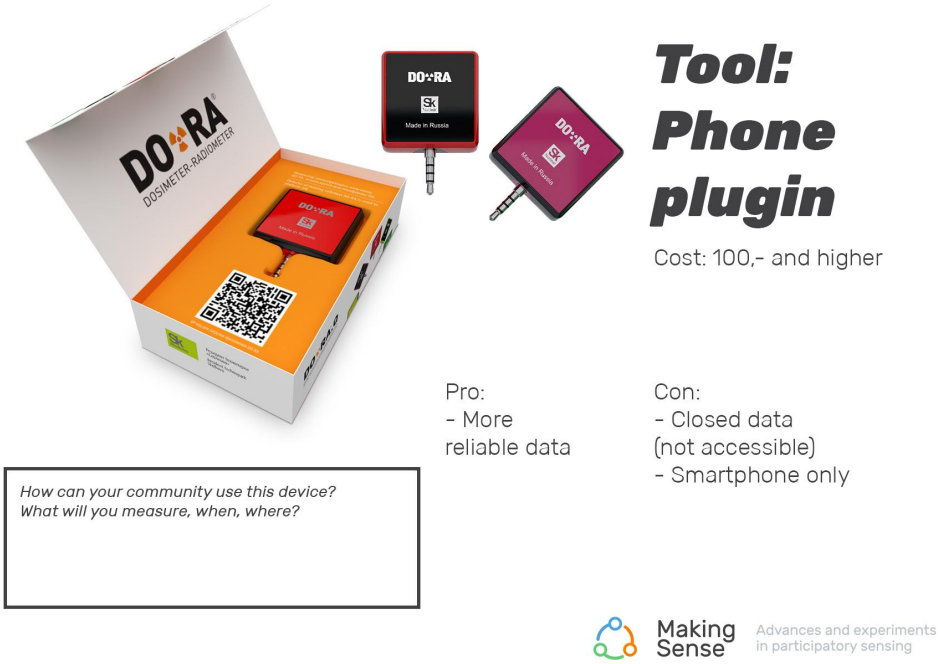


Figure 4: Alternative measurement tool sheet for gamma radiation

The Gamma Sense beta app is currently located at: https://gammasense.org/ The website consists of instructions of how to cover your device's camera with black tape and then measures and captures radiation data.

As part of the media strategy, an interview on a local news station was given about the project at a national protest against nuclear power. One of the project organisers discussed the opportunities for environmental sensing by citizens and gammasense.org.

Barcelona

The table below (Table 3) shows the tools that were used in the Barcelona Making Sense campaigns by the Framework phase they were used in. Each pilot campaign has one column. For more information on the application of the tools within the pilots, please see D3.2 Documentation on Activities in Barcelona.

All of the tools that are not starred in Table 3 are described in detail in Appendix 1 (p16-95), apart from sensor onboarding. The Barcelona pilots used the Smart Citizen Kit for their sensors and the Smart Citizen Kit along with its sensor onboarding method is described in detail in the document D2.4 Documentation on Toolkit Add-ons. Community Level Indicators as a tool and method also has two dedicated deliverables focused on it, these are: D5.4 Community Level Indicators and D5.5 Report and Assessment of Impact and Policy Outcomes using Community Level Indicators. Starred tools are described below.

Framework	Tools used in pilots

Phase	Barcelona Community Champions	Barcelona Fab Kids	Barcelona Gracia Sounds
Scoping	Mapping commons Collaborative pilot schedule Geographical mapping		Mapping commons Geographical mapping
Community building	Empathy timeline Onboarding kit Community level indicators	Bird books*	Empathy timeline
Planning	Heuristics sheet* Sensing strategy Sensor calibration Sensor onboarding		Community level indicators v2 Sensing strategy v2 Sensor onboarding
Sensing	Open hardware Sensing guides/notes Sensor manuals	Smart Kids Lab (acid, air quality)* Open hardware	Open hardware Data journals Sensing guides/notes
Awareness	Data discussion sheets Data postcards* Data dashboards	Scavenger hunt map*	Data acetates*
Action	Future newspaper Fabrication tools* (Noisebox)	Fabrication tools* (bird feeder)	Action design comic* Digital presence Fabrication tools* (installation) Co-creation assembly ● Future postcards ● Placa installation
Reflection	Questionnaire Pilot appraisal Graduation ceremony		
Legacy	Storylines		

Table 3: A list of tools used across the Barcelona pilots, shown by Framework phase, starred tools are discussed below

Barcelona Community Champions

This pilot in Barcelona had a focus on noise pollution as the environmental issue. The main goal for the pilot was to train a set of 'community champions' in fabrication of technology, data literacy and the methods to develop future communities through co-creation and collaboration workshops. By instilling this level of skill and knowledge in the community

champions it was intended that they would pass on this knowledge to other citizens who may not be as technologically minded.

Within the Planning phase, heuristics sheets aimed to evaluate the usability of the sensors and onboarding process (Figure 5). Post-its were used to document additions or aspects to improve to make the installation process of the sensors better.

Figure 5: A blank example of the heuristics sheet

Data postcards were used in the Awareness phase (Figure 6) using the Dear Data method (Lupi & Posavec, 2016).

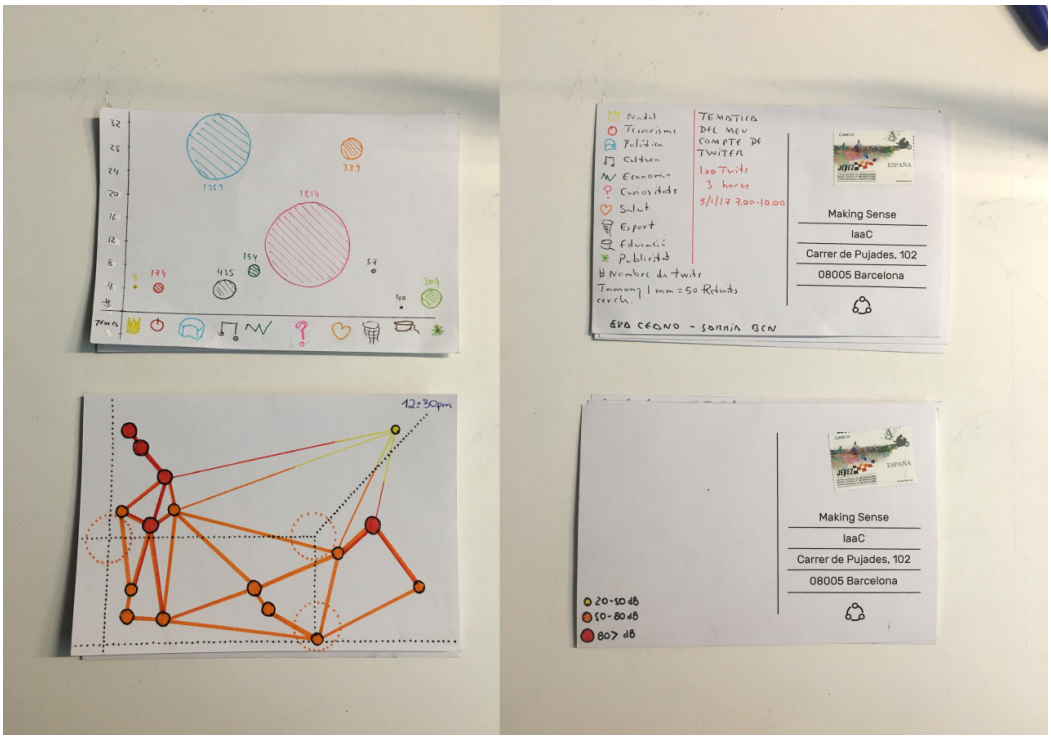


Figure 6: Filled in examples of data postcards using the Dear Data method

Fabrication tools were used at IAAC, this is a small scale workshop where there are tools available for personal digital fabrication. These tools include computers and software, a laser cutter, a 3D printer, electronics lab, hand tools, a cnc router, a vinyl cutter, sewing machines and various materials to work with. For this pilot, the community champions made an installation called Noisebox. This installation captured and displayed noise levels on the street in Barcelona.

Barcelona Fab Kids

This pilot was planned to convey abstract concepts such as sensing and data to young people in a way that would enable them to understand these concepts. Finding a narrative that pulled these ideas together in a way that made sense for children involved storytelling about how pollution affects birds. This included identifying different bird species in order to create 'empathy' with different birds, e.g. a shy bird or a happy bird. The narrative also included learning about migration patterns, eating habits and examining the local environment around the Fab Lab. This pilot used the Smart Kids Lab activities designed in the Amsterdam pilot.

Bird books were created for this pilot. These books had details of the various bird species local to the area, including bird behaviour, where they prefer to nest and the types of foods they eat with the aim of building bird feeders suitable for each species.

A scavenger hunt map was used as part of the activities (Figure 7). This was a map of the local area where the kids could mark on it as they found the Smart Citizen Kits they were searching for.

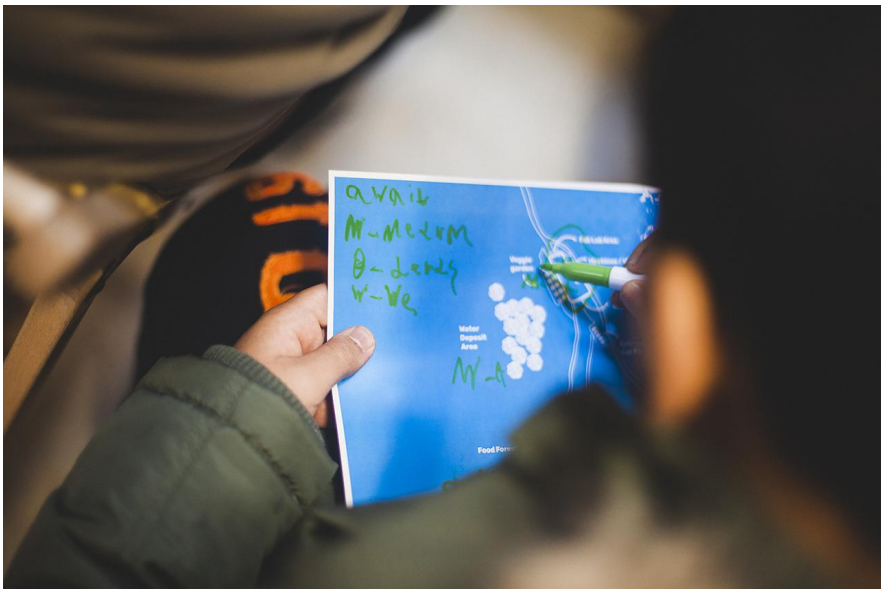


Figure 7: A scavenger hunt map

The local Fab Lab where the fabrication tools were used was the Green Fab Lab based in Valldaura in Collserola National Park. They used several tools available in the Fab Lab, such as laser and wood cutters, to make bird feeders.

Barcelona Gracia Sounds

This pilot directly built on the work conducted in the Barcelona Community Champions pilot, using what had been developed in terms of structure, methods, and experience. The aim of the pilot was understanding the issue of noise in Placa del Sol. The Community Champions from the first pilot were involved in the design of this pilot and used their experience of the first pilot throughout.

Data acetates were simple blank acetate sheets that could be overlaid on top of printouts of the noise data collected by sensors (Figure 8). The citizens could mark additional information on the acetates, such as time of day or data from other sources.

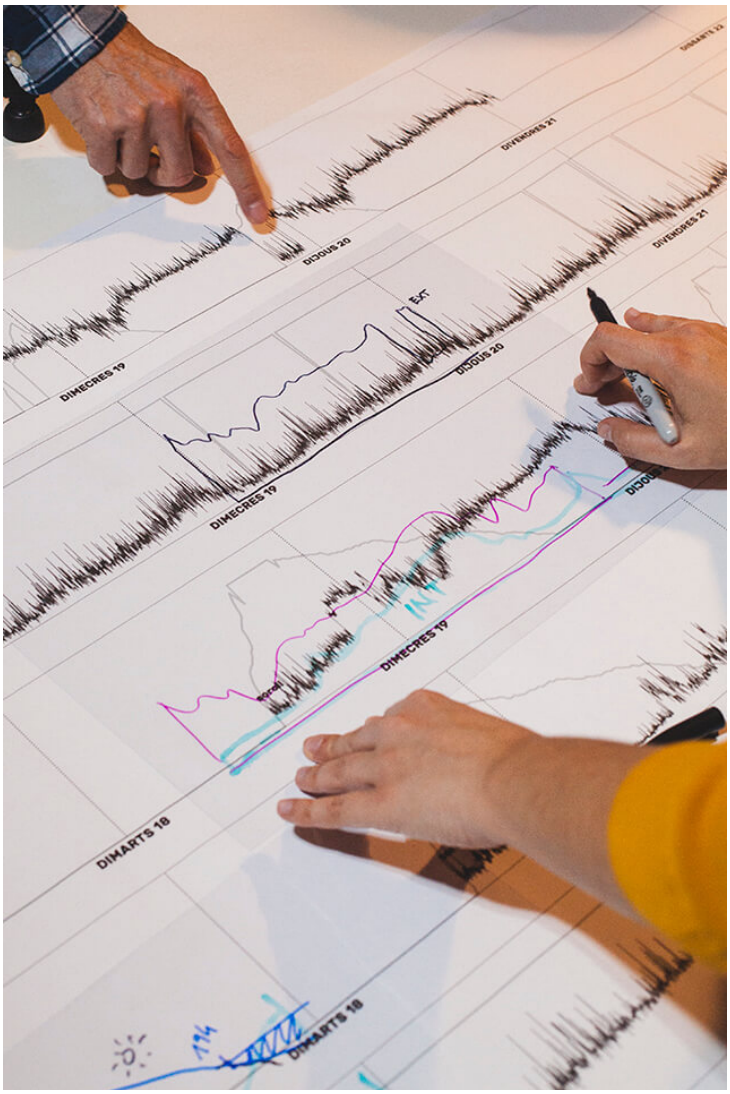


Figure 8: Data acetates used to mark additional data on top of sensor noise data

The action design comics were completed by children who took part in one of the workshops as part of the pilot (Figure 9). They consisted of a sheet designed to look like a comic where children were asked to rewrite the story of the Placa del Sol. There were three panels for the children to draw in. The first panel was titled (translated from Catalan): “Once upon a time in a very noisy Placa...”. The second was titled: “One day the children from [local school name] had a fantastic idea...”. The final panel was titled: “And so they made…”

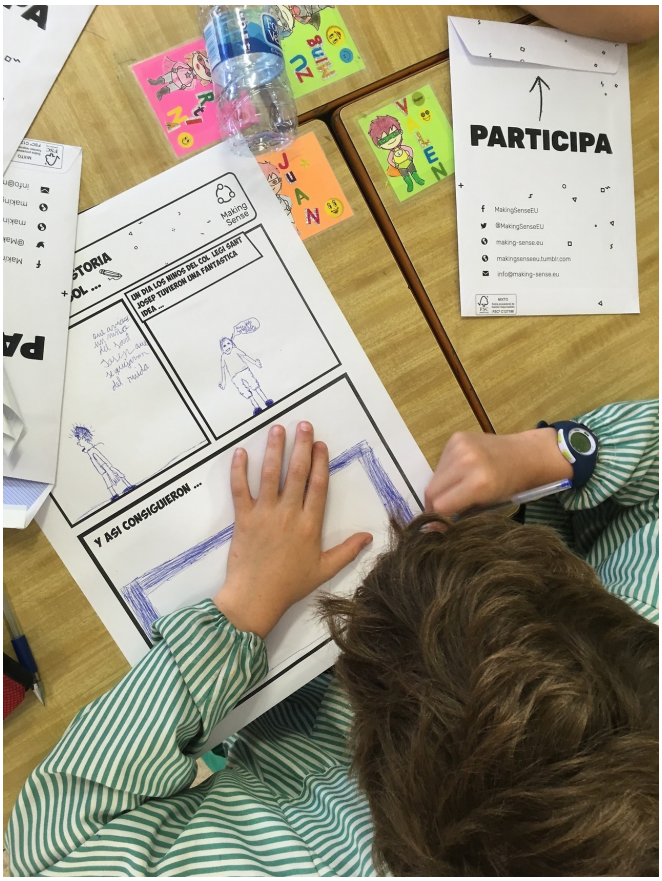


Figure 9: A child completing an action design comic

The fabrication tools that were used to make the installation for the co-creation assembly were used in the IAAC as described above.

Prishtina

The table below (Table 4) shows the tools that were used in the Prishtina Making Sense campaigns by the Framework phase they were used in. There is only one column for all three pilots to reflect that the Prishtina pilots were conducted with the same participants, addressed the same issue of air quality and followed an iterative process. For more information on the application of the tools within the pilots, please see D3.3 Documentation on Activities in Prishtina.

All of the tools that are not starred in Table 4 are described in detail in Appendix 1 (p16-95), starred tools are described below. Bio-indicators, shown in the table in the sensing phase, is a Community Level Indicator and is reported in-depth in the deliverable: D5.5 Report and Assessment of Impact and Policy Outcomes using Community Level Indicators.

Framework phase	Tools used in pilots
	Kosovo Season 1, 2 & 3
Scoping	Interviews* Geographical mapping Survey*
Community building	Recruitment tools Onboarding kit Digital bootcamps (non-formal environmental education workshops)* • Campaign plan
Planning	Sensing strategy Sensor calibration Sensor manuals*
Sensing	Open hardware Bio-indicators
Awareness	Young reporters activity* Smart Kids Lab instructables (water, sound, air) Media strategy*
Action	Interventions* • Mannequins • Air pollution masks • Slogans • Pop up information stand • Artistic performance • Ballot for clean air • Pollution level chart • Tree decorated with coal Digital presence (social media accounts)
Reflection	Questionnaire General assemblies (monthly)* • Pilot appraisal
Legacy	Making Sense branded materials* Training the next generation Green school committee strategy* Hackathon* • Data charts • Data dashboard • Visualisation map • Website

Table 4: A list of tools used across the Prishtina pilots, shown by Framework phase, starred tools are discussed below

The pilots aimed to establish a youth environmental movement to investigate air pollution at a local level and to re-frame the public narrative around air pollution in Kosovo through public campaign interventions. The pilots were designed to be participatory and democratic and to

empower young people to make change in their community. The participants were referred to as Committee Members and took active roles and ownership of the project. The three committees were: research and monitoring, education and campaign and mobilisation. The first pilot focused on air quality in Pristina, the second pilot focused on air quality around a primary school and the last focused on areas around power plants. The pilots had the same committee members throughout and followed the same participatory process, activities were reflective and iterated from lessons learned.

Interviews were conducted that aimed to map the existing situation in some of Kosovo's most excluded communities; to identify whether the local and central institutions, or other organizations, were implementing similar types of interventions on air pollution; and to measure the interest of the community to engage directly in an experimental initiative.

A comprehensive survey of pioneering community citizen science projects was carried out, to find sensing methods accessible to the community. The overlap of community concerns, research experience, and accessible citizen science techniques indicated that air quality should be the focus, along with youth empowerment and involvement through intensive participatory training in three main fields: air pollution measurements; campaigning and mobilisation; and educational work with children.

The first *Digital Bootcamp: Making Tech. Making Actions. Making Sense* took place on October 2016 aimed at pioneering a participatory methodology to develop the first campaign and its actions in Kosovo (Figure 10). The Bootcamp involved all the Committee Members and newly-recruited participants. It took place over three days and aimed to develop knowledge, build skills, build sensors, reflect on any data already collected and design the actions of the first pilot[16]. It led to the first campaign plan of the pilot[17].

Figure 10: Digital bootcamp

[16] https://drive.google.com/file/d/0BxGelKshATD8cC1zbVZuRGxIdFU/view

[17] https://docs.google.com/document/d/1Djd2hnndhyLupZrsYTjTGggjPW4ytRCMu5UPu2IdC0E/edit

The project team created several sensor manuals to help their committee members use and install the various sensors used. This was combined with workshop training to boost skills and encourage independence.

A young reporter's activity was created and conducted in the primary school. In this activity, the pupils identified different issues: whether the school ensures full security for children in an emergency and from traffic and how the school recycles and deals with hygiene. The pupils then discussed these issues along with their findings from the Smart Kids Lab activities and came up with a list of actions for them to take to make changes at school (Figure 11).

Figure 11: Smart Kids Lab (left) and young reporter's (right) activities

Media coverage has been a major outcome of the pilots, mainly through the campaign actions. Air pollution, but environmental issues generally, were not part of the public discourse previously. From November 2016, when for the first time people started to protest, all the major media outlets started to report on it, and social media channels were filled with concerns about air pollution. In order to have a consistent message for the media, a 'Talking points' document was created and shared with all the activists. The document includes positions, (counter) arguments, facts and data so that the activists have ready replies for media questions. Framing the narrative around air pollution, packaging scientific research for citizen-friendly language, and being in media headlines were key outcomes towards changing and reclaiming the public discourse.

Various interventions were a key component of the three Prishtina pilots (Figure 12). They were designed to get the topic of air pollution into public discourse and to raise awareness about the issue. The interventions were all designed by the committee members as part of the strategy of self-governance and empowerment.

Figure 12: Hand decorated air pollution masks for the public (left) and musical performance (right)

Monthly general assemblies were held with the committee members and the project organisers (Figure 13). These monthly meetings had a dual purpose, the first was to reflect on the work, challenges and achievements of the previous month and the second was to plan activities and make decisions for the upcoming months. The assemblies were designed to give everyone a safe place to air their questions or concerns and come up with proposals. All decisions were passed by consensus in the assemblies and agendas were proposed by both the committee members and the project team. This was designed as part of a radical democratic process to encourage ownership, self-governance and empowerment.

Figure 13: General assembly participants

Making Sense materials with the Making Sense logo and branding were used for many activities, including workshops, bootcamps and interventions (Figure 14). Figure 14 shows artefacts designed to mimic electoral papers, produced as part of the final campaign to highlight the lack of discussion about environmental policy and lack of candidates addressing these issues during the Kosovo election.

Figure 14: Making Sense branded materials

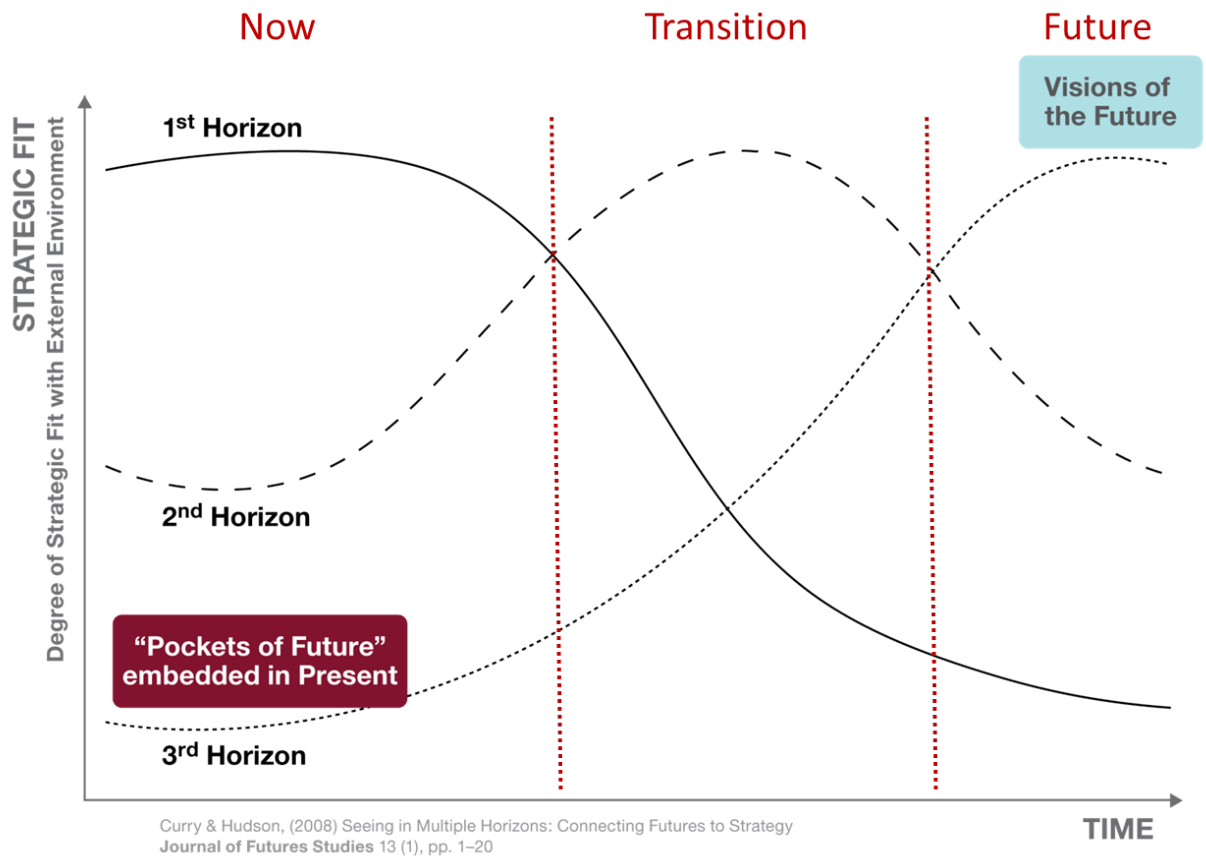
The Green School Committee was formed during part of the second pilot where air quality measurements were based around a primary school. The aim of the Green School Committee was to further engage parents and teachers around the issue of air quality. Two participants were selected at a General Assembly to act as a focal point between Making Sense Kosovo and the Green School Committee. Meetings were held to plan the development of the Green School Committee.

The final event of the third pilot was a hackathon with the main goal of the event being the visualisation of data (Figure 15). The hackathon ran over the course of a weekend and participants were tasked with creating a prototype that had the following criteria: user-friendly and interactive data visualisation, be a 'campaignable' visualisation and have interactive features that aimed to increase engagement with young people and citizens. The winner of the hackathon was a team that created a website that displayed air pollution data gathered from the pilots and advice for citizens on how to protect themselves from air pollution.

Figure 15: Materials set up for the hackathon event

3. Sustainability and Uptake of Tools

Sustainability and scalability of citizen sensing and environmental action was a key aim for Making Sense, and to this end the toolkit formed a critical pathway towards this. During a consortium meeting eight months prior to the completion of the project, partners co-created an ambition for the sustainability and legacy of the knowledge and toolkit created during Making Sense. Table 5 represents the key objectives which came out of this activity, which were grouped into the period of time the Making Sensing partners thought this would occur; 'now', 'near future' or 'far future'. This table was created with reference to the Three Horizons (Curry & Hodgson, 2008) [Figure 16], which is a framework for looking towards the future to discuss how different activities instigate different levels of change.



NOW	NEAR FUTURE	FAR FUTURE
A toolkit for citizen sensing Citizen sensing tools used in co-created citizen science projects Artistic interventions and data visualisations in public spaces Smart Citizen 1.5 Developed area of co-created citizen science Spin-off Making Sense projects doing citizen sensing Knowledge transfer into other	Wider uptake of Smart Citizen platform and Smart Citizen Kit Toolkit modules Education programmes on citizen sensing Increased accuracy of data from low-cost tech Making Sense documentary international screenings and spin-off action Online publication on citizen sensing	Establishing global crowdsensing and citizen sensing networks Established World Sensing Day Citizen sensing network interim annual meeting (annual World Sensing Day) Widespread data literacy amongst citizens Citizen-led democracy Citizen science approaches embedded into national and

projects, e.g. DECODE	More citizen sensing in large and often 'closed' tech organisations Launch of World Sensing Day	EU policies Open tech taken up globally to challenge current business models

Table 5: Ambition of the sustainability and uptake of the Making Sense approach and citizen sensing tools.

From the table, we note that the present ambitions are concerned with the transfer of knowledge and tools to other projects and fields, such as citizen science. Looking towards the near future, dissemination and wider uptake was key, like a bigger network on the Smart Citizen platform, the creation of other online social networks for citizen sensing and international screenings of the Making Sense documentary. Another key objective was the increased accuracy of the low-cost sensors which would continue to advance with the wider uptake and iteration of the tools through the open source ethos. Also in the near future, is the launch of World Sensing Day, which aims to bring further awareness to citizen sensing.

In the far future, the consortium aimed at transformative change. Primarily, this would be in national and European Union policy agendas, namely, by appropriating citizen sensing practices and using the information created as authoritative sources to collect data from. Furthermore, there will be a change in culture and how not only governments but also in industry, with current and mainstream business models being challenged by this new way of working. A more citizen-led approach to democracy would also mean that in general, people would feel more empowered to take matters into their own hands. Lastly, a more tangible ambition for the far future would be to establish networks and the World Sensing Day.

The following section details the uptake and sustainability of the tools and methods of the Making Sense project so far, divided into subsections for each pilot city, and the headings above have been mapped to indicate progress against our ambitions.

Amsterdam

Smart Kids Lab

The Smart Kids Lab instructables (section 2, sub-section Amsterdam this document) were initially designed for the second Amsterdam pilot and were appropriated and used across the other two pilot cities. Barcelona used them in the Fab Kids pilot and Prishtina used them in their second pilot based around a primary school.

In September 2017 Waag Society combined with the Do It Together Science Bus[18] to create a full day Smart Kids Lab workshop. A new experiment was conducted every hour and consisted

[18] https://togethersciencebus.eu/

of the children going on a tour of the local terrain to do measurements and then mapping their experimental results on a large map of the terrain. The instructables used were: microbe, mineral, acid, sound and particle. **[Knowledge transfer into other projects, Education programmes on citizen sensing].**

The Smart Kids Lab tools have been used in a long term program called Fabschool Kids, combining DIY skills for kids with environmental sensing[19]. [**Education programmes on citizen sensing**].

The Smart Kids Lab tools have also been picked up by the Public Library in a program called 'Maakplaats' integrating Fablab like spaces into the facilities of the Public Libraries in Amsterdam[20]. [**Education programmes on citizen sensing**].

Sensor appropriation

The National Institute for Public Health and the Environment (RIVM) has also launched a citizen science platform[21] that gives an overview of all relevant air quality projects in the Netherlands, which includes a page showing current low cost methods and sensor. There a derivative of the Urban Air Quality Lora Bora sensor is shown, the 'mushroom'[22]. [**More citizen sensing in large and often 'closed' tech organisations**].

Data from Urban Air Quality Pilot

The National Institute for Public Health and the Environment (RIVM) has been involved in data collection and analysis from the beginning of the air quality pilot. They now have launched a beta version of a citizen sensing platform that will collect and aggregate data coming from citizen sensing projects, including the Urban Air Quality data[23]. [**More citizen sensing in large and often 'closed' tech organisations**].

Barcelona

Community Level Indicators

Community Level Indicators (CLIs) have also been appropriated across two pilots within Making Sense. They were used in both Barcelona noise pollution pilots and in the third Prishtina pilot where they were implemented as bio-indicators.

This concept has also been taken up and developed in CityVerve[24], a smart city demonstrator. CLIs were used as a framework to involve citizens in the design process of the smart city and

[19] http://fabschool.nl/?p=761
[20] https://www.oba.nl/jeugd/maakplaats-021.html
[21] https://www.samenmetenaanluchtkwaliteit.nl/
[22] https://www.samenmetenaanluchtkwaliteit.nl/meetinstrumenten
[23] http://meetnetdata.rivm.nl/dataportaal/
[24] http://www.cityverve.org.uk/

to define and measure the success of the CityVerve project (Hemment, Woods, Appadoo & Bui, 2016). [**Knowledge transfer into other projects].**

Sensing notes/guides

Sensing notes (Appendix 1 p52-55) have been used in another European project called The GROW Observatory[25]. This project is engaging thousands of growers, scientists and other people passionate about land to contribute to scientific monitoring of soil. The tool has been adapted and expanded to include a semi-structured format where there are defined fields for people to input data as well as the more freeform note taking of the original tool. It also includes guidelines to fill in. This tool has been implemented across three countries: Greece, Hungary and the Republic of Ireland, supporting approx 90 people. It has been translated into Greek and Hungarian. Data is being collected with this tool from 1st Nov 2017 to end December 2017. [**Knowledge transfer into other projects].**

Sensing strategy and onboarding tools

These Making Sense Tools (p42-44 & p29-30 respectively in Appendix 1) have been used to orchestrate a new pilot intervention in Barcelona, in collaboration with Ideas for Change, ISGlobal and the City Council of Barcelona, during the "sustainable mobility week", in September. The stakeholders collaborated with a community in the neighbourhood of Sant Antoni to deploy sensors in order to measure air quality and noise pollution. In particular, the sensing strategy canvas and the onboarding tools were used. [**Knowledge transfer into other projects, Spin-off Making Sense projects doing citizen sensing].**

Smart Kids Lab and Education

The DO-IT EU project will build on the Making Sense experience by using the toolkit to orchestrate citizen sensing activities in schools. In particular, the tools developed in Fab Kids Lab and Smart Kids Lab (section 2, sub-section Amsterdam, this document) will be implemented. Both Waag Society and IAAC are partners in the DO-IT project. [**Knowledge transfer into other projects, Education programmes on citizen sensing].**

Across the Fab Lab Network, a number of Fab Labs are setting up sensing learning activities using the Making Sense toolkit (e.g. http://fablabsantiago.org/fab-city-campus-barrio-italia/). [**Education programmes on citizen sensing].**

Building on Gracia Sound pilot

DECODE Project EU (https://www.decodeproject.eu/), an H2020 CAPS funded project that aims to develop tools that put individuals in control of their data, will build on one of the Making Sense pilots in Barcelona. This entails continuing collaborations with neighbours from the Plaza del Sol in order to augment the Smart Citizen Kit onboarding application by integrating data licensing functionality. As a result, citizens will be able to chose how they

[25] http://growobservatory.org/

want to share their data and who with, and register such choices using smart contracts[26]. **[Knowledge transfer into other projects].**

Also in Amsterdam new citizen sensing projects will serve as a testbed for the DECODE tools, making sure sensing data is private and ownership is with the citizens. **[Knowledge transfer into other projects].**

Prishtina

Kosovo website (hackathon)

One of the outcomes of the Hackathon (section 2, sub-section Pristina, this document), organized in June 2017 that brought together designers, developers, data scientists, activists, and artists, will be an Android app and a platform which will centralize and visualize all the data collected across three pilots. The platform and the app will also integrate other data in real-time (e.g. data from U.S. Embassy in Kosovo) and display it. Further, the app and the platform will allow citizens to campaign and interact with data by sharing on social media, forwarding to mailing lists, etc. Last but not least, the app will also push out notifications when the levels of pollution reach high peaks and inform citizens about the measures they should undertake to protect themselves.

Campaign plan

During the Digital Bootcamp (section 2, sub-section Pristina, this document), the existing Committee members and newly recruited group, worked throughout the three days to develop different campaign elements, such as: campaign theme; campaign goal and objectives; campaign target groups; campaign actions. Participants worked in three parallel workshops:

1. Campaigning with Data;
2. Campaigning with Media (online and mainstream);
3. Campaigning Physically (offline).

The results from all the three workshops were brought together in the Campaign Plan, so they can Make Sense and serve the overall goals of the project.

This plan, however, served more as a guide of the campaign and not necessarily as a final, static plan. We took an *agile approach*: being flexible when it needed to be; pivoting and responding to the new circumstances created by the campaign and changing plans when they needed to be changed.

Green School Committee

The Green School Committee (section 2, sub-section Pristina, this document) is made up of children, parents, carers and teachers concerned about the environment and air quality in Prishtina and is continuing to meet after the pilots have finished. [**Education programmes on citizen sensing].**

[26] https://www.decodeproject.eu/blog/pilots-which-will-help-citizens-regain-control-over-their-personal-data

Section 4

Citizen Sensing: A Toolkit

Background

As stated above, one of the main aims of Making Sense was to create a set of tools and methods that could be appropriated by communities and intermediary organisations who had a pressing local issue. As such, the Making Sense team designed and planned a book (Appendix 1) that would be accessible and easy to use and understand with communities as the main audience. It is expected that intermediary organisations, researchers and public policy officials will also find value in this book. The book's main contribution and largest section has details of the tools used across the project. It is a companion to this deliverable in that this deliverable covers those tools not included in the book or within other deliverables.

Structure

The tools within the book are separated by Framework phase (Table 1). Each Framework phase has a description of what happens in that phase of citizen sensing, followed by three or four tools. Each tool has a section describing the tool and its purpose, followed by a how-to guide that shows how a community could use the tool. There is an accompanying example of how a tool was used in the Making Sense project for one tool per Framework phase.

The book also includes a section for case studies, these case studies focus on two pilots per pilot city. This section therefore covers six of the nine pilots that were conducted as part of Making Sense. The book ends on several key learnings that have come out of the Making Sense project and should serve as guides for communities planning a citizen sensing project.

Development

The main content of the book was planned and developed during a three-day booksprint. This booksprint gathered people from each of the Making Sense organisations together for three intense days of planning and writing. The team spent the time in a manor house in the Scottish countryside where they could work exclusively on the book. There were several sessions to plan audience, structure and content of the book. Breakout sessions were conducted to create detailed plans once the overall structural decisions had been made. Partners separated to write their own sections and then came together to discuss progress and make further decisions. The whole book, in a pre-published state, is attached as Appendix 1.

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Appendix 1

Citizen Sensing: A toolkit

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Annex 2: WeObserve Toolkit Survey

WeObserve Toolkit Survey

Section 1 of 5

WeObserve (www.weobserve.eu) is an EU-funded project that aims to support awareness, acceptability and sustainability of Citizens Observatories (COs). As part of this project, we will create a series of toolkits to support the wider uptake of COs.

Citizen Observatories (COs) are community-based environmental monitoring and information systems, that invite individuals to share observations, typically via mobile phone or the web. Further information about this can be found at: https://www.weobserve.eu/about/citizen-observatories/

This survey is intended for those who have experience of citizen observation and other associated fields, that include, but are not limited to; citizen science, participatory sensing, citizen sensing and environmental observation. We are keen to hear from you if you have a tool you that you have used and would like to share, and promote through WeObserve.

We define the term 'tool' very broadly, this might include, for example:
- a low-fidelity sensor (e.g. DampBusters, Smart Citizen, BoraBora sensor)
- a testing protocol (e.g. GROW Sensing Guide; The Cornell Lab Citizen Science Toolkit for refining protocols)
- instructions for running participatory workshops (e.g. Community Level Indicators in Citizen Sensing: A Toolkit)

Please answer every question to the best of your knowledge, but do not feel you have to answer everything.

To contribute, please fill out one form per tool. You are allowed to complete as many forms as you would like. Completion of one form should take between 5-10 mins.

You may contact us at any time to ask questions or withdraw from this study, to do so, please email Saskia at weobserve@dundee.ac.uk

Section 2 of 5

Your details

We will use your personal data provided above to keep in touch with you about the tool, and in order to aid communication within WeObserve. We will never sell your data and we promise to keep your details safe and secure. You can unsubscribe or request that your data be deleted at any time. Please indicate your consent with this below.

- Agree

First Name

Last Name

Organization

E-mail address

Section 3 of 5

Description and information on the tool

Name of tool

Has the tool been used in a citizen observatory or citizen science project? Select one.

- Yes
- No
- Other

If yes, which project?

Please provide a short description of the tool:

Does the tool support one or more of the following steps?

Understanding the issue or problem (e.g. environmental, ecological, etc.) Select all that apply.

- Forming a team
- Creating a community
- Choosing a question
- Deciding what data to collect
- Developing protocols for data collection

- Training for data collection
- Capturing or generating the data
- Managing the data
- Understanding the data
- Analysing the data
- Visualising the data
- Disseminating results
- Informs decision making
- Change-making / planning action
- Measuring impacts
- Other

Please provide a short description as to how the tool supports the step(s) above.

Who is the intended user of this tool? Select all the apply.

- Citizens
- Policy makers
- NGOs
- Educators
- Scientists / Researchers
- Industry / Businesses / Technologist
- Other

Please provide a link to the tool, if available.

Are there any restrictions in using this tool? Select all that apply.

- Requires a specific device
- Works only on certain mobile devices (iPhone, Android, etc)
- Requires internet connection
- Requires a lot of training to use and master
- Requires more than one person
- Requires a lot of effort / time in the short-term
- Requires a lot of effort / time in the long-term
- High costs to buy / use
- Acknowledgement and reference to creator
- Other

What are the benefits of using this tool? Select all the apply.

- Low or no cost to buy / use
- Easy to make / use
- Can be used by many different people
- Can be used offline
- Educational / helpful to learn about the issue at hand
- Suitable for environmental issues

- Other

How familiar are you with this tool?

Not so familiar 1 2 3 4 5 Very familiar

What is your relationship to the tool? Select one.

- Owner / creator
- Adapter / iterator
- User
- Observer
- Interested in
- Other

Section 4 of 5

Definition of terms

In the introduction to this survey we included a working definition of Citizen Observatories and identified several other terms (i.e. citizen science, environmental monitoring, etc). which are used to describe similar fields. However, we acknowledge that there are a variety of definitions for these terms.

This short section is provided for you to identify and define the term in which you feel your work is most suited to.

What term(s) do you use to define the field in which you work?

Please give a short definition of the term(s) and include any references:

Section 5 of 5

Thank you for completing this survey, it is greatly appreciated. WeObserve will be using the information of the survey as part of a wider scoping process that seeks to discover and develop toolkits and resources for citizen observatories. You can follow the progress of these efforts on our website (www.WeObserve.eu).

If you have another tool you would like to submit, please start a new form here: https://goo.gl/forms/1zZzgUXl8VwxhANS2

To view our Privacy Policy please click here:https://www.weobserve.eu/privacy-policy-for-the-weobserve-toolkit-survey/

WeObserve has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 776740.

We may need to contact you to discuss your tool, please let us know if we can get in touch with you regarding the information you have provided. We will not contact you for any other reason.

- Yes
- No

An Ecosystem of Citizen Observatories for Environmental Monitoring