eu-citizen.science

The Platform for Sharing, Initiating and Learning Citizen Science in Europe

Deliverable 4.1

Guidelines and Recommendations Based on a Range of Best Practices for Achieving Societal and Policy-Maker Engagement

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Acknowledgement

The EU-Citizen.Science project has received funding from the European Union´s Horizon 2020 Framework Programme for Research and Innovation under grant agreement No. 824580.

Reference

Please cite this work as:

Latham, M., and Ceccaroni, L. (2020). D4.1: Guidelines and recommendations based on a range of best practices for achieving societal and policy-maker engagement. *Deliverable report of project H2020 EU-Citizen.Science (grant agreement No 824580*).

Acknowledgement

EU-Citizen.Science has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement no. 824580

Document Identification Sheet

Project Ref. No.	824580
Project acronym	EU-Citizen.Science
Project Full Name	The Platform for Sharing, Initiating and Learning Citizen Science in Europe
Document Name	EU-Citizen.Science_WP4_D4.1.pdf
Dissemination Level	Public
Contractual Date of Delivery	Month 12 (31st December 2019)
Actual Date of Delivery	Month 14 (29th February 2020)
Type	Report
Deliverable number	D4.1
Deliverable name	Guidelines and Recommendations Based on a Range of Best Practices for Achieving Societal and Policy-Maker Engagement
WP / Task	WP4: Awareness and Engagement – Public and Policy Makers
Number of pages	37
Authors	Mollie Latham Luigi Ceccaroni
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Abstract	The EU-Citizen.Science project will create a platform to, among other things, raise awareness of citizen science, and facilitate anyone to engage with citizen-science projects. This document presents a list of recommendations for achieving engagement of society, including policymakers, with citizen science. Through the identification of existing projects and analysis of best practice, this report aims to establish a framework for improving engagement in existing and new projects. A list of recommendations for engagement among stakeholders is formulated based on existing literature. These recommendations are then allocated to the identified groups of stakeholders to suggest the most appropriate ways to engage different audiences.
Keywords	Engagement, Citizen Science, Recommendations

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1 Version Log

Version	Date	Released by	Nature of Change
V0.1	20/11/2019	Mollie Latham	First Draft
V.02	17/12/2019	Mollie Latham	Draft for external review
V.03	24/01/2020	Mollie Latham	Draft for the second round of external review
V.04	27/02/2020	Mollie Latham	Final version

2 Definitions and Acronyms

AI	Artificial intelligence
CA	Consortium Agreement
CC	Creative Commons
CSA	Coordination and Support Action
CSO	Civil society organisation
Data	Information, in particular facts or numbers, collected to be examined and considered as a basis for reasoning, discussion, or calculation. In a research context, examples of data include statistics, results of experiments, measurements, observations resulting from fieldwork, survey results, interview recordings and images. The focus is on research data that is available in digital form. (European Commission, 2016)
Dataset	A grouping of data
Digital Curation	Selection, preservation, maintenance and archiving of electronically stored data
DMP	Data Management Plan
DS	Data Set
EC	European Commission
ECSA	European Citizen Science Association
FAIR	Findable, Accessible, Interoperable and Reusable
GA	Grant Agreement
GDPR	General Data Protection Regulation
H2020	Horizon 2020
ICR	Immediate civic response
IPR	Intellectual Property Rights
Metadata	A description of data
MoRRI	Monitoring the evolution and benefits of responsible research and innovation

NGO	Non-Governmental Organisation
Open Access	Access that is free to all and free of any restrictions
Open Data	Data that can be freely used, shared and built on by anyone for any purpose
OpenAIRE	Open Access Infrastructure for Research in Europe
PPSR	Public Participation in Scientific Research
Repository	A location in which data is stored or managed
RIA	Research and Innovation Action
RRI	Responsible Research and Innovation
SDGs	Sustainable Development Goals
SME	Small- and Medium-sized Enterprise

3 Executive summary

The EU-Citizen.Science project will create a platform to, among other things, raise awareness of citizen science, and facilitate anyone to engage with citizen-science projects. This document presents a list of recommendations for achieving engagement of society, including policymakers, with citizen science. Through the identification of existing projects and analysis of best practice, this report aims to establish a framework for improving engagement in existing and new projects. A list of recommendations for engagement among stakeholders is formulated based on existing literature. These recommendations are then allocated to the identified groups of stakeholders to suggest the most appropriate ways to engage different audiences.

4 Introduction

The EU-Citizen.Science project aims to develop tools, training and frameworks for effective planning and delivery of citizen science projects in Europe. The creation of a multifaceted platform will provide a co-ordinated approach to raising awareness of citizen science, allowing anyone to engage with current or new projects. The project and its partners aim to provide a comprehensive and sustainable space that offers relevant scientific direction and best-practise examples, carefully curated to be accessible to the stakeholders that encompass citizen science in Europe.

The EU-Citizen.Science project develops an innovative online platform, making citizen science accessible to all. The provision of resources, tools, guidelines and training modules will enable people to initiate their activities, allowing anybody to learn more and immerse themselves in citizen science. Specifically, the project aims to:

- coordinate citizen science actions and leverage existing resources in the currently fragmented landscape of citizen science in Europe;
- engage stakeholders at all levels (local, national and European);
- create a mutual learning space and a set of comprehensive codesigned training modules for the different target audiences.

The result of this is interdisciplinary collaboration and the provision of novel tools and approaches to citizen science. The platform will be populated with carefully curated resources and tools accessible to different stakeholders, ranging from interested citizens to scientific institutions, up to politicians and public media, to facilitate Citizen science on a broader scale. The EU-Citizen.Science project intends to create a change in the awareness of citizen science among the general public, augmenting the presence of citizen science in education and improving communication among scientific publication and project participants. Similarly, the project emphasizes the role of communication to inform societal and policy-maker action.

Work Package 4 focuses on awareness and engagement of society and policymakers. The work package and its deliverables facilitate the achievement of project objectives, namely in empowering diverse stakeholders to adopt citizen science practices and advancing citizen science into the mainstream of public engagement and education. Across this work package, Earthwatch will provide strategies and tools to facilitate engagement with and awareness of citizen science in Europe. Critically, it will also provide guidance on best practise, including how to engage society, including policy-makers, with citizen science and how to create new initiatives, aided by the work conducted across the consortium.

4.1 Purpose and Scope of this Report

This report on "Guidelines and Recommendations Based on A Range of Best Practices for Achieving Societal and Policy-Maker Engagement" is a deliverable of Task 4.1 'Achieving societal awareness and engagement in science through existing citizen-science networks, projects and multiplier events', which contributes to the overall aims and objectives of Work Package 4 'Awareness and Engagement - Public and Policy Makers'. With the ambition to streamline citizen science in Europe and provide material accessible to a wide range of audiences, Work Package 4 encompasses the engagement and awareness of a diverse catalogue of stakeholders. Guidance and assistance in achieving awareness of and engagement with citizen science are critical aspects of the interdisciplinary nature of the platform.

This deliverable will provide a list of recommendations explaining the processes of implementing the EU-Citizen. Science framework through ongoing activities and events, and achieving societal and policymaker engagement. Additionally, this document will provide guidance on starting a new citizen science initiative, which will be made available on the resulting platform. The result of these outcomes will be the provision of concrete assistance on how to achieve engagement of identified stakeholders in citizen science through new and existing activities. This deliverable is part of a series, meaning that the content of this deliverable will be processed further by testing and feedback.

4.1.1 Scope of the deliverable

Work Package 4 focuses on awareness and engagement across stakeholders, demonstrating a conceptual model for engagement, awareness and empowerment in citizen science. Within this work package and its respective tasks and deliverables, Earthwatch will develop strategies for engagement, consolidating existing initiatives and increasing sustained engagement among stakeholders, and providing consistency to citizen science across initiatives. Task 4.1 details the approach to Achieving societal awareness and engagement in science through existing citizen-science networks, projects and multiplier events, and encompasses the provision of guidance with achieving societal awareness and engagement in citizen science through existing activities. Task 4.2 considers general policy recommendations for citizen science, in which the work package will create a citizen science model for impacting science and research policy, and produce a set of policy recommendations on how to make use of and support citizen science. Task 3 represents a case study for the implementation of policy recommendations for citizen science. Tasks 1 and 2 are developed within this deliverable. This deliverable has allowed collaboration and co-operation with other project partners, encompassing the breadth of knowledge and expertise within the consortium.

Deliverable 4.1 (this deliverable) presents recommendations on "engagement" of all types of stakeholders. Deliverable 4.2, published separately, offers recommendations on "awareness raising" in all kinds of stakeholders.

4.2 Definitions

4.2.1 Engagement

When considering deliverables 4.1 and 4.2, it was necessary to clearly define the difference between awareness and engagement and establish the difference in definition to support the difference in approach. For this project, "engagement" is defined as the active participation or involvement of an audience member with a citizen science project, activity or event, on one or more occasions. "Awareness" is defined as knowledge of a citizen-science project, activity or event, and summarises a more superficial interaction with a project with respect to "engagement", limited to a knowledge of its existence, opposed to involvement with it.

This definition is in line with the Collins dictionary definition "Verb: If you engage in an activity, you do it or are actively involved with it" (Collins, 2019). Similarly, Cambridge dictionary highlight that public engagement encompasses the "process of encouraging people to be interested in the work of an organisation" (Cambridge Dictionary,

2019).

4.2.2 Audiences

For this report, the audiences (or stakeholders) considered are:

- academia
- educators
- the public
- non-governmental organisations (NGOs) and civil society organisations (CSOs)
- industry and small- and medium-sized enterprises (SMEs)
- the press and media
- policymakers and funders.

These stakeholders have been identified via *Deliverable 2.1: Stakeholders, Network and Community Mapping Report*, a deliverable part of *Work Package 2: Platform, Community and Network Building* (*Figure 1*). For this study, the public will encompass volunteers (or participants), as traditionally, in citizen science, volunteers are part of the public. It is essential to remain consistent in audience terminology among the consortium, as consistency in terms impacts the development of knowledge, as referenced in Eitzel et al. (2017).

Figure 1- Stakeholder Map from Deliverable 2.1: Stakeholders, Network and Community Mapping Report, a deliverable part of Work Package 2: Platform, Community and Network Building

4.3 The EU-Citizen.Science platform

As a central platform for sharing knowledge, initiating action and supporting learning, the EU-Citizen.Science platform will provide resources surrounding engagement for all stakeholders. The provision of resources, training and examples of best practice will provide content to meet the varying needs of society and policymakers. The platform will act as a guidance tool for those wishing to expand their understanding of citizen science, get involved with a project, or begin a

new project. Also, the platform will highlight opportunities and guidance for funding citizen science and provide an understanding of how citizen science can inform local decisions and broaden understanding of communities. This deliverable will be hosted on the platform to guide and support citizen science practitioners and participants in achieving engagement with critical stakeholders.

4.4 Methodology

Deliverable 4.1 explores the literature surrounding engagement with citizen science, assessing the discussion surrounding strategy and optimization for participation, to develop a comprehensive list of recommendations for engagement across the stakeholders. These recommendations will explain the process of achieving societal and policymaker engagement within the EU-Citizen.Science framework and beginning a new citizen science project, information which will be subsequently made available on the platform.

Following discussion among work-package members, the key focus areas for the deliverable were established. The critical sections of the report included the recommendations, case studies and the creation of a new project. An extensive literature review was carried out, including a range of best practise examples and recommendations.
A draft of these recommendations was offered to the project partners and some third-party members, at the project meeting in Vilnius (month 9); this was to gather feedback on the existing recommendations and to ask for suggestions on missing recommendations. Feedback gathered was used to conduct the second round of internal review regarding the list of recommendations.

Staff within Earthwatch were consulted to demonstrate case studies of citizen science projects in which the recommendations were used. Accessing the range of expertise available allowed WP4 to show real examples of how the recommendations could be used in practise. Within the distribution of the draft versions of D4.1 and 4.2, project partners were asked to contribute case studies.

Reviewers from European Citizen Science Association (ECSA), Museum für Naturkunde (MfN), International Institute for Applied Systems Analysis (IIASA) and Ministry of Economy and Competitiveness (MINECO) were consulted for the review process, following which the deliverable was redistributed for comments from partners who were not involved in the initial review.

5 State of the Art

In citizen science, there is a strong need to dedicate efforts to prolonged and repeated engagement, particularly when conducting studies over a long period or with broad data (Schade et al., 2017). A study conducted by Rotman et al. (2014) suggested that while initial uptake of volunteers in a project is high, long-term participation is often much lower and that the reasons for this are complex and due to a range of factors. There are various options available to engage diverse audiences. Broadening the participation in citizen science requires appropriate approaches to engagement, with strong alignment of priorities with community focus (Robinson et al., 2018). Engagement is a crucial challenge of citizen science projects and is often impacted by the strategies utilised in the initiation and continuation of the project. Similarly, problems arise owing to the varying levels of engagement, serving various purposes; there are engagement forms with minimal commitment for small tasks that do not take a lot of time and skills, up to an engagement that requires long-term commitment, more in-depth expertise and often, projects purposefully chose between these forms (Shirk et al., 2012). Importantly, no matter the depth of engagement, it is essential that commitment is sustained. Therefore, it is critical to understand the factors affecting sustained engagement with citizen science and the strategies, functions and structures of a successful project, to promote them in current and future citizen science activities.

With an increased interest in public involvement within science, it is essential to understand how we can achieve sustained participation from various groups. The importance of effective engagement is cited consistently as a critical component for sustaining volunteers (Tweddle et al., 2012; West and Pateman, 2016). When planned and executed well, engagement can be the driving factor of a project, while simultaneously increasing scientific understanding and raising awareness for important issues (Tweddle et al., 2012). Citizen science offers the opportunity for a more flexible and diverse approach than traditional scientific methods, owing to the more significant role of the public (Guerrini et al., 2018). It is, therefore, critical to consider engagement on a broad scale, to ensure an inclusive approach that involves all audiences. While being an essential component for participation in citizen-science organisations, projects and activities, engagement also offers a way to connect various stakeholders.

5.1 Audience perspectives

A critical component of engagement is related to perspectives and experience. Factors such as lack of support, poor communication and lack of understanding of audience and motivations are all cited as barriers to prolonged engagement and participation with projects and activities on a broad scale. (Bonney et al., 2009; Tweddle et al., 2012; Vann-Sandera et al., 2016). For example, achieving project aims and ensuring the best quality data are collected rely on effective stakeholder management, providing a high-quality experience for all (Vann-Sander et al., 2016). One of the critical benefits of engagement with citizen science is access to a broad range of participant knowledge and motivations. Accessing diverse groups that are often not included in mainstream science can help in establishing personal relevance of science and common ground between scientists and volunteers (Varner, 2014). It is essential, however, to ensure the uniqueness of communities is respected and represented within projects. Identification of target participants allows for more effective engagement strategies to be implemented, including tailored materials, communications and training. Running small scale trials or focus groups with target communities is a standard method of assessing the effectiveness of engagement techniques, and how suited materials and methodology are to the communities (Tweddle et al., 2012).

Similarly, it is essential to be inclusive of communities (and sensitive to their values and motivations), including those that are commonly under-represented in science, such as legislators or cultural organisations (Varner, 2014). Establishing a connection between science and community, and considering the topic and audience are essential components of building relationships between volunteers and project managers (Richter et al., 2018). Some studies suggest that locality is a crucial aspect of engagement with citizen science, and acts as a catalyst for sustained commitment. Designing activities and projects that are grounded in local issues creates a captive audience and can maintain engagement for more extended periods (Rotman et al., 2012).

Strong links between audiences and project managers are essential motivators for consistent engagement and future participation with citizen science. They can be promoted in many ways, most considerably through providing support

systems and communication channels. Communication and support are critical components of a participant's experience, integral to achieving the outcomes of a project or activity, and citizen science in general. Establishing efficient communication channels early on promotes positive relationships, collaboration and co-operation between audiences and the project team (Vann-Sander et al., 2016). When considering the initial design of the project, communication and support roles should be carefully deliberated to ensure demands are met sufficiently. Providing support through communication channels can promote successful collaboration and can be achieved through forums, blogs, email or social networking techniques (Richter et al., 2018). An investigation of the "Foldit" online citizen science game suggested that sustained participation was fostered by the opportunities for interaction between participants and project developers, such as fora and instant-messaging chat rooms (Curtis, 2015). Foldit offers an opportunity for active and responsive communication, as well as a platform to ask questions and receive support from project developers, nurturing a positive engagement experience.

Participants cite feeling undervalued for their contributions as a cause of discontinued engagement (West and Pateman, 2016). As highlighted in the ten principles of citizen science (Robinson et al., 2018), it is critical that audiences, in particular volunteers, are acknowledged in publications resulting from the project and when data are made publicly available. Similarly, the European Commission states that feedback is crucial to promote sustained engagement, integrating acknowledgement of data collection efforts and contributions more systematically (Figueiredo Nascimento et al., 2016). Acknowledgement can take on a variety of formats and will vary from project to project, but reports suggest that volunteers who were not acknowledged at all felt demotivated and disappointed (Rotman et al., 2014). The acknowledged impact of audience's work is a motivating factor for long-term engagement.

Also, an understanding of audience motivations is critical for long term engagement. Motivations to partake in citizen science are highly variable, and it is essential to understand these to make citizen science attractive to potential participants. Matching activities or projects to interests and skills is challenging without first understanding why people want to participate (Roy et al., 2012). Motivations include contributing to science and research, new learning and career opportunities, altruistic concern for a cause or group, opportunities to socialize or personal development (West and Pateman, 2016). A study of audience motivations showed a large gap between intent to participate and actual participation with a project, with the critical difference being that individuals felt compelled to actively engage when the project aligned with their motivations (Rotman et al., 2014). This research also highlighted that motivations often developed when a participant was involved for long periods and developed relationships with the project team and other participants. A study of the project 'Stardust @ Home' found that individuals were motivated to participate initially due to the importance of the research topic. Still, sustained participation was driven by the enjoyment of the task and by feeling like they were learning more about the subject area (Curtis, 2015).

Indeed, the opportunity for learning provides a critical motivation for sustained engagement with citizen science. While providing an incentive for continued commitment, it also addresses concerns with data quality and capability of volunteers. Research into the OPAL project suggested that many participants who do not upload their results refrain from doing so due to a lack of confidence in the accuracy of their data (Tweddle et al., 2012). Working with individuals to develop their skills and confidence benefits all stakeholders. Retention of interest is much higher when audiences feel they have the skills needed to complete the project to a high standard, as well as offering increased confidence and larger investment (Tweddle et al., 2012). There are a plethora of methods for providing learning opportunities or supporting materials to promote sustained engagement, such as Train the Trainer courses, identification skills classes (e.g., species identification) and providing survey instructions. The British Trust of Ornithology offers training courses ran by regional representatives, providing guidance of survey techniques and use of recording booklets and identification guides. Additionally, they also offer bespoke training for individuals wishing to partake in specific projects (The Conservation Volunteers, 2014).

The potential for engagement of policymakers with citizen science projects is often underdeveloped, in part due to the lack of synergy between policy demands and citizen science data (Hecker et al., 2018). Alignment with policy debate is a key aspect of stakeholder engagement. Policymakers require appropriate and high-quality data that is relevant to policy demands and implements sound reporting and collection/analytical technique (Hecker et al., 2018). Similarly, public participation in policy development is important to consider. The methods of contribution range from defining issues and learning more about them to weighing in with an opinion on topics and pushing towards a desirable decision or

alternative (Hollow et al., 2015). Precise analysis and project structure are integral to extract the most critical insights from project results and present them to interested stakeholders (Figueiredo Nascimento et al., 2016). The extraction of the essential ideas establishes relevancy, particularly for policymakers, who often want only the most important details with respect to current and future policy debates.

Active involvement of citizens in science is the foundation of citizen science. The level of involvement, however, is important to consider when attempting to sustain engagement levels. A key principle of citizen science is that stakeholders should be given the option to be involved in multiple stages of the process (Robinson et al., 2018). Successful projects often mention functional structure in stakeholder involvement as a key to sustained engagement, clearly citing effective information flow and established channels as critical to this (Richter et al., 2018). This alludes to the identification of key areas in which individuals can be involved, and making these opportunities well known. Inclusive in this is the consideration of audience perspectives, which can be gathered and utilised to refine the aims and methods of the project. Encouraging participation with multiple aspects of projects or activities facilitates engagement, forging connections between audiences and project scientists, as well as establishing a sense of involvement and responsibility within individuals (Varner, 2014).

5.2 Technology and Data

Quality and efficiency of data collection can be improved by utilising new technologies to gather, record and manage data. This can aid engagement, owing to the simplified collection technique, the potential reduction in collection time and confidence that data are correct (Newman et al., 2012). It is important, however, to ensure that the process and platforms are efficient and utilised, as failure to deliver on use of technology can discourage volunteers (Rotman et al., 2014). Use of technologies such as online gaming has been popular in projects such as Foldit, with users citing the aspect of competition as motivation to participate and win awards, which has led to sustained engagement with the project (Newman et al., 2012). Similarly, engagement with citizen science is often limited by concerns over data quality. A key challenge of projects and activities is to ensure that the data-quality concerns are addressed throughout, including in the project's design and results' dissemination. The European Commission reflects upon this and acknowledges that more inclusive practices regarding the validity and usefulness of volunteer data are necessary (Figueiredo Nascimento et al., 2016). It is then critical that citizen science upholds scientific, policy and environmental standards and methods in order to engage stakeholders (Hecker et al., 2018).

Concerning the use of *artificial intelligence* (AI) in citizen science, risks exist that audiences disengage if (Ceccaroni et al., 2019):

- when contributing expertise to develop and train AI, they are not adequately and fairly acknowledged, respected, and rewarded;
- they think that new technologies could be driven more by short-term commercial necessity than longer-term social good;
- they are not comfortable sharing their data because of concerns that their data might be unfairly appropriated (especially for business purposes);
- they are forced (because of ethical considerations) to provide too-frequent re-confirmation of their willingness to share their data openly. (See GDPR (2016) as an example of where good intention can sometimes become burdensome).

5.3 Project design

A critical component of engagement is managing initial expectations. Participants contribute their time freely but often cite feeling overworked as a cause of disengagement (West and Pateman, 2016). Although this does not happen in all projects, as some individuals enjoy larger or more lengthy tasks, many studies suggest that being realistic about the

expected workload is critical for sustained engagement (Farley, 2013; Curtis, 2015). Indeed, it is suggested that sustained participation primarily stems from continued interest, which is complemented by the ability and time to continue contributing (Jennett et al., 2016). It is noted that, despite strong motivations to continue participating, engagement can be disrupted if there are excessive time demands made. A study revealed that some participants felt their time was unappreciated and were uneasy in continuing engaging with activities that were too time-consuming (Rotman et al., 2014).

Microvolunteerism, thus labelled after the idea that people are more likely to volunteer their time in short and convenient, bite-sized chunks, is a new approach to community action, which offers volunteers a series of easy tasks that can be done anytime, anywhere, on their own terms (Curtis, 2015). In a study of the online game Foldit [https://fold.it/], the small and short tasks were easily distributed, allowing contribution whenever participants had time free. A similar study of the same project suggested that 44% of a studied group of volunteers cited they did not have enough free time to continue contributing (Farley, 2013). Therefore, managing expectations is critical, as, often, the strategy that provides the optimal data for scientists, policymakers and other stakeholders is not achievable in practice, owing to the high demands to conduct complicated and time-consuming tasks or frequent site visits (Roy et al., 2012).

Project design is critical in improving the ability of project managers and participants to mobilise the objectives of projects. Utilising frameworks of best practice allows for effective design, ensuring the aims are fulfilled, and the project or activity integrates the principles of citizen science. Project design remains critical in ensuring high-quality data; planning data collection methods and ensuring standardization among techniques and analysis yields quality outcomes and minimises scepticism regarding the quality of data produced by citizen science. Indeed, much of the perceived scepticism surrounding data quality can be limited by ensuring rigorous planning during the project design that concentrates on the robustness of questions, aims and data management, including collection and analysis (Steven et al., 2019).

5.4 Awareness

Raising awareness of a project is the initiation for engagement with citizen science (Thornhill et al., 2016). It is crucial, therefore, to ensure these communities are informed of the opportunities available to them. In Deliverable 4.2, we explore the methods of awareness-raising among key stakeholders and awareness-raising activities in more depth, yet, here, we acknowledge its role in engagement. It is critical to raise awareness of the benefits of Citizen science, particularly among policymakers. Research suggests that policy is often at its best when it is fostered from science in which public audiences can contribute (Hollow et al., 2015). Also, citizen science offers benefits related to actively involving citizens with current issues and science, leading to a more informed society and a more transparent government (Martin, 2017; Hecker et al., 2018). Raising awareness of these attributes promotes engagement with citizen science across key stakeholders.

6 Recommendations

6.1 List of Recommendations

The following list of recommendations attempts to aid achieving and improving engagement in citizen science. Recommendations and their target audience are described below. It is important to note that the following list of recommendations is not exhaustive; understanding of engagement strategies is continuously growing, and will, therefore, be expanded upon across the course of the project to encompass the broad range of experience from different projects, countries and audiences.
The recommendations are listed to align with project life cycle and then clustered them vaguely by the stages - concept, definition, development, handover and closure - as detailed by the Association for Project management (APM, 2019).

Recommendation 1: Carefully consider the design of the project

Effective project design is critical for engagement, as well as mobilising the aims and objectives of participants. Projects should be relevant, targeted and organised, identifying areas of interest, appropriate funding and expert planning to sustain engagement and ensure the project works as intended. Projects should design protocols and ways of working, ensuring everybody agrees. They should account for engagement within the design of the project, considering techniques that will sustain participation with the project or activity (Tweddle et al., 2012). Importantly, the type of project selected during project design limits the level of engagement that participants can have. Contributory projects engage participants primarily through data collection, whereas co-created projects are designed collaboratively between project managers and participants, allowing participants to be engaged in most or all aspects of the project or activity (Shirk et al., 2012).

> **Example**
>
> In order to achieve the aims of a project or activity, project managers must carefully consider project design. Existing frameworks of best practise offer guidelines for effective design, ensuring that the project or activity integrates the principles of citizen science and aligns with its projected aims (Steven et al., 2019). Such frameworks are highlighted below in section *4.4 Creating a new project* and will also be provided on the EU-Citizen.Science platform. Structuring processes, protocols and strategies that span the project establish ways of working and ensure consistency among all stakeholders (Tweddle et al., 2012).

Recommendation 2: Provide a systematic and tailored approach

A systematic and tailored approach to meeting the overall aims of a project, including the engagement objectives, provides a structure that supports the project and its result. Pre-defined protocols and strategies for achieving the aims of the project or activity and for distributing findings and results should be agreed upon to ensure the message and purpose is clear, and that all involved stakeholders understand and work to the same framework. Having a fixed plan or system to all aspects of the project establishes a unanimous understanding of the projects goals and unified ways of working. Clarity among project partners allows them to accurately and sufficiently detail the project, and its aims and ways of working to stakeholders. Opportunities tailored to an audience offer stakeholders the option to engage in a capacity that works for them; methods of contribution range from defining issues and learning more about them to contributing data, weighing in with opinions or advocating for a desirable result (Hollow et al., 2015). Creating a summary document, detailing the goals and outcomes of the project, will grab stakeholder's attention. A summary document will prove effective in commanding the attention of audiences with limited time, in particular policymakers. Policymaker engagement is limited when considering citizen science, with a key limitation being lack of time and inability to recognise the relevance of projects and activities to current issues. Tailored summary documents that extract significant information, with respect to ongoing and future policy debate, prove effective in engaging policymakers (Hollow et al., 2015).

Example

Capturing Our Coast (CoCoast) was a 3-year project, that trained nearly 3,000 citizen scientists to survey rocky shores, gathering data on marine species to create a wider understanding of coastal biodiversity. The collaboration between 8 partners meant that a systematic approach to planning and delivering this project was essential, to ensure unified ways of working and a clear and consistent message. Each partner was responsible for running free training sessions surrounding identification techniques and survey methodology. It was critical that volunteers were trained to ensure consistency across survey techniques and results. The project created and delivered a 'Train the Trainer' course to professionals in the marine conservation sector. The overall aim of this was to expand the geographic reach beyond the partners' locality to cover regions that were previously not covered. It was critical, therefore, to develop a central technique for the training of volunteers and the training of the 'trainers' to ensure a systematic approach and to ensure consistency in data quality and collection. The project had a clear and systematic approach, identifying its target audience and training requirements early on in the project design. Partners acknowledged that a certain level of scientific knowledge was required, thus prompting the decision to provide face to face training and expand their geographic reach via the 'Train the Trainer' aspect of the project. Clear communication channels and a systematic schedule allowed hubs to exchange ideas of what worked well in their regions and apply them to others to implement and trial with their communities. Critically, the project listened to community needs and identified new opportunities, showing a willingness to tailor their approach to suit the needs of the participant.

Project URL: https://www.capturingourcoast.co.uk/

Recommendation 3: Highlight the benefits of citizen science

In order to establish why stakeholders should engage with citizen science, it is important to highlight the numerous benefits, particularly those that appeal to them. When engaging with policymakers, discuss the benefits of engaging the public with science, leading to a more informed and supportive society. Communities that have a direct understanding of issues feel empowered to act for them, which could increase support for individuals who are legislating for said issues. The involvement of citizens in the evidence base for critical issues increases transparency and promotes participation in the development of policy (Thornhill et al., 2016). Increasingly, importance is placed upon increasing engagement (policy issues) with legislation, with studies suggesting that policy is at its best when members of the public can understand and contribute in some way (Hollow et al., 2015). Collaboration on current policy issues presents the opportunity for a more informed society, who could be more likely to support decisions made by policymakers; this could be done through utilising citizen science data in legislation or running focus groups with participants (Figueiredo Nascimento et al., 2016). Scientists with limited time or funding may wish to establish a citizen science method; a 2017 study determined that, among several citizen science projects, for each hour of training delivered, participants invested 9 hours of sampling, equating a large return on investment (Martin, 2017). Citizen science offers educational opportunities and valuable skills and knowledge to participants, resulting in a more informed and understanding society Educators may be more interested in engaging with citizen science if they understand its benefits; a maintained interest and increased self-efficacy are just some of the benefits of incorporating citizen science in the curriculum (Vitone et al., 2016). It is important to publicize these benefits and inspire participation from other stakeholders.

Example

Industry professionals, scientists and legislators working in the agricultural sector recognise the importance of early detection of invasive pest species in order to implement responsive and preventative procedures. A 2016 study identified the benefits of utilising citizen science for such purposes, highlighting the ability to obtain data rapidly as essential to fast action (Maistrello et al., 2016). A prime fruit-growing region of Italy first recorded evidence of the Asian brown marmorated stink bug in 2012 – citizen science surveys enabled researchers to gather data sets in a short period of time and identified key areas in which breeding populations were established and posed a high risk of damage to crops. In utilising citizen science, professionals were able to see its value, as early detection of potential risks allowed for pre-emptive management strategies to be employed in other at-risk areas (Maistrello et al., 2016). The activity has been developed into an extensive monitoring programme,

while data obtained and strategies employed provided a global model that can be used to identify the invasive pest. Both provide extensive benefits to industry professionals.

Recommendation 4: Consider current policy concerns and align projects with current policy standards

Research suggests that decisions guiding involvement are determined by the purpose and nature of the topic or issue (Hollow et al., 2015). Suggestions can be made, therefore, to consider ongoing or future policy concerns within a project design. In some cases, there is a scientific or societal need for a topic to be researched; in this instance, projects may wish to identify alignment with policy or gather interest among policymakers. However, some projects may wish to identify current or upcoming concerns among policymakers and use them to inform the project topic or design. This increases the relevance of the project to society and offers opportunities to use results to influence policy. Similarly, projects should adhere to the standards and processes appropriate to policymakers, including rigorous and justified methods of data collection, reporting and analysis (Hecker et al., 2018). Pollution is an issue that is widely reported on and is often in the news. Interest from the public, surrounding health and the environment, has led to pollution becoming a topic of mass debate, and so policymakers are already interested in the subject area. Contributing scientific data that can support this debate and aid legislation will be valuable to policymakers. Similarly, pollution is often of local concern and so will attract interest from other key stakeholders, which could further motivate engagement among policymakers, such as local council people.

Example

The Volkswagen emissions scandal was widely reported upon across Europe; the company had been cheating emissions tests and cars had been releasing between 250,000 and 1 million extra tonnes of polluting gases than initially thought (Topham et al., 2015). These gases include Nitrogen Dioxide, which is linked to severe environmental damage and poses a risk to human health, including respiratory problems such as bronchitis (Bosson et al., 2019). Antwerp has high levels of Nitrogen Dioxide, owing to the extensive and busy road systems that span the city, a cause for concern among local residents (Curieuzeneuzen.eu., 2016). CurieuzeNeuzen is a citizen science project that addresses the concern, enabling residents of Antwerp to measure air quality in their local area. Participants mounted an air quality measurement device outside of their street-side window to measure levels of Nitrogen Dioxide. The results implied that a high percentage of sampling locations had project levels that exceed the maximum level detailed by the World Health Organization (Curieuzeneuzen.eu., 2016). Following the study, a survey of participants indicated a rise in the use of bicycles in Antwerp. Similarly, interest in policy options to improve air quality in the city rose, and many participants reported increased positivity and interest in suggestions such as low-emission zones and car-sharing schemes (Curieuzeneuzen.eu., 2016). The project produced accessible and clear data that indicated a key cause for concern; concrete data of this calibre supports the need for debate and can aid legislation by the provision of scientific evidence.

Project URL: https://curieuzeneuzen.be/

Recommendation 5: Identify and respect the uniqueness of communities

Successful projects consider the interests and concerns of target audiences and adapt accordingly in order to promote sustained engagement (Roy et al., 2012). It is important to respect the uniqueness of communities and plan for the targeted demographic, considering the varying motivations, needs and issues of importance to different stakeholders. Conducting projects based on subjects that are of local interest could facilitate continued engagement. For example, alignment with local interest acts as a catalyst for sustained engagement and allow communities to act synergistically and contribute to issues that they identify as pressing to them personally (Rotman et al., 2012). Consideration of the unique interests and needs of audiences is also critical for establishing relationships among participants and project managers, demonstrating consideration of participant motivations (Richter et al., 2018). Frameworks for designing and implementing citizen science projects suggest planning a range of activities that represent the diverse and unique interest of communities. Tailoring supporting materials or activities to specific stakeholders shows respect for diverse interests and motivations (Tweddle et al., 2012).

Example

Mapping for Change is a citizen science project supporting communities to utilise citizen science in response to concerns over local air quality. Utilising citizen science has enabled communities to gather data in their local area and access and understand the results. Understanding the needs of the involved communities allowed Mapping for Change to tailor the approach to suit participants. For example, methods of measurement utilised were less technical and more affordable, allowing participation from all sectors of the communities, including low-income families and more deprived communities (Mapping for Change, 2016).

Project URL: https://mappingforchange.org.uk/projects/citizen-science-used-to-map-community-air-quality/

Recommendation 6: Understand participant motivations

Understanding participant motivations is a critical component of engagement, as motivations differ widely among stakeholders and often determine an individual's desire to contribute to a project or activity (Roy et al., 2012). Additionally, a key principle of citizen science is that all stakeholders benefit from participation, which is often a result of conducting activities or meeting goals that align with motivations (Robinson et al., 2018). For a project to resonate with and appeal to target audiences, considerations should be made as to why people join initially, which will foster ideas for sustaining engagement. This could be explored through surveys, interviews or questionnaires; West (2015) utilised questionnaires to gather opinions surrounding environmental education projects, the findings of which were utilised to reflect upon the work of practitioners in the field and evaluate individual projects. Understanding why volunteers choose to participate means tasks, activities and events can be aligned with the motivations of key stakeholders, initiating engagement with a project.

Example

An essential component of sustained engagement is the enjoyment of the task, which is often in direct correlation to alignment with motivations to participate and fulfilment of personal goals (Curtis, 2015). Galaxy Zoo is an online citizen science project, utilising the efforts of volunteers to categorise galaxies and identify features within them. Raddick et al. (2013) conducted a survey of 11,862 Galaxy Zoo volunteers to identify their motivations for participating. An interest in astronomy (12.4%) and the opportunity to observe galaxies that many others have not (10.4% "Discovery") are popular motivations for participating with this project. The opportunity to contribute to science and research (39.8%), and the recognition of this, motivates a significant proportion of volunteers. Understanding this has allowed the Galaxy Zoo project to implement changes and streamline the activities to better align with people's motivations and maximise participation. For example, recognising volunteers as collaborators to the research and, wherever possible, identifying them by name aligns with the motivation to be recognised as contributing to science and research (Raddick et al., 2010). This also allows other citizen science projects to be planned and executed in light of this information, increasing participation with projects and activities (Raddick et al., 2013).

Project URL: http://zoo1.galaxyzoo.org/

Recommendation 7: Consider instant-gratification citizen-science

Instant gratification, related to congratulatory hits of dopamine and other neurotransmitters, is the mechanism behind motivations for participating in citizen science including selfish or personal interest and enjoyment of gamification and games (Werbach and Hunter, 2012). But beyond the immediate sensation of feeling "good," longer-term motivations such as altruism are also linked to similar neurochemical processes (Bachner-Melman et al., 2005). Citizens may be classified into three types (Ceccaroni et al., 2017):

(1) people who care about and contribute to place-based communities converging around a shared, social concern;
(2) people, not included in type-1, for whom public discourse, social media including games, and citizen science all run through the same router;

(3) people not included in the first two types.

This recommendation focuses on type-2 citizens. Ceccaroni et al. (2017) define "immediate civic response" (ICR) as the response generated in cases in which instant gratification is linked to participation in citizen science, which is often blunted by significant requirements of long-term commitment: type-2 citizens may not want to go through the trouble of membership of the communities that type-1 people appreciate. We now have digital tools fast enough to keep up with citizens' empathy trigger. If people want to help, they take part in a specific, one-off action and suddenly they are part of the solution. ICR potential can be considered together with the socio-technological advances empowering citizens to act as a decentralized super-organism: a pan-humanity sensor-array capable of sensing where problematic issues are, and collecting responses in real-time.

Example

Humans participate *en masse* to BioBlitz's. Being part of the solution feels "good" on a neurochemical level. On the next "Fukushima-style earthquake and nuclear accident", celebrities could tweet for the activation of a global, citizen-science action to collect background radiation measurements (and, more generally, to empower people with data about their environments). Of course, initially, the involvement of celebrities will be felt as an unwelcome invasion of the scientific territory. This involvement can be part of concerts, video footage on consequences of invasive species, or flashing BioBlitz information.

Recommendation 8: Manage expectations of participant workload

It is important to consider strategy and workload extensively, limiting demands of complicated or time-consuming tasks unless otherwise requested. In a studied group of citizen science volunteers, 44% cited they did not have enough free time to continue contributing, highlighting the importance of managing volunteer workload to reflect demand (Farley, 2013). It is recommended that project managers manage their expectations regarding workload. While some volunteers will have lengthy time commitments and will want to contribute a lot, many volunteers cite feeling overworked as a reason for disrupted engagement. Indeed, a lack of clear expectations – in combination with insufficient information to complete a job well – is a known risk factor for volunteer "burnout" (Maslach et al., 2001). Some projects choose to employ microvolunteerism, providing the opportunity for volunteers to make small contributions and vary the time contributed (Bernstein et al., 2013). Bioblitzes – rapid field-based surveys in which volunteers document as many species as possible in a defined location during a defined period (Parker et al., 2018) – allow volunteers to make more varied contributions in terms of intensity and time, and reduces their risk of physical or mental exhaustion.

Example

Running a short scale trial will allow you to gather feedback on the workload and whether it is suitable for your target audience. You may choose to allocate tasks equally among volunteers or register interest and time availability, in order to allocate tasks accordingly. Volunteers who sign up may wish to know the minimum contribution required prior to involvement with the project or activity. The Zooniverse platform encompasses a collection of projects that utilise volunteer effort to analyse large data sets (Cox et al., 2015). Members who sign up to the platform have the option to opt in to be beta testers. During the introduction of new projects to the Zooniverse site, a dedicated community of volunteers test the activity and offer feedback on qualities such as clarity, task design, instructions and ease of completion. As part of this process, Zooniverse requires citizen science project designers to consider, "How much time do you estimate each task (or group of tasks) will take?" and, "Are there any 'easy targets', such as existing interest groups, online communities or clubs?" as part of a questionnaire designed to help manage expectations of volunteer workload.

Platform URL: https://www.zooniverse.org/

Recommendation 9: Involve participants in as many stages of the scientific process as desired

A key principle of citizen science is to allow participants to be involved with multiple stages of the process within a

project or activity (Robinson et al., 2018). Emphasis should be placed on the opportunity for all stakeholders to be involved at multiple points across the lifespan of the project. Early recruitment of participants, for example, allows for the contribution to project design - including aims, protocols, strategies and techniques - providing clarity on the issues of importance to those groups. Involving citizen scientists at multiple stages of the project offers extensive benefits; making participants feel valued and engaged with the intrinsic nature of the project, initiating a sense of belonging and responsibility, and fostering working relationships among all stakeholders (Rotman et al., 2014). These benefits are mutual to participant and project: offering a broader range of knowledge and expertise that could expand the breadth and understanding of the project through a diverse team. It should be noted that there are very successful citizen science projects with highly motivated citizens that are involved only in one activity or phase. It is important to highlight the opportunities in which to involve citizens (see section 4.4) and consider the advantages for the citizens and the project alike.

Example

Farming Concrete, which aimed to determine the amount of food produced in New York City's community gardens, involved gardeners throughout the project. During the initial phase of the project, much of the work involved outreach, where a core team of organizers, community gardeners, and volunteer researchers spoke to community and school gardeners to sign up participants. Once a gardener agreed to participate, they collected data in one or both of two distinct phases: weighing produce throughout the season and counting plants at one to three points in the growing season. This organizational method, whereby participants were involved in multiple stages of the project, encouraged enthusiastic gardeners to partake not just in quantifying their food production, but in outreach as well – providing mutual benefit to the volunteers and project itself (Gittleman 2012).

Project URL: https://farmingconcrete.org/

Recommendation 10: Establish positive working relationships with stakeholders

It is important to ensure positive relationships and effective communication with stakeholders, regardless of audience type or level of participation. Often, sustained engagement is promoted via a connection to the project, something that is often aided by well-established partnerships. Effective communication and relationships are critical for stakeholder engagement and are essential in establishing a shared understanding (Tweddle et al., 2012). Indeed, these relationships have the ability to sustain collaboration and the sharing of knowledge and resource. Positive working relationships are also important for influencing policy; this process is grounded in trust and communication, and so establishing working relationships should remain a motivation among all stakeholders (Vann-Sander et al., 2016). To sustain engagement among stakeholders, it is critical to ground effective communication and a shared understanding of projects. Long term participation is cited as a result of an established relationship, cultivated in common goals and communication (Rotman et al., 2014). Importantly, citizen science is unable to have profound implications among policy development if there is not an established relationship grounded in mutual motivation and common outcome (Vann-Sander et al., 2016).

Example

A 2017 study investigating stakeholder perceptions highlights the importance of establishing positive relationships. The study considered the incentives to participate with monitoring in an engineering project on the river Waal in The Netherlands. Stakeholders included citizens, recreational anglers and boaters and shipping professionals. The participatory nature of the project required trust and established relationships between project partners and stakeholders, and so the study also aimed to gather insights into the relationships between project partners and stakeholders, in order to facilitate engagement. The study found that an established relationship, forged on reciprocal trust, was essential for cooperation between shipping representatives and local water companies. Similarly, it was found that establishing relationships formed the basis of the recruitment of participants for activities within the project (Verbrugge et al., 2017).

Recommendation 11: Use state-of-the-art technology and online tools

The use of new technology and online tools is an efficient way of data collection, and can benefit engagement rates when conducted correctly. Survey123 is a survey-based platform that can be utilised for data collection. Platforms like this, available via mobile devices and not requiring an internet connection, broaden the accessibility for users, allowing for a broader scope and scale of sampling. Utilising online tools for awareness-raising and support is invaluable for projects and activities. Websites, forums and project platforms act as hubs for information surrounding citizen science projects, and so their design and implementation should be carefully considered. Websites that have a clear user journey, accurate and informative content and easy navigation play a large role in sustained engagement, due to their role as a central hub for guidance and information (Newman et al., 2012). Delivering citizen science through media such as online games is a motivating and fun method of engagement. It is important, however, to consider risks associated with advances in technology. Increased utilisation of new technologies in citizen science increases the risk of audience disengagement, particularly when audiences are not acknowledged for their contribution to developing online tools or when the necessity of technologies is not apparent for long term gain within the project (Ceccaroni et al., 2019). This recommendation may be suited more to those creating exclusively online citizen science projects.

Example

Platforms that facilitate the gathering and management of data from participants are increasingly important in citizen science (Lamoureux and Fast, 2019). Survey123 is a free online tool that offers users the option to create forms for an easy and accessible method data collection. In a study of 5 platforms, Survey123 was the only platform that supported web-based surveys and mobile apps that worked on iOS and Android devices (Lamoureux and Fast, 2019). Similarly, the platform also allows built-in databases, the option to import data in various formats and vats options for data management within the app/website and within the overall database. Coastwatch Europe investigates waste found on beaches across the globe, and utilised Survey123 to access data from the global network of volunteers working on the project (Chivite, 2017). Additionally, Glacier National Park utilises real-time functions such as live mapping to assess when and where data is being collected, offering a more visual and exciting way for participants to understand their data (Wold, 2018). The opportunity to access a broader audience geographically is a critical hook for engagement. However, platforms such as this, while free initially, often do incur a cost for more complex analysis and function (Lamoureux and Fast, 2019).

Platform URL: https://survey123.arcgis.com/

Recommendation 12: Offer training and learning opportunities

A key motivation of many participants surrounds the opportunity to learn and experience new things. Where there is a gap between intended participation and actual participation, many volunteers cite opportunities for training or supporting materials as a factor in initial and sustained engagement (Rotman et al., 2014). Offering training, learning opportunities and support is appealing to many members of society; learning new skills like practical work or species identification promotes new opportunities and increases confidence with the tasks, meaning participants are less likely to drop out due to feeling they cannot complete the necessary activities. This remains important when considering that many participants refrain from contributing or uploading data due to lack of confidence in their skills or results and has the additional benefit of increasing the accuracy of data and reducing concerns surrounding data quality (Tweddle et al., 2012). It is important to stress that informal learning is also an important method of skill development within citizen science; conducting the tasks or interacting with the community can offer incidental learning opportunities and develop participant understanding substantially (Jennett et al., 2016).

Example

The British Trust of Ornithology offers a range of survey types to accommodate a breadth of audiences. Volunteers have the opportunity to contribute to information about populations and health of groups of birds by providing details of sightings on an ad hoc or continuous basis. The trust offers a schedule of relevant training courses that vary in strategy, information and length, to suit a wide array of audience needs. Community groups

wishing to participate may choose to opt for a bespoke training specific to their needs and research focus. Many regions host a regional representative, who acts as the point of contact for interested parties to gather information, guidance and resources. For certain surveys, the trust supplies dedicated identification guides and booklets to record findings (The Conservation Volunteers, 2014).

Organisation URL: https://www.bto.org/

Recommendation 13: Address concerns surrounding the quality of data resulting from citizen science projects

Citizen science has the capacity to produce high-quality data that can contribute to research and solve problems; key factors in this are rigorous protocols, correct design and appropriate evaluation, all of which maintain the quality of data (McKinley et al., 2017). Data quality concerns are a key limitation to the recognition of the results and outcomes of citizen science projects. Addressing data quality concerns is critical in engaging stakeholders, particularly policymakers; addressing concerns increases the likelihood of policymakers accepting data into their formal data streams. Projects must consider current and relevant scientific standards and methods, and ensure effective and rigorous data collection and evaluation, in order to present accurate and robust data to policymakers. This will increase the likelihood of being considered and utilised. Concerns with citizen science extend beyond data quality, with many policymakers questioning if citizen science projects uphold scientific standards for monitoring, as well as environmental, scientific and policy standards and methods (Hecker et al., 2018). Implementing thorough protocols, training and planning allow participants to contribute high-quality data (Bonney et al., 2014). Emerging technologies can add to the automation of data quality checks, highlighting anomalous data and analysing trends and patterns (Newman et al., 2012).
It is important to implement current and relevant scientific standards and ensure data are correctly collated, certified and analysed. For example, if collecting water samples, strategies should be designed and enforced to reduce cross-contamination. In addition, when designing projects and allocating workload, an allotted time should be dedicated to identify and remove anomalies within data sets. Resources should be dedicated to addressing data quality concerns; effective methods of quality control, data analysis and curation should be among priorities when considering resource requirements (Figueiredo Nascimento et al., 2016).

Example

As a signatory on the Convention on Biological Diversity, the UK has committed to a strategic plan, detailing goals, targets and information surrounding biodiversity. As part of this, the UK monitors indicator species to analyse trends and assess progress towards the specific goals. Monitoring of the UK biodiversity indicators allows surveillance of key species that offer insight into the overall diversity of nature across the nation (JNCC, 2019). Observation of these indicators, supported by supporting information, has proved effective in communicating key scientific messages to a broad audience. Indicators are reported on by a range of audiences, from the general public to private industries and NGOs. Citizen science is a common method of gathering data to be used within the reports produced (JNCC, 2019). Commonly, NGOs employ citizen science in their data collection strategies. The Joint Nature Conservation Committee, the governmental body analysing the data and producing the report, works closely with the general public and contributing organisations to ensure the results are meeting the standards necessary. Similarly, NGOs employing citizen science are subject to strict data quality regulations, overseen by statisticians in DEFRA (JNCC, 2019). The data gathered and interpreted in these reports feed into policy on a national and global scale; an example of this is the Convention on Biological Diversity Strategic Plan for Biodiversity 2011-2020 (British Ecological Society, 2013).

Organisation URL: https://jncc.gov.uk/

Recommendation 14: Support participants during the project and respond to community needs

Projects and activities work best when participants are well supported, and support channels and methods are carefully

considered. Providing support for participants will not only yield better quality data (a result of increased guidance and confidence) but will also sustain engagement (Tweddle et al., 2012). Communication is critical for sustained engagement; online communities, forums to ask questions, and designated points of contact among project partners all fulfil a variety of support roles to assist participants with issues and facilitate social interaction. Aspects such as quality data and length of engagement are determined by the appropriate support and management of participants. You could offer platforms in which volunteers talk among themselves or fora in which they can submit feedback or suggest improvements. Listen to the community to identify needs and new directions and be willing to adapt and incorporate change. It is important to consider the maintenance cost of support platforms. Monitoring the platform and responding to questions incurs a cost of time from a project manager or volunteer, particularly if supporting a large user base. Investment in resources and person-hours are necessary to provide optimum support, a consideration that should be made when designing the project (Pocock et al., 2014).

Example

Whilst a "one size fits all" approach support does not work because support given needs to be tailored to the individual (Natural England, undated), the OPAL Bugs Count Survey (developed by the Natural History Museum with the University of York, University of Birmingham and Imperial College) – which investigated the effects of urbanisation on terrestrial invertebrates - utilised a wide range of training materials and supporting resources. They provided identification guides tailored to the audience, including a poster showing where to look for invertebrates in urban settings, as well as an identification quiz and PowerPoint training presentation. They also provided a free-to-download group leader support pack and a teaching supplement containing curriculum links for Key Stages 1 to 4 as well as GCSE and A level, whilst also encouraging participants to engage with each other on social media platforms. Moreover, each support element was designed and tested with input from the target audience (see Recommendation 7: Involve participants in as many stages of the scientific process as desired)

Project URL: https://www.opalexplorenature.org/bugscount

Recommendation 15: Provide participants with recognition for their work

Lack of recognition and feeling undervalued often result in suspended engagement with a project or lack of engagement with future projects. Providing recognition for work should be systematically integrated within a project's priorities and design (Figueiredo Nascimento et al., 2016). Adding an "acknowledgements" section to the paper or mentioning the work contributed by participants is a simple yet effective method of recognising participant efforts. Participants could be listed by name; however, this does have implications regarding general data protection regulations (GDPR). A general statement addressing the group of participants as a whole negates this issue. Additionally, the satisfaction of seeing one's efforts put to good use during the project, as a result of sharing data, detailing its use and providing information of progress throughout promotes future engagement and is an important method of making participants feel valued for their contribution.

Example

In 2016, the National Health Service (NHS) launched a new initiative in England in which members of the public who had donated blood received a text message or email, detailing when their blood had been utilised in a hospital. The email thanks individuals for their donation and then explains the process of testing and processing the blood, before describing the name and location of the hospital that it has been used in. Additionally, a fact or statistic (such as the one below) is given regarding the blood type donated and what it can be used for (NHS, 2016).

"Over 1 in 3 people share your O positive blood, which means it's always needed to help treat victims of accidents, mothers in difficult childbirths, and cancer sufferers."

This process highlights the importance of giving blood and encourages repeat donations and inspires others to give also. Only donors who provide contact information and opt-in will be contacted, a process which considers GDPR. Recipients

of the messages state that they enjoy knowing their blood has been used and that understanding the process and location of their donation adds a personal component to the process, of which they were keen to share with friends and family (NHS, 2016). A similar process could be designed and implemented among citizen science, in which participants receive information regarding where and for what their data is used.

Campaign URL: https://www.blood.co.uk/news-and-campaigns/news-and-statements/blood-donors-texted-when-their-blood-goes-to-hospitals-to-save-lives/

6.2 Stakeholder Mapping

Table 1 depicts which of the recommendations would be suitable for use in engaging different stakeholders. Stakeholders are identified in figure 1, encompassing academia, educators, the public, NGOs and CSOs, industry and SMEs, the press and media and policymakers and funders. The table uses crosses to indicate whether the listed recommendation (numerical value only) is able to be utilized among the listed audience.

	Recommendation														
Stakeholder	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Academia	X	X	X		X	X	X			X	X			X	
Educators	X	X	X		X		X			X	X	X		X	
The Public	X	X	X		X	X	X	X	X	X	X	X		X	X
NGOs and CSOs	X	X		X	X	X	X	X		X	X		X		
Industry and SMEs	X	X	X		X	X	X			X	X	X	X		
The Press and Media	X									X	X				
Policymakers and Funders	X	X	X	X	X					X	X		X		

Table 1 - Relevant recommendations among the identified groups of stakeholders

6.3 Case Studies

The following case studies give examples of how citizen science projects have utilized the above recommendations.

6.3.1 Naturehood

Naturehood is a UK based citizen science project, focusing on local garden wildlife. Volunteers sign up via the website and are presented with several options. Participants can map their garden, conduct wildlife surveys, and record their wildlife actions (already existing and newly implemented).

Naturehood uses a website that is mobile-optimised for data collection (*recommendation 11: Use state-of-the-art technology and online tools*). Volunteers have the option to print paper versions of the ecological surveys but are asked to upload the results of these to the survey forms on the website. Directly inputting the data and not using a paper form, for example by using a mobile device whilst outside, removes a step that could be a barrier to some people and is more efficient than copying the results/sending in paper forms (*recommendation 14: Provide participants with support during the project and respond to community needs*).

Participants are offered 'spotters guides' that give them key identification tips and help them identify focus species. Naturehood also runs events, such as public walks and talks by experts, who give participants more information on the species. Participants can also test their knowledge by taking online wildlife quizzes to understand how well they can identify key species or signs of species they are surveying for. The quizzes provide the project team with a measure of the likely accuracy of the participants' surveys and allow them to filter out and check responses when people get a low score on the quiz (*recommendation 12: Offer training and learning opportunities*). The team also consider existing biological recording for each area to check if the sightings provided are likely or not (*recommendation 13: Address concerns surrounding the quality of data resulting from citizen science projects*).

Participant motivations are carefully considered in project engagement plans. The team also conducted local and national consultation surveys to try and identify motivations and barriers, and designed the project in a way to try and minimise the barriers and capitalise on the motivations people may have for getting involved *(recommendation 6: Understand participant motivations and recommendation 5: Identify and respect the uniqueness of communities*). Naturehood is advertised online in many ways. Search engine optimisation is used to boost the website if people search for terms involving garden wildlife or citizen science. Naturehood has active social media accounts (Facebook and Twitter) for each individual area as well as the general Earthwatch social media channels. A communications plan is used to engage local radio/TV, and Community Engagement Officers have been interviewed in local newspaper and radio shows through seasonal campaigns. A range of events are run within the Naturehood's, often alongside other local groups in order to increase awareness of Naturehood. The project also plans to provide signs that people can put up in their gardens/windows to show that they are taking part in Naturehood and gardening for wildlife, as signs may help to change perceptions of untidy gardening. There are plans to launch a YouTube channel, hosting short monthly videos focusing on what people can do for wildlife. Engagement approaches are consistently evaluated by checking how many people sign-up and act (*recommendation 1: Carefully consider the design of the project*).

6.3.2 FreshWater Watch

FreshWater Watch (FWW) is a global citizen-science project, started in 2012, investigating the health of the world's freshwater ecosystems. The main parameters measured are nitrates, phosphates, bank vegetation, wildlife presence, pollution sources, water level, water colour, presence of algae, and turbidity. A project leader is established to run sub-projects in a designated area. FWW has an app which can be used to upload data in the field. For those with access to mobile phones with internet capabilities, this can be a very fast and simple method of uploading their data. The app will also pinpoint your location using GPS, making it easier to provide the required information on where you are sampling. However, there is also the option of using a paper sheet to record, and either uploading the data yourself on the website, or sending your results to the project leader to upload. This was critical to the project design as a flexible method, so as not to exclude anyone from participating (*recommendation 11: Use state-of-the-art technology and online tools and recommendation 14: Provide participants with support during the project and respond to community needs*).

Often, project leaders have had direct training via the Train the Trainer methodology, as well as having access to in-depth support to help them understand how to use FWW (*recommendation 12: Offer training and learning opportunities*). For group members, an email inbox is monitored, offering help and support. This usually consists of

technical support, understanding how data are used, and understanding the implications of the findings (*recommendation 14: Provide participants with support during the project and respond to community needs*). When group members sign up to FreshWater Watch, they have to watch a training video and pass a quiz to show they have understood how to use the FreshWater Watch method (*recommendation 13: Address concerns surrounding the quality of data resulting from citizen science projects*). There are also training materials available online, including learning modules about freshwater challenges, which users can access to learn more.
The data-collection method used is simple, replicable and clearly laid out (*recommendation 1: Carefully consider the design of the project*). Volunteers are trained by their project lead and their sampling is often replicated by the project lead in the early stages of the project and checked for consistency. Data are reviewed after they have been uploaded for inconsistencies or mistakes. Data should be open access and available for anyone to scrutinise and use in their own work (*recommendation 13: Address concerns surrounding the quality of data resulting from citizen science projects*).

6.3.3. Doing It Together Science

Doing It Together Science (DITOs) began in 2014, and aimed to raise awareness of citizen science among the public and policymakers. This was primarily conducted by hosting over 500 events, workshops and activities of varying scale and subject across Europe.

The DITOs partners consisted of organisations spanning multiple European countries. The expanse of project partners allowed for a diversity of understanding, skills and languages spoken, spanning a broad range of accessibility for different audiences (*recommendation 1: carefully consider the design of the project*).

DITOs employed a variety of techniques and approaches to engagement in order to enable diverse audiences, interests and skill-levels to be accommodated within their events, providing a wide range of activity types to appeal to different interests and desired participation (*recommendation 5: Identify and respect the uniqueness of communities*). Similarly, DITOs directly appeals for participants to get involved with activities that align with their interests, needs, skills and, importantly, time availability, offering activities that engage people from a range of backgrounds and interests (*recommendation 6: understand participant motivations and recommendation 8: Manage expectations of participant workload*). Workshops provided opportunities to get involved with pre-made activities that provided step-by-step instructions (available in 7 languages) so that all participants can take part, no matter their skill level (*recommendation 12: Offer training and learning opportunities*). During the final event of the project, a presentation was given detailing the participant journey, in which those involved were recognised for their contribution (*recommendation 15: Provide participants with recognition for their work*)

6.4 Creating a new project

Below is guidance, based on existing literature, on how to create a new citizen science project that includes long term engagement and awareness, but also encompasses clear aims, design and implementation, and volunteers' perspectives and involvement.

Consider a research topic or question.

It is important that the focus of the project is clearly defined and offers an opportunity to generate new understanding or knowledge of the subject area (Robinson et al., 2018). The project should aspire to conclude with a clear scientific relevance, answering a key question or informing policy, decision or action (Robinson et al., 2018). There are various strategies for designing a research question or topic, such as (1) scientist driven, top-down approaches, or (2) community-driven, bottom-up approaches, both of which offer unique perspectives and ground the topic in issues of importance (Newman et al., 2012). A topic of importance to policy needs or debate could be the foundation for research focus.

Consideration of the target audience is important at this stage. In many citizen science projects, data collection will be conducted by volunteers who may have a lower level of understanding of the topic than project scientists. Therefore, a complicated research topic or question will require a higher level of resource and training investment, and will likely attract fewer participants (Bonney et al., 2009).

Form a project team.

An interdisciplinary team of stakeholders is a critical component for success in citizen science projects. The benefits of a united and diverse approach are numerous, offering the opportunity to share knowledge, expertise and resources (Elwood et al., 2017). Relevant stakeholders will vary dependent upon subject area and context of the research project, but could include communities and groups, businesses, researchers and policymakers (Grace et al., 2015). Emerging technologies may shift the process of recruiting a team, allowing the identification and location of professionals and resources that may not be accessible otherwise (Newman et al., 2012). When building a team, it is important to make considerations for the array of needs of the project, including scientific understanding, communications, data analysis and volunteer management. Needs may vary depending on the scope of the project, so it is important to consider this extensively to ensure the achievement of the project aims (Dickinson and Bonney, 2012).
Also, it is important at this stage to consider the level of involvement of volunteers. Contributory Citizen science projects utilise a top-down approach to design, in which projects and activities are designed and ran entirely by scientists and the project team, limiting volunteer involvement to data collection. Co-created projects establish a partnership between the project team and the volunteers, allowing collaborative design and involvement of volunteers in most, if not all, aspects of the process, including design of the research question and process, data collection and analysis (Tweddle et al., 2012; Robinson et al., 2018).

Establish clear project aims and consider if a citizen science approach meets these aims.

It is important that the aims of the project are agreed upon and established early within the process. Clear, defined aims are important for tracking progress and ensuring the outcome of the project is met. Communication of aims, both personal and project-wide, is important to ensure a consensus in priorities.

Establishing these aims will allow project managers to consider whether citizen science is the best approach. As illustrated in 31Figure 2, created by Pocock et al. (2014), considerations should be made to many aspects of the process. The approach taken should be carefully considered to ensure a citizen science approach is most appropriate. Considerations made should include how clear the aim or question is, the importance of engagement to the project or activity, the resources available, the sampling scale, how simple the protocol is and the motivation of participants. Aims surrounding engagement, resource, sampling scale and complexity, and volunteers should be considered when designing the approach to be taken.

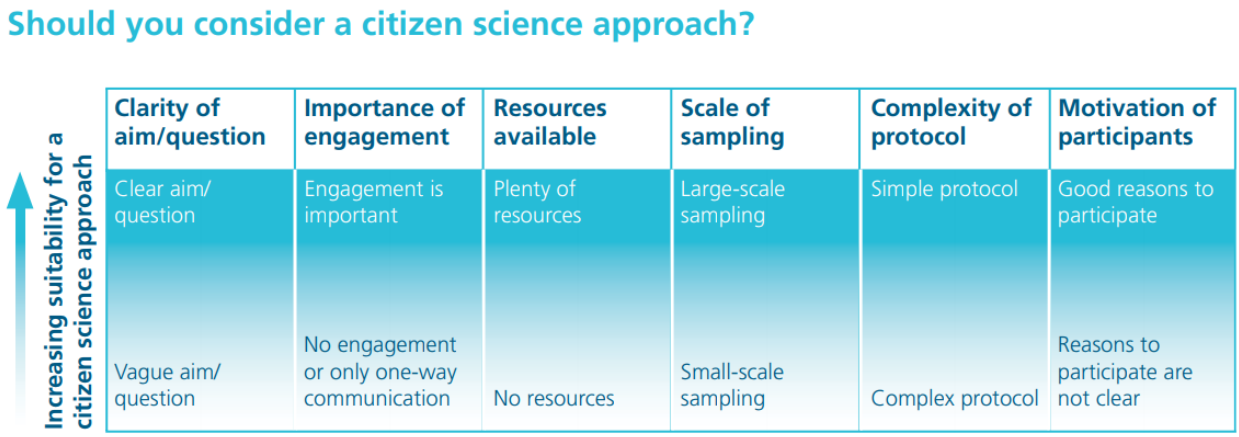

Figure 2 - Diagram describing the factors to consider when exploring a citizen science approach. Source - Pocock et al., 2014.

Consider resources and funding.

Though citizen science is generally considered to be a cost-effective approach, high costs are incurred within projects, often for resources and platforms. Resource and funding needs will vary depending upon the scope, scale and size of the project, so it is important to establish requirements among the team early on, in order to begin sourcing accessible funding from external organisations and funding bodies, which could take time to consider and approve applications (Locke et al., 2019). Use of free platforms for hosting websites or resources that are readily available through project partners could be a cost-effective way of sourcing required resources.

Develop protocols and strategies, data collection techniques and supporting materials.

The developmental phase of the project is critical, and establishes the ways of working and ultimately, the outcome of the project. During this phase, project managers could choose to test these protocols through small scale trials with target audiences. This allows the opportunity for protocols to be refined to maximise outputs. Critically, this phase considers the limitations of the project. Considerations should be made to the following:

- *Designing the data collection method* – this is the foundation of many citizen-science projects and so should be agreed upon as soon as possible. Will volunteers be collecting samples in remote areas? Is there any risk assigned to data collection? Will data be submitted digitally, online or via an app, or will paper forms be distributed? Strong protocols for data collection allow participants to understand collection methods clearly, and are integral for the collection of accurate data (Bonney et al., 2009).

- *Protocols for data quality and upholding scientific standards/techniques* – a key detriment to citizen science projects is the consideration that data are of a lesser quality than traditional science projects. It is essential to establish protocols for sampling to ensure that the data collected are as accurate as possible. It is critical to ensure that established protocols and methods are utilised to align with recognised scientific standards and techniques.

- *Methods for storage and analysis of collected data* – this process is often lengthy and requires significant person-hours, so considerations should be made early on about designation of tasks to project partners or volunteers. Analysis of data is an important step, as it offers the potential to highlight and remove any incorrect data.

  Engagement and support of volunteers – provision of supporting and learning materials and training should be established prior to the recruitment of volunteers. Additionally, methods of sustaining engagement are important

to consider to retain volunteers for the duration of the project.

- *Technological requirements* – digital platforms, such as websites, apps and online data collection methods need to be adopted, adapted or developed. They then need to be tested for issues and usability before the launch of the project.

- *Learning/support materials* – learning and support materials need to be developed to address potential knowledge gaps or issues with survey and identification techniques. These materials are an important component of establishing an understanding of the project and ensuring volunteers feel confident and capable of sampling.

- *Legal and ethical protocols* – it is the responsibility of project leaders to consider the legal or ethical implications of their research. This could include, but is not limited to, issues surrounding copyright or intellectual property, confidentiality, and the impact of activities (e.g. environmental damage) (Robinson et al., 2018).

Recruit volunteers and raise awareness of the project.

Target audiences should be identified clearly by the project team; communities are unique, and strategies for recruitment and retention may vary depending upon the targeted groups. Understanding and respecting the motivations of participants is important to recruitment, as it will determine the protocols and approaches used. Commonly identified approaches that are determined by variance in volunteer motivations include language style, training methods, supporting materials and sampling strategies, all of which will vary among potential volunteers (Locke et al., 2019). As with the previous step, it can be useful to test protocols and approaches to assess their suitability for the target audience, offering the opportunity to refine methods and having the additional benefit of engaging with a community, establishing a working relationship (Tweddle et al., 2012).
Awareness-raising is an important component of recruitment, as it highlights the available opportunity in a variety of channels and facilitates gathering interest from potential volunteers. Awareness-raising methods vary, and are discussed in detail in deliverable 4.2. Recruitment methods and materials should reflect the target audience, and should be varied to attract volunteers using different channels (Bonney et al., 2009). This could include, but is not limited to, articles, radio and television, social media, flyers, posters and presentations. Also, it is important to raise awareness of projects directly with potential volunteers, through face-to-face channels such as attending conferences and events or hosting workshops, and appealing to established groups (Cooper et al., 2007). It is critical, regardless of the channel, to ensure there is a clear hook and that the aims of the project are conveyed (Locke et al., 2019).

Offer training for volunteers.

Provision of training for volunteers is an essential component of citizen science projects and activities. A key motivation of many volunteers is the opportunity to learn new skills. At the same time, data quality concerns can be addressed through the provision of training, equipping volunteers with the necessary understanding and confidence to partake in data collection (Bonney et al., 2009). Sustained participation and high-quality data are often a result of rigorous support and training; therefore, it is important not only to consider this, but also to ensure it is useful. Gathering input from volunteers on the training provided is an essential step in the process of creating a project, as it ensures volunteers are sound with their understanding of data collection (Cooper et al., 2007).

There is a variety of methods that offer support in this area, such as Train the Trainer courses, identification-skills classes, mentoring schemes, provision of learning materials and provision of survey instructions. Resources of this nature will be hosted on the EU-Citizen.Science platform. For example, the British Trust of Ornithology offers training courses ran by regional representatives, providing guidance of survey techniques and use of recording booklets and identification guides (British Trust of Ornithology, 2019).

Data collection, analysis and interpretation.

During this phase, data will be gathered and submitted. It is important, during data collection, to offer initial feedback

to participants, to guide them on next steps. This could be regarding the expansion of spatial range, increasing the number of data sets or supporting the accuracy of data points.

Information submitted must be analysed and edited; the large size of data sets can be a challenge, but are often favourable in citizen science projects, as they yield strong trends and patterns, making anomalies easily identifiable (Bonney et al., 2009). Large quantities of data are increasingly easy to manage, owing to innovations in software's that can store, analyse and interpret data (Newman et al., 2012). Raw data should be made accessible to volunteers and external audiences, encouraging them to study data and make interpretations, offering an additional learning experience (Bonney et al., 2009). Data analysis techniques will vary depending upon the type of data being collected (e.g. qualitative or quantitative).

Distribute and publish results.

A key principle of citizen science is to provide the results to the public, sharing data in an open-access format, providing there are no conflicts with data privacy or ethical consideration (Robinson et al., 2018). This is important not just for interested parties, but also for demonstrating the impact that volunteers have had, which could encourage new participants to get involved (Bonney et al., 2009). Methods of distributing the results may vary from publication on project websites and media channels, to formal publication in scientific journals or distribution among scientific and educational organisations. It is important to recognise and acknowledge the valuable contribution made by volunteers – this can be done in the form of acknowledgement in any formal or informal publication, sending thanks via project channels or hosting an event (Tweddle et al., 2012).

Evaluate the project and its outcomes.

The final step is to evaluate the project, considering the quality and collection of data, volunteer experience, scientific output and wider impact (Robinson et al., 2018). It is important to consider how the project outcomes and aims have been met, highlighting areas of success that can be used to inform other projects and taking into account improvements to be made in projects to follow (Bonney et al., 2009). Projects such as the Measuring Impact of Citizen science (MICs) project aim to establish new solutions for evaluating the impact of citizen science, on a social and environmental scale, and could prove valuable in the evaluation stages of projects and activities. At this stage, volunteers should receive feedback from the project team, detailing the outcomes and implications of their work, particularly where it has had an impact on science and policy (Robinson et al., 2018).

7 Conclusion

The EU-Citizen.Science project and its partners aim to provide a comprehensive and sustainable platform, offering relevant scientific direction and best-practice examples, carefully curated to be accessible to various stakeholders that encompass citizen science in Europe. This deliverable contributes to this, providing a list of recommendations for achieving engagement of multiple stakeholders with citizen science. Through identification of existing projects and analysis of best practice, this report establishes a framework for improving sustained engagement with projects.

Deliverable 4.1 is an output of tasks 4.1 “Achieving societal awareness and engagement in science through existing citizen-science networks, projects and multiplier events” (Months 1 – 34) and task 4.2 “General policy recommendations for citizen science” (Months 1 – 30). Parallel steps include the delivery of D4.2, which focuses on awareness-raising for citizen science, as well as contributing to WP5 through the development of a “Train the Trainer” methodology. Within this deliverable and deliverable 4.2, WP4 has provided the consortium with guidance and concrete assistance on how to achieve societal awareness and engagement in citizen science, producing an overarching set of guidelines and developing instructions on how to start a new citizen-science initiative.

8 Next Steps

This deliverable will be adapted to become an accessible and transparent resource that will be hosted on the project platform. This adaptation will include a further review of the list of recommendations to ensure clarity and usability. It will include supporting information regarding the use of its content to promote engagement in new and existing activities. This deliverable will also contribute to other resources hosted on the platform, following a period of review and adaptation. The set of recommendations produced in D4.1 aims to assist practitioners and participants with achieving long term engagement among all stakeholders; initially, these recommendations are based on literature, but WP4 will use the platform to provide guidance on how to include them locally. Within this list of recommendations, the examples will be developed upon to include links to reports or media contributions (where relevant) and visuals, for example. Section 6.4. of this deliverable details how to create a new citizen science initiative. This section will be developed into an online resource that can be hosted on the platform and utilised by practitioners and participants. We will highlight the critical points that emphasise tools for engagement. We will highlight the different project types and phases available in citizen science in greater detail, to appeal to those with a lesser understanding of these components of project creation and highlight the various methods of stakeholder involvement. Between months 15 and 34, WP4 will guide partners to develop a business plan to engage local entrepreneurs in citizen-science activities as a way to enhance participation. The work package will consult project partners and use the expertise of the corporate-partnerships team hosted within Earthwatch to describe how best to engage local businesses. WP4 will update the project platform throughout the project and task timelines, to reflect consultation with project partners and developments in the field.

While the deliverable provides the consortium with guidance and concrete assistance on how to achieve societal engagement, future activities will include liaising with project partners and third parties to identify existing activities in their country within which the recommendations can be utilised to improve engagement. We will liaise closely with project partners to discuss local activities, following which we will begin to catalogue the identified events and their target audiences, to provide appropriate recommendations. This work will be conducted between months 15 and 34. WP4 will work with partners in adapting existing events and using workshop materials and the training tools developed in other WPs to improve engagement. Earthwatch will also assist partners in identifying stakeholders, audiences and activities at the local level, as well as demonstrating the benefits of linking existing networks and agencies to improve engagement and awareness. This work will be conducted between months 15 and 34.

Discussion with project partners highlighted the necessity to offer specific guidance for individual stakeholders, incorporating participation at the various phases of initiatives, examples of best practice, the benefits to these stakeholders, and statistics that promote the relevance and successes of citizen science. As a result of this discussion, WP4 aims to develop a toolkit, including a series of documents aimed at individual stakeholder groups, that will guide partners, third parties and external parties in engaging specific audiences with citizen-science initiatives.

The outputs of tasks 4.1 and 4.2 will be measured using the EU-Citizen.Science evaluation framework, a result of task 7.1 produced by work package 7. As an output of these tasks, deliverable 4.1 will be measured using this framework. Within the tasks' remaining timeline (months 15 to 34), this framework will be utilised to ensure that the envisioned impact is achieved.

The deliverables of tasks 4.1, 4.2 and 4.3 aim to help the EU-Citizen.Science consortium to strengthen engagement with citizen science across Europe, providing examples of good practice and excellent resources, useful to a broad community. As a result of the activities in WP4, the project expects to achieve an increased engagement with citizen science amongst the identified stakeholders across Europe. Therefore, it is essential to evaluate the outputs to ensure they align with the aims of the project. Throughout the tasks, and following the development of resources for the platform resulting from this deliverable, the evaluation framework will be utilised to ensure that the outputs align with the project objectives.

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