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D6.1
IMPACT ASSESSMENT METHODOLOGICAL FRAMEWORK

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ACTION

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Abstract	This deliverable describes the ACTION impact assessment methodology, the co-design process followed for its development and how it will be applied to CS projects and to ACTION overall. The ACTION impact assessment methodology considers scientific, social, economic and political impacts; it links CS impacts to EU Sustainable Development Goals (SDGs) and considers also the potential contributions to MORRI indicators. Its aim is to support the ACTION consortium, but also CS managers and researchers working on the benefits of CS, by providing a multi-dimensional, flexible and adaptable framework to be used in their work. This framework is under usage at the time of writing as an internal tool for assessing ACTION's pilots and will be regularly improved and updated in the next months of the project by taking on board feedback coming from its application. It is complementary with D6.2 which offers data gathering instruments to be used in the actual application of the methodology here described.
Keywords	Impact assessment, CS, SDGs, MORRI

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ACTION

EXECUTIVE SUMMARY

This document presents the first version of the ACTION methodological framework for impact assessment. It has been developed following a co-design approach engaging the ACTION consortium partners and the six citizen science pilots participating to the first edition of the ACTION accelerator. What presented in the document is, nevertheless, a work in progress: this framework is going to be constantly improved during the next months of the ACTION project by taking on board the lessons learned during its application and the feedback that will be gathered by the citizen science projects that will participate in the second edition of the ACTION accelerator.

The ACTION impact assessment framework considers five areas of impact: scientific, social, economic, political and environmental which are articulated in several dimensions each, for a total of 23 dimensions. These include, but are not limited to, impact on scientific knowledge, community empowerment, inclusiveness, impact on learning, behavioural change, impact on policy process, job creation and economic empowerment of local communities. An analysis of previous impact assessment methodologies supported the definition and the operationalisation of each dimension.

Besides these five areas of impact, the methodology considers also the transformative potential of the CS pilots, i.e. the degree to which the pilot can help to change, alter, or replace current systems, the business-as-usual in one or more fields such as science production or environmental protection. Finally, the methodology considers also how CS pilots and ACTION as a whole contribute to the United Nations Sustainable Development Goals (SDGs) and to the promotion of Responsible Research and Innovation (RRI).

The methodology is quali-quantitative and is designed to be modular and flexible in order to be able to adapt to the specificities of each CS pilot but, at the same time, assure a cross-pilot and cumulative analysis. Indeed, not all the dimensions are (equally) relevant for all the CS pilots, depending on their nature, their specific focus and the level of citizen engagement they show. The specific needs of each pilot in terms of impact assessment and the relevance of the various dimensions were collected and presented through an impact assessment canvas: a four pages graphic form that supports CS pilots in mapping their stakeholders, their main outputs and the relevance of the impact dimensions. Then, for each pilot, an ad hoc impact assessment process is defined, accompanied by the necessary data gathering instruments (questionnaires, focus group guidelines, data recording matrixes).

In the following months of the ACTION project, the methodology here described will be applied to approximately eight CS pilots, following a mixed methods approach. At the end of this process the methodology and the related data gathering tools will be updated and applied to the six pilots engaged in the second edition of the ACTION accelerator. In parallel, the impact of ACTION as a whole will be assessed considering the aggregated impact of all the CS pilots plus other specific impacts generated by the ACTION outputs, such as the ACTION toolkit, policy briefs and other research outputs. At the end of the ACTION project (January 2022) a final impact assessment report and a final version of this methodology will be released.

The methodology and the related data gathering instruments will be included in the ACTION CS toolkit, accompanied by a video tutorial so that other CS pilots, even after then end of the ACTION project, will be able to access it, adapt it to their specific needs and carry out impact assessment activities in an autonomous way.

List of abbreviation

CBA: Cost Benefit Analysis
CS: Citizen Science
DIY: Do-It-Yourself
EC: European Commission
ECSA: European Citizen Science Association
MCA: Multi-criteria analysis
MORRI: Metrics and indicators of Responsible Research and Innovation
PPSR: Public Participation in Scientific Research
ROI: Return on Investment
RRI: Responsible Research and Innovation
SDGs: Sustainable Development Goals
SROI: Social Return on Investment
VIVA: Volunteer Investment and value Audit

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1 INTRODUCTION

As reported by the International Association for Impact Assessment (AIAI) on their website, “Impact Assessment simply defined is the process of identifying the future consequences of a current or proposed action. The ‘impact’ is the difference between what would happen with the action and what would happen without it” (IAIA, 2010).

Accordingly, the aim of this deliverable (and more generally of Task 6.1) is to develop a methodological framework to assess the impacts of the ACTION project and of its citizen science (CS) pilots. This means replying to the following question: “What is the difference the ACTION project makes?”.

More precisely, in the case of ACTION, its impact is represented by the sum of its CS pilots’ impacts, plus other project activities. We are also interested in understanding how the ACTION activities and outputs support the maximisation of the CS pilots’ impacts. In order to be able to investigate these research questions, we need to carefully assess the impact of the ACTION’s CS pilots first.

To this end, we developed a modular and flexible framework that will support us in doing so. The impact assessment team will use this framework to evaluate the impact of ACTION’s pilots at the end of the ACTION Accelerator (round 1 and 2) and the impact of the ACTION project overall (at the end of its second year of activity and at its conclusion).

After rounds of improvement of the framework in collaboration with the ACTION pilots, we will turn the impact assessment framework into dedicated tools that will be included in the ACTION CS toolkit (WP4-5). This will help CS initiatives to define and evaluate their impacts in an autonomous way after the end of the ACTION project.

The ACTION impact assessment framework considers five areas of impact. These areas are: scientific, social, economic, political and environmental. Each area of impact is articulated in several dimensions: overall this framework considers 24 dimensions.

The ACTION impact assessment framework also considers the relevance of the project achievements against the United Nation Sustainable Development Goal (SDGs)(UN, 2015) and its contribution to responsible research and innovation (RRI to be analysed referring to the MORRI indicators; EC, 2018b).

The deliverable is structured as follows: section 2 sets the scene and provides the background of the ACTION impact assessment methodology by pointing at relevant references on the topic, describing the co-design process followed for developing the methodology and mapping the ACTION stakeholders.

Section 3 represents the core of this document and defines the five areas of impact considered and the related dimensions and indicators. It also describes how we will consider the transformative potential of the ACTION’s CS pilots and how we will move from the analysis of the CS pilots to the assessment of ACTION project as a whole.

Section 4 discusses how we will map pilots’ contribution towards SDGs targets and discuss the applicability of MORRI indicators to ACTION.

Section 5 presents the data gathering and analysis process that will be undertaken in the next months. Finally, in the conclusions section recap the next steps of the impact assessment activities to be performed in the next months and show the complementarity of this deliverable with others.

ACTION

2. Toward the ACTION impact assessment framework: definitions and references

The socio-economic impact assessment methodology here proposed is based on frameworks developed and validated in previous European projects by the authors, including SEQUOIA (Passani et al., 2014), MAXICULTURE and, especially, IA4SI (Bellini et al., 2014; 2016; Passani et al., 2015) and iScape (Nurmi et al, 2017). These approaches have been reconsidered and adapted according to ACTION's field of work and enriched by the results of the literature review activity that is reported in section 2.

The ACTION methodology follows the impact value chain approach (Figure 1**Errore. L'origine riferimento non è stata trovata.**), which is the de facto standard for many international bodies, including the European Commission (EC).

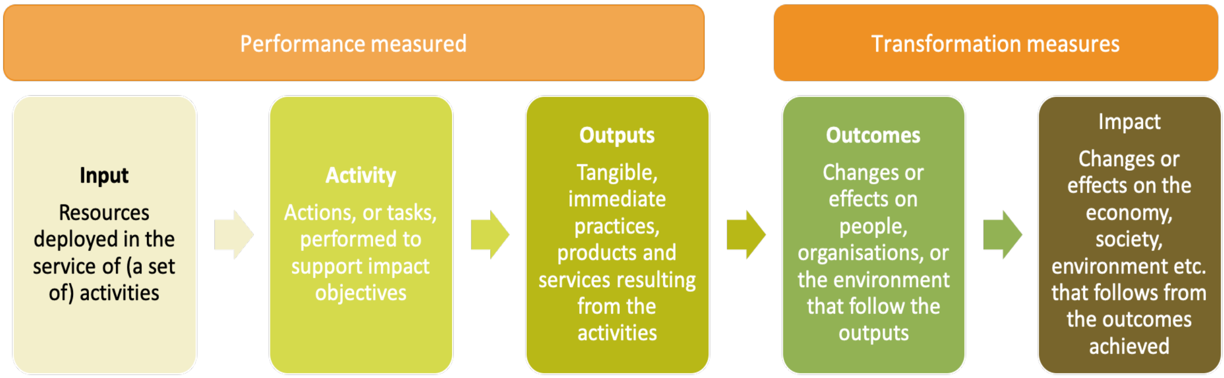


Figure 1 Impact assessment framework: the value-chain approach (T6 elaboration on IMWG, 2014:6).

As reported in Figure 1, the impact is the result of the input available (i.e., the EC grant for ACTION and the ACTION open call funds for the ACTION's pilots), of the activities carried out and the tangible results developed during the project lifetime (outputs). The aggregation and analysis of the outputs is the preliminary step to derive the outcomes of the project's activities. Another important element is the identification of the stakeholders and the analysis of how each of them will be impacted by the project (see subsection 2.5).

It is important to consider that we will describe the impact developed by the ACTION and by its pilot at the end of their activities, while most of the impacts need a longer time frame to become visible (EC, 1999). Therefore, we will be talking, mainly, about expected impact: impacts that appear to be probable to happen under certain circumstances that are observable at the time of the impact assessment or that will be set as hypotheses.

2.1 Assessing the impacts of CS

There are indications that CS projects provide inputs for both science and society, to foster innovation and to find common solutions to regional, national and global challenges (Theobald et al., 2015).

Accordingly to Kieslinger et al. (2017, p. 3), CS can have several positive impacts, among others:

- collect a large amount of data sets widespread in many different areas across the world, with a significant impact on environmental research and biological science,

- attract more scientists in trans-disciplinary work,
- innovate science communication,
- create knowledge about scientific enquiry and enhance a deeper understanding of scientific outcomes and
- contribute to Responsible Research and Innovation (RRI).

There are different ways to recognize and evaluate CS projects outcomes but collecting evidence to assess CS projects' impacts in a systematic way (considering several dimensions at the same time) is still a challenge. This is mainly due to the diversity of CS activities, ways of engaging citizens and fields of action. Beside this, there is often a lack of competences, time and/or resources of CS teams to carry out impact assessment activities.

As we will see in the following sub-sections, some attempts have been made to create guidelines for supporting CS projects' managers (e.g., Citizen Science White Paper, Socientize, 2015) and Green Paper on the Citizen Science Strategy 2020 for Germany (Bonn et al., 2016)), but the research in the field is still ongoing and this deliverable wishes to contribute to the related debate.

Indeed, despite the steps made, a standardized impact assessment framework - including relative indicators and operational tools - is still missing. There are several tools dedicated to one or more specific impacts of CS (impact on learning, for example) but, as stated by Shirk et al. (2012), "dealing with the Citizen Science project impact assessment implies the necessity to adopt a more holistic approach" (Dickinson et al., 2012; Haywood B. K.. Besley J. C., 2014).

Kieslinger et al., (2017) deeply studied the issue and carried out an extensive literature review, which results are summarized in the Table 1.

Outcome focus	**Discussed and described in (exemplary selection)**	**Attributes[1] of the evaluation**	**Measures of the evaluation**	**Actors/social object involved in evaluation**
Learning outcomes	Phillips T. et al. 2014	Summative evaluation (evaluation report based on evaluation plan and evaluation questions) Self-reports or observations	• self-efficacy for science • self-efficacy for environmental action • increased motivation • behaviour change • development of stewardship • skills, knowledge and interest in and for science	Practitioners, Project leaders/coordinators, educators/outreach specialists
Learning outcomes	Bonney et al. 2009	Quantitative and qualitative measures: • pre- and post-project surveys • surveys of self-reported knowledge gains • interviews with focus groups	• the duration of involvement • numbers of participants • improved and enhanced understanding • better attitude • development of skills and interests	Participants

[1] For the authors Kieslinger B. et al., "the attributes provide the context to measures"

			• examination of e-mail and listserv messages	
Scientific outcomes	Bonney et al. 2009	Quantitative and qualitative measures: • pre- and post-project surveys • surveys of self-reported knowledge gains • interviews with focus groups	• numbers of papers published • numbers of citations • numbers of grants received • size and quantity of citizen science databases • numbers of theses • frequency of media exposure	Participants
Socio-ecological outcomes	Jordan et al. 2012	Not explained	• Enhanced social capital • community capacity building • economic building (in terms of job creation) • creation of trust between public and scientist, and land managers • Development of resilience of socio-ecological systems	Community

Table 1 Literature review's results, (source: Kieslinger et al. 2017)

In the following, we introduce the frameworks that have been more useful for us in developing our approach and elaborate on what is missing from them, as well as how we have integrated them in our framework (see section 3). For a systematic literature review on impact assessment methodologies in the field of CS the reader can refer to the recent outputs of the MICS project reported in When et al (2020a) and (2020b).

Shirk et al. (2012) elaborated a framework that can be used by project designers to align CS project design "with specific desired outcomes". This framework, as ours, is based on the impact value chain approach and, as reported in Figure 2, considers three types of outcomes: for science, for socio-ecological systems and for individuals.

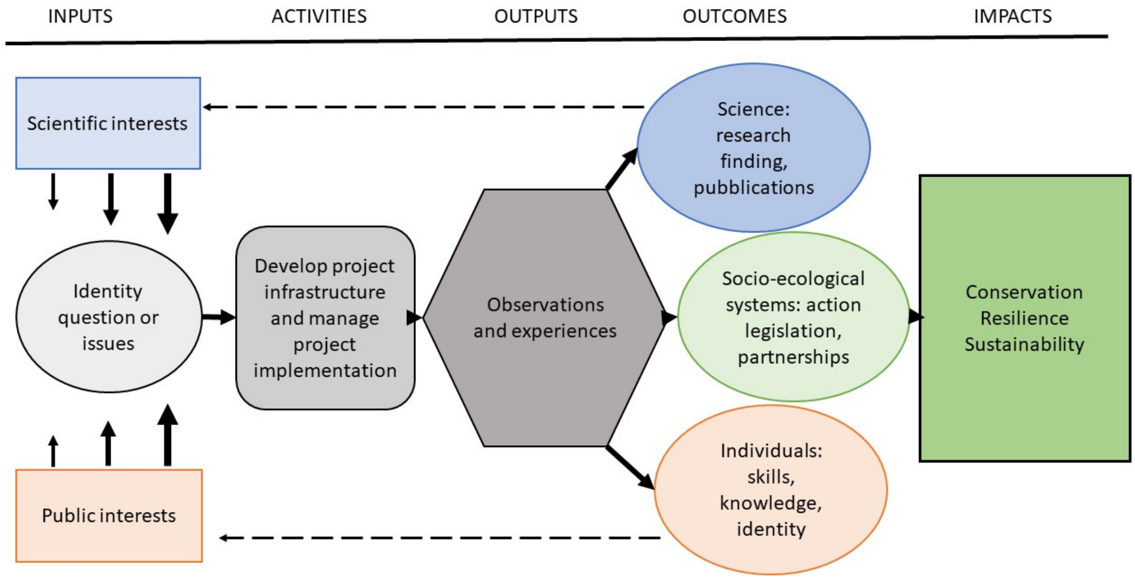


Figure 2 Framework for public participation of scientific research projects, ACTION elaboration on Shirk et al. (2012)

Considering the outcomes on science, a crucial one is the project's ability to access otherwise unavailable knowledge together, of course, with publications.

Outcomes for individual participants include the acquisition of new skills, an incremented understanding of scientific research processes, an improved sense of place and/or stewardship and opportunities to deepen the contact with the natural world and with other people. In addition, the authors consider the benefits for scientists as individuals, and these are related to the possibility to put knowledge into action, the acquisition of skills and of new social resources.

Outcomes for socio-ecological systems refers to advancements in the relationship between management agencies and social communities, access and use of data to monitor environmental degradation and improved participation of public communities to policy decisions.

Considered impacts include conservation, citizens empowerment and resilient communities and natural resources.

As said, the main goal of the framework developed by Shirk et al. (2012) is to guide CS project managers in designing CS activities thinking, since their real beginning, to the desired outcomes. In this sense the framework is a support for design and monitoring more than an impact assessment per se, because, as stated by the authors "Impacts are difficult to measure and confirm" (p. 11).

Haywood & Besley (2014) worked towards an integrated assessment framework for Public Participation in Scientific Research (PPSR) projects which we can consider a wider label for CS. They recognized most of all two dominant theoretical traditions, that include the "public understanding of science", guided by science education and literacy goals, and the "public engagement in science", guided by participatory democratic ideals. The first looks at the "education outreach" goal, while the second at the "participatory engagement" goal. Depending on the goal, the impacts of the project will be different. The authors stress the existing interconnection between the two traditions, and state how aims reach in one of those (e.g. knowledge and skills) may lead to outcomes and impact in the other (e.g. expanding the scope and interest of research).

They theorized a set of indicators to assess potential broad, community-scale CS projects' outcomes. These meso-level outputs indicators have to be taken in account for both the enhancing of the scientific knowledge and the democratic engagement, and are:

- Needs met ("degree to which the product generated, intellectual or material, meet the legitimate needs and expectation of participants);
- Scooper and influence ("degree to which product generated, intellectual or material, impacts broader social, economic, or environmental systems and relevant policy);
- Community/social capacity ("degree to which the project influences the capacity of communities/social groups to respond to social or ecological challenges, negotiate conflicts, and develop solutions");
- Trust, confidence and respect ("degree to which the project fosters general trust, confidence and respect, among project participants and in science").

For the authors the challenge in this kind of project is to create a common impact assessment framework able to evaluate the projects in a holistic way, that comprehend also other fields of influence of CS projects (ex: economic and environmental impacts). For this, "indicators that are theory-driven, flexible and comprehensive are required" (Haywood B., Besley J. C., 2013).

After Haywood B. K. Besley J. C. (2014), Kieslinger et al. (2017) developed a new framework considering three core dimensions:
1. Scientific dimension;
2. Citizen Scientists dimension;
3. Socio-ecological and economic dimension.

For each of these dimensions two evaluation stages have been identified; one is the "process and feasibility" evaluation, implemented during the initial phase of CS projects and the other is the "outcome and impact" evaluation, where the first impacts can be measured. (Kieslinger et al. 2017). Figure 3 Figure 3: Impact assessment framework, ACTION elaboration on Kieslinger et al. (2017)below summarizes the proposed framework.

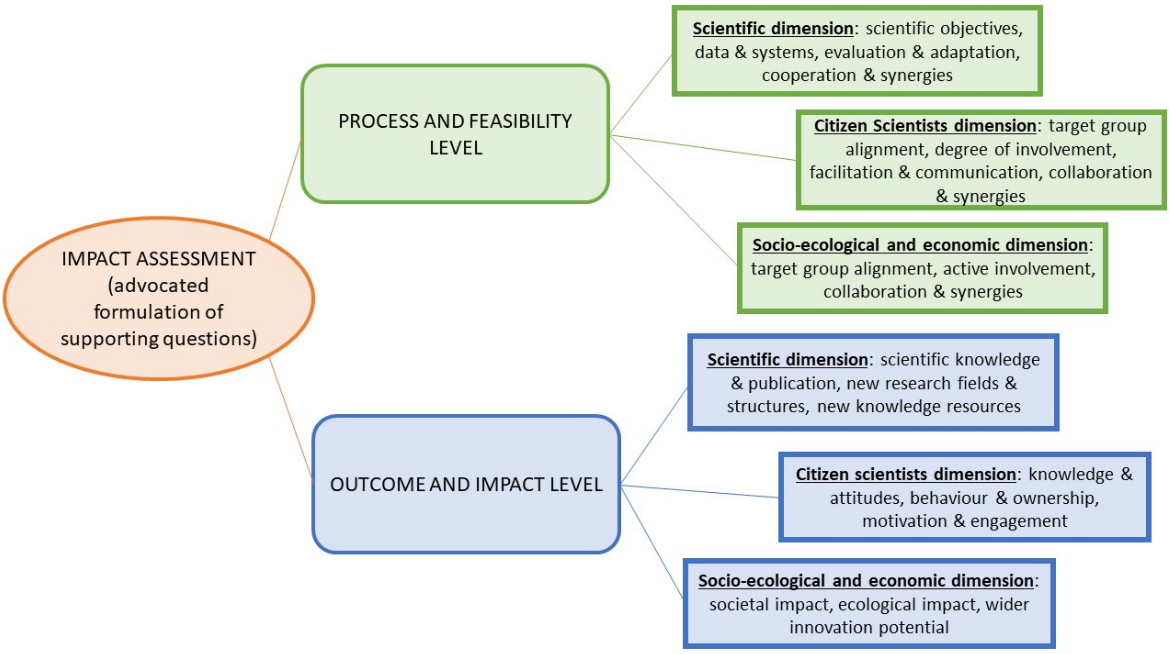


Figure 3: Impact assessment framework, ACTION elaboration on Kieslinger et al. (2017)

Considering the goal of our task, we are more interested in the outcome and impact level than of the process and feasibility level. The work of Kieslinger et al., as stated by the authors, *is intended to be open to additional inputs* and we try to work in this direction.

In our framework we tried to keep together the dimensions and key points of the above mentioned frameworks and adapt them to the ACTION needs.

More explicitly, we do so by:

- Developing a flexible and modular framework that allows personalisation but, at the same time, can be used for considering *different CS projects at the same time* and evaluate their impact at an aggregated level
- Operationalising the different dimensions considered in a quali-quantitative way and developing ad hoc data gathering tools for each of them (see D6.2)
- Enriching the number of dimensions considered in each area of impact by combining different approaches and especially elaborating further the environmental and political impact assessment areas and the social inclusion dimension
- Adding to the framework a model for evaluating the transformative capability of CS projects, i.e. the possibility for them to propose an alternative way of doing science and engaging citizens in the scientific process at a systemic level (see sub-section 3.6)
- Offering a methodology that can be adapted and practically used in an autonomous way by CS project managers also after the end of ACTION project.

2.2 Co-design the ACTION impact assessment methodology

Coherently with the ACTION overall approach, the impact assessment framework has been developed following a co-design approach. What is presented in this deliverable is, therefore, the result of the interaction with ACTION partners and pilots.

The process followed is visualised in the Figure 4 below. It is important to point out that the ACTION impact assessment framework presented in this deliverable will evolve in the next months: it will be adjusted and improved during the whole duration of the project taking on board the feedback and suggestions of the actors engaged in the impact assessment (ACTION partners, pilots, other CS projects outside ACTION and other SwafS projects working on CS).

The process started with a literature review which led to the presentation to the ACTION consortium of a first draft of the impact assessment framework. This first draft included the five areas of impacts that are presented later in this deliverable and several dimensions. During the consortium meeting held in Rotterdam in December 2019, partners' feedback was gathered. The feedback and comments collected suggested some specific changes to the dimensions to be considered. Besides, it emerged the necessity to provide more guidance to CS pilots on impact assessment overall and on its application. In order to answer to this need, the idea of creating an impact assessment canvas for ACTION CS pilots emerged.

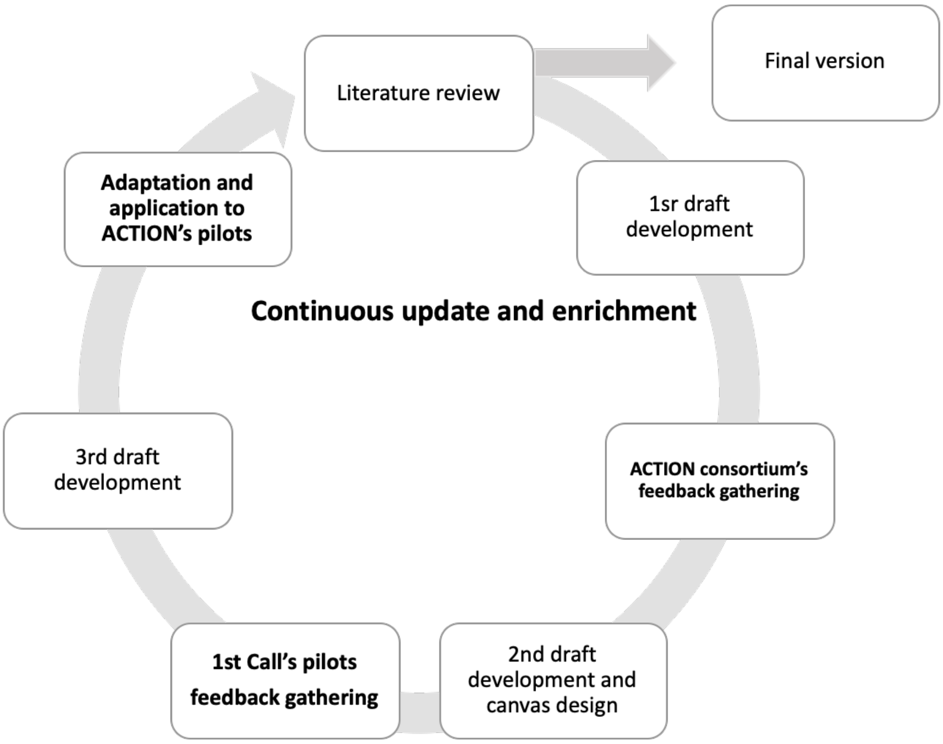


Figure 4 Impact assessment framework: ACTION co-design approach

The ACTION impact assessment canvas is a 4 pages visual document that guides CS project managers to think about the impacts of their project and navigate the ACTION impact assessment framework while discussing to what extent the various dimensions are relevant for their project. The ACTION impact assessment canvas will be described in more detail in the next section.

Finally, the canvas was provided to the ACTION pilots, they filled it in and provided feedback through one-to-one interviews. These provided input to the third version of the ACTION impact assessment framework that is hereafter described (see section 3). This version of the framework takes on board also the suggestions emerged during the first project review meeting held in June 2020.

It is important to underline that we do not consider the framework presented in this deliverable as final. At the time of writing we are applying it to different ACTION pilots: this will give us the possibility to understand if and where improvements are needed. Updates of the methodology will be presented in the next WP6 deliverables (D6.3 and D6.4 and in the ACTION CS toolkit).

2.3 The ACTION impact assessment canvas

The ACTION impact canvas (see Annex 1 and figures below) design is inspired by different business and impact canvas and adapted to the specificity of CS projects (Phillips et al, 2017; Ratto-Nielsen, 2017[2]).

More specifically:

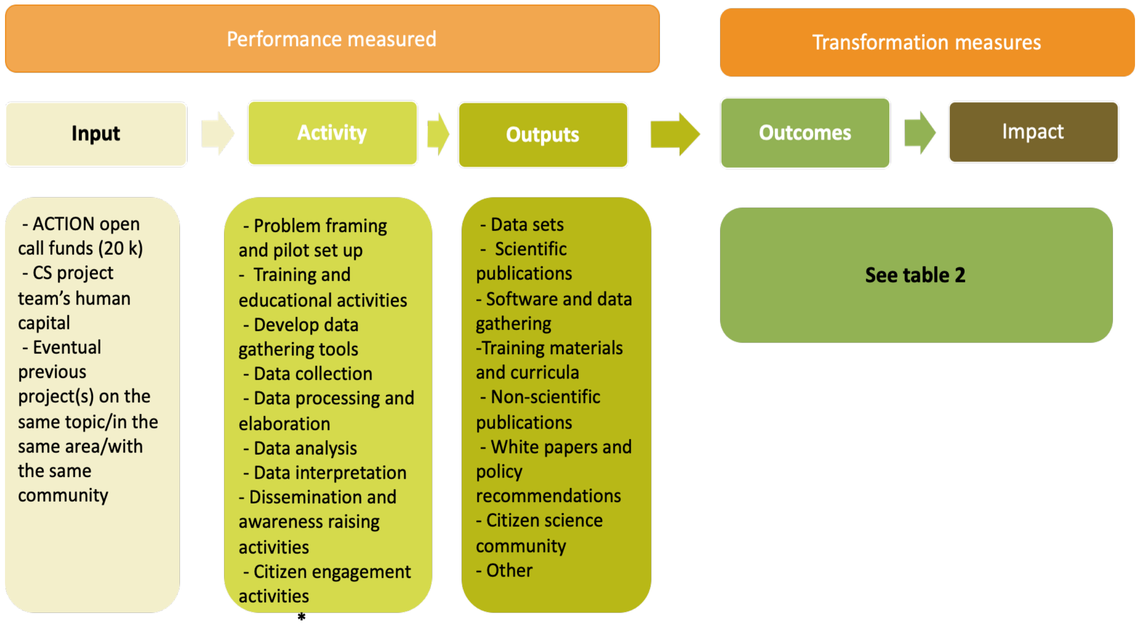
- The first page helps CS managers to synthesize the main problem the project is addressing, the main research questions, the key stakeholders of the project and the typology of the CS project they belong to. With reference to the stakeholder's definition, the canvas suggests the following: Researchers, Citizen scientists, Policy/decision makers, General public, Business actors, Other organisations they might be collaborating with. The canvas also suggests to the user to define its project as belonging to one of the following categories (Bonney et al 2009; Shirk at al, 2012, Wiggins and Crowston, 2011; Schafer and Kieslinger, 2016): Contributory project, Collaborative project, Conservation project, Co-created project, Education project, Action project.
- The second page guide the CS manager is describing its project in terms of the impact value chain framework.
- The third page presents the ACTION impact assessment framework: its areas of impact and dimensions and asks the user to attribute a value from 1 to 5 to each of them according to the relevance each dimension might have for the specific CS project.

The impact assessment canvas is accompanied by a summary of the ACTION impact assessment framework and defines and describes its areas of impact and dimensions. The impact assessment framework presented in the canvas represents the second version of the methodology and takes on board the feedback gathered at the Rotterdam consortium meeting.

2.4 The impact value-chain approach applied to ACTION and its pilots

The Figure 5 and Figure 6 that follow visualize the impact value chain of an ideal CS project first and of the ACTION project considered as whole. They show how expected impacts are linked to projects input, activities and outputs.

[2] Other source of inspiration have been: https://www.artsculturefinance.org/wp-content/uploads/2018/09/Impact-Management-Canvas.pdf and https://www.threebility.com/sustainability-impact-canvas



* The activities here listed are inspired by the Participatory Science Lifecycle developed by ACTION

Figure 5 Impact value chain of an ideal CS project

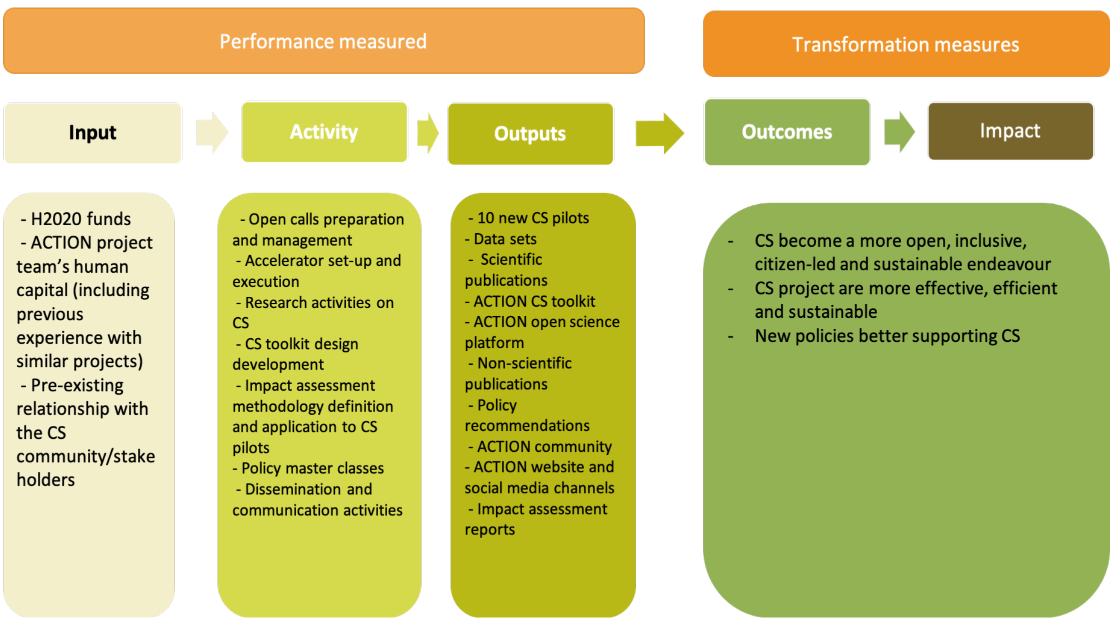


Figure 6 ACTION 's impact value chain

2.5 ACTION stakeholders: impact on whom?

As mentioned in the previous sections, when talking about impact it is important to consider who the stakeholders are that will be touched by the project/pilot we want to assess. Moreover, in a project or pilot, not all the activities and outputs are relevant to all the stakeholders, so it is important to map the expected impact for each of them.

In the Table 2 below we summarize the stakeholders relevant for the ACTION pilots at the time of writing and provide examples of the main expected impacts.

ACTION

Stakeholder	Expected impact
Researchers and CS managers	• Access to new knowledge and data on the specific topic covered by the pilot • New competence on how to carry out a similar CS project • Increase in interdisciplinary research • New competence on inclusiveness and diversity management
Citizen scientists	• Access to new knowledge and know-how • Acquisition of more pro-environmental way of thinking • Adoption of more pro-science way of thinking • Adoption of more sustainable behaviours • Increase in social interactions • Social inclusion of disadvantaged groups
Local communities	• Community empowerment • Increase in local sense of community • Increase in democratic participation • Positive economic impacts related to pro-environmental action related to the pilots activities and/or outputs
Policy/decision makers	• Access to new knowledge useful for informing policy action
Business actors	• Access to new knowledge or tools with a potential for commercial exploitation
Other organisations	• Expected impacts vary accordingly to the nature of the organisation considered. For example for an educational CS project working with high school students, considering the impact on the schools and on the teachers engaged will be crucial.
General public	• Access to new knowledge generated by the pilot • Getting to know about CS and the possibility to be engaged in related activities • Acquisition of more pro-environmental way of thinking • Adoption of more pro-science way of thinking • Adoption of more sustainable behaviours

Table 2 CS projects' expected impacts

The stakeholders of the ACTION pilots' and that of ACTION overall as a project are similar, but the expected impacts are not the same as the project activities and outputs differ. The Table 3 below focuses on the ACTION's stakeholders and the main expected impacts on them. In brackets we outline the ACTION's outputs that are expected to impact the different stakeholders and are linked to the ACTION impact value chain reported in the previous sub-section.

Stakeholder	Expected impact
Researchers and CS managers	• Access to new knowledge on CS practices, results and impacts (ACTION CS toolkit, plus publications) • Access to new knowledge and related data (ACTION open science portal) • Access to funds for carry on CS pilots (ACTION open calls and possibly other funds resulting from a better understanding of CS by policy makers as a result of the policy masterclasses) • Access to ACTION's accelerator services (ACTION accelerator) • Develop new collaborations • Increase in interdisciplinary research • Increase in open science practices (ACTION open science portal)
Policy/decision makers	• Learn more on CS • Access to new knowledge useful for informing policy action • Learn how to support CS (ACTION policy-masterclasses)
General public	• Getting to know about CS and the possibility to be engaged in related activities • More pro-science way of thinking and behaviours
Other EU projects and CS organisations	• Access to new knowledge on CS practices, results and impacts (ACTION CS toolkit) • Access to new knowledge and related data (ACTION open science portal) • Develop new collaborations

Table 3 ACTION' expected impacts

3 The ACTION impact assessment framework: areas of impacts and dimensions

The action impact assessment framework, as anticipated, considers five areas of impact: scientific, social, economic, political and environmental. Each area of impact is articulated in several dimensions: 24 overall (Figure 7). Each dimension is operationalised in different variables. The framework is quali-quantitative: each dimension is operationalised considering how well it can be expressed in numerical or non-numerical terms. When possible, also qualitative indicators are expressed in numerical terms using Likert Scale in order to facilitate comparison among pilots and aggregation across pilots (when considering the overall impact generated by ACTION, see sub-section 3.8). When relevant, for example in the economic impact assessment, indicators are expressed in monetary terms too.

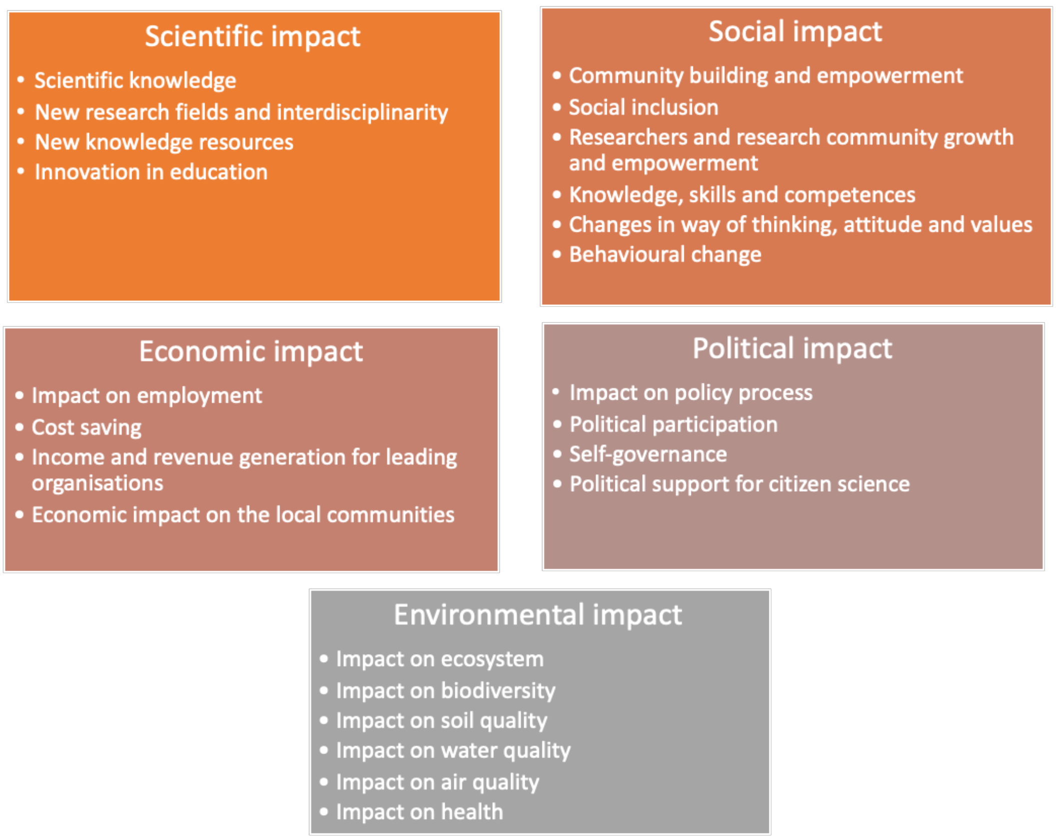


Figure 7 ACTION areas of impact and dimensions

The dimensions considered are reported in the next sub-sections together with the main variables/indicators/methods that will be used during the assessment. Therefore, the next subsections are aligned as follows: sub-sections from 3.1 to 3.5 are dedicated to the five areas of impact and describe one area of impact each, the related dimensions and the indicators. Section 3.6 introduces an additional element to the ACTION framework: the transformative potential of CS projects. This investigates the capability of CS projects, in the long run, to transform science and society in a substantial way. All these sub-sections describe the areas of impact and dimensions as they will be applied when assessing CS pilots. Sub-section 3.7 discusses how this framework will be adapted and applied to ACTION project in order to analyse its overall value added.

3.1 Scientific impact

Scientific impact is one of the most important areas of impact for a citizen science project. It is included in every impact framework of citizen science, even if the exact interpretation or measures differ. As mentioned in previous sub-sections of this deliverable, some articles focus on scientific learning of participants: improvement of their skills and new knowledge they gained (Phillips et al., 2014). Others focus on the system level impact of citizen science on science and society (Bonney et al. 2014, Jordan et al., 2012, Tulloch et al., 2013). In addition, some authors propose to combine the two views (Haywood and Besley, 2014, Bonney et al., 2009).

In academia, scientific impact is usually measured by looking at publications, be it by counting citations (Garfield 1999) or by other measures such as analysing social networks and usage log data (Bollen et al, 2009). How does this translate to the context of citizen science? On the one hand, the academic indicators are important and if we are to take citizen science seriously, we need to take them into account. On the other hand, citizen science has the potential to expand the definition of scientific knowledge (Gijsel et al,. 2019), which means scientific impact should not only be limited to traditional academic impact (Kieslinger et al., 2017).

3.1.1 Working definition of scientific impact

This dimension considers to what extent the citizen science project produces new knowledge and can influence scientists and research organisations. Partly, this is an evaluation by traditional academic standards, such as the generation of scientific knowledge, captured in publications and possibly leading to new projects. Also, this dimension assesses the project impact on institutional or organizational structures, for example by creating new research fields, stimulating interdisciplinarity, or facilitating innovation in education. Furthermore, it assesses new forms of integrating traditional and local knowledge, thereby facilitating true knowledge exchange between science and society.

Kieslinger et al.'s interpretation of scientific impact (2017) was heavily influenced by Bonney et al (2009). On the outcome and impact level, they divide the scientific dimension into three sub-dimensions: scientific knowledge & publications, new research fields & structures, and new knowledge resources. For the ACTION impact assessment framework (seeTable 4), we have adopted the same sub-dimensions, but added innovation in education. We added this sub-dimension to mimic the institutional structure of most academic organisations, in the sense that research and education are their main, and separate, activities. We think it can be expected that citizen science projects have some impact on education, because many CS projects themselves focus on education and learning. In this way, the innovations in education and learning in citizen science projects might influence education systems and methods. These can be the education system within academia, but also within primary or secondary education.

3.1.2 Scientific impact: ACTION dimensions and indicators

Dimension	***Indicators***
Scientific knowledge	Quantity of new data created (N. of data points)
	Quality of data in datasets
	Research outputs' visibility on social media and research platforms (Academia, Research.edu, etc.)
	Research outputs' compliance with FAIR principles of open data.
	Citizen scientists' participation and recognition in the scientific output.
	N. of published articles/books/book chapters (multiplier for peer-reviewed articles, impact factor)
	N. of other scientific outputs (new specimen collections, conservation outcomes, GitHub entries, etc)
	N. of non-scientific publications
	N. of theses
	Citizen scientists' participation and recognition in the scientific output.
New research fields and interdisciplinarity	Self-reported level of interdisciplinarity
	N. of new research groups created
	Sub-disciplines emerging
New knowledge resources	Ease access to knowledge that is otherwise hard to access
	Facilitate knowledge creation among societal actors and groups
	Development of new data-gathering tools
Innovation in education	Innovation in academic or school curricula
	Innovation in (other) educational/training methods

Table 4 ACTION scientific impact's dimensions and Indicators/variables

Another adaptation that we made is to add interdisciplinarity as an explicit part of new research structures (the second sub-dimension). We agree with Crain et al (2014) that citizen science has substantial potential to increase the interdisciplinarity of science. In general, many citizen science projects are already interdisciplinary in nature. But especially when we look at citizen science projects with an environmental focus (which is the case for ACTION), integrating a natural science perspective with a social perspective is at the core of these projects.

Table 4 reflects the sub-dimensions that we have adopted for scientific impact, and also shows their translation into variables. The first sub-dimension - scientific knowledge - is a more traditional scientific impact assessment and measures the number of publications (split up into different categories) and in addition includes a measure of the visibility of those publications. It also addresses the amount of data generated by the project in terms of data points, as well as the quality of the data (Kosmala et al. 2016) and its compliance with open science principles[3].

The sub-dimension of new research fields and interdisciplinarity has three variables. Self-reported level of interdisciplinarity refers to the extent to which the topic or content of the citizen science project combines different existing disciplines (such as ecology and sound engineering), whereas sub-disciplines emerging would be the creation of a new specific topic of a discipline, such as sound engineering in aquatic media. The variable new research groups created is more institutional and refers to bringing people together to form new research groups (that endure for a substantial amount of time).

The new knowledge resources sub-dimension is about knowledge creation outside of academia and has two variables. With ease access to knowledge that is otherwise hard to access (Shirk et al., 2012) we mean knowledge that a particular community already has (such as how to care for their local land) which the citizen science project makes more accessible to a wider community (Berkes et al., 2000). Alternatively, a citizen science project could draw on large-scale networks, which would also make knowledge accessible that is hard to access in more traditional scientific projects (Sullivan et al. 2009). Facilitate knowledge creation among societal actors and groups refers to new knowledge that a community can create together, supported by the citizen science project. This knowledge creation can lead to increased self-governance, see sub-section 3.4. Last, development of new data-gathering tools means that the project developed new tools for data gathering such as air quality sensors, sound sensors, or software that helps with data-gathering.

Innovation in education translates into the variables innovation in curricula, and innovation in (other) educational or training methods. While curricula refer to the content of the education, educational or training methods are the manner of teaching or training.

3.2 Social impact

In the previous sub-section we discussed how to evaluate the impact of CS projects on science and, more generally, on knowledge generation. For many projects, this represents their main goal and it is one of the main direct impacts of CS.

However, as stated by Hacker and al. (2018a), CS can have an important impact also at social level: “Citizen science can [...] positively influence society by providing opportunities for learning, empowerment, enjoyment of nature, social engagement or enhanced scientific capital”.

In line with this, Kieslinger et al. (2017) suggest evaluating these elements both at individual level, by considering the impact of CS on citizen scientists and at societal level. With reference to the impacts at individual level they consider impacts in terms of acquisition of new knowledge, skills and competencies, attitudes and values and behaviours and ownership. These three dimensions are included also in our framework and an operationalisation of each of them, based on several sources, is provided. At social level, they consider civic resilience, social cohesion and specific social impacts related to the topics covered by individual CS projects. The underlined topics are present in our framework too but are framed in a different way based on our experience in previous projects (Passani et al., 2015; Nurmi et al., 2017). Indeed, we consider the impacts on communities, especially looking at the capability of CS projects of promoting social inclusion and cohesion, community empowerment and the increment in social relationships among participants, within the research community and among local stakeholders. The impact of CS projects at societal level will

[3] https://www.go-fair.org/fair-principles/

be considered mainly looking at all the areas of impacts together, especially considering the impact at policy level and the transformative capability of the projects.

It is important to notice that social impact can vary and are mainly indirect impacts generated by the acquisition of new knowledge and skills by participants and the diffusion of scientific reasoning and methods at society level.

Coherently with this, in the social impact assessment we will discuss how the knowledge generated and the process of its generation (social interaction) is able to influence on one hand citizens' way of thinking and behaviours and, on the other hand, their social relationships and their capability to act effectively at social level.

As said, another important aspect to be considered when talking about social impact is inclusiveness, which is especially relevant for CS considering its link with open science. Indeed, as described by Hacker and al. (2018a) innovation opportunities and access to science have been traditionally accessible only by experts while CS open research and innovation to citizens, thus “making science more inclusive”. If this is true for CS overall, it is important to evaluate the level of inclusiveness of each CS project and consider who are the citizens scientists engaged from a demographic point of view and also from a value-orientation point of view.

In this sense this framework will support CS projects to better consider their capability to engage people of different ages, genders, cultural, educational and economic backgrounds and to see if participants were already close to the values and “ethos” of the project. The latter aspect is crucial as there is the risk to engage in CS projects citizens that are already sensitive to the topic addressed by the project (pollution in the case of ACTION’s pilots) and, for example, already advanced in terms of scientific literacy and trust in science.

Finally, another way to consider social impacts is by looking at the 10 principle of CS developed by ECSA (Robinson et al., 2018) and focus on the third principle that says: “both the professional scientists and the citizens scientists benefit from taking part” and see social impact assessment as a way to describe how citizens benefit from participating in CS projects. In explaining the third principle the following benefits are mentioned: learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to scientific evidence for example, to address local, national and international issues and through that, the potential to influence policy”.

In order to cover as many as possible of this potential benefit the social impact assessment area is articulated in 6 dimensions:

- Community building and empowerment
- Social inclusion
- Researchers and research community growth and empowerment
- Knowledge, skills and competences
- Changes in way of thinking, attitude and values
- Behavioural change

3.2.1 Working definition of social impact

This dimension considers how CS can support community creation, empowerment and inclusiveness, the acquisition of new knowledge and skills by participants and how this can influence way of thinking and behaviours.

3.2.2 Social impact: ACTION dimensions and indicators

The tables below provide a snapshot of all the dimensions considered when looking at social impacts and the associated indicators. The next sub-sections describe in more details each dimension.

Dimensions	***Indicators***
Community building and empowerment	
Community building	N. of citizens scientists engaged in project activities
	Role of the citizen scientists in the participatory research process
	N. of awareness level/dissemination events organised
	N. of participants to organised events
	N. of persons/organisation reached through social media
Community empowerment	Level of interaction among citizen scientist
	Changes in bonding social capital among citizen scientists
	Changes in bridging social capital among citizen scientists
	Changes in linking social capital
	N. of new social relations established
	Increase in the perceived quality of social relations
	Self-assessment on project capability to influence trust among participants
	Project self-assessment of its capacity to foster the creations and the enlargement of local communities/groups
	Improvement in the self-perceived efficacy of citizen scientists

Table 5 Social impact dimensions, community building and empowerment

Dimensions	***Indicators***
Social Inclusion	Percentage of participants belonging to underrepresented social groups
	Ration among age groups of participants
	Male/female share among participants
	Diversity of participants in terms of education level

	Diversity of participants in terms of income
	Diversity of participants in terms of cultural differences
	Diversity of participants in terms of value orientation (materialistic/post materialistic)
	Presence and description of a dedicated strategy for social inclusion and diversity management
Researchers and research community growth and empowerment	N. of new collaborations established with other researchers/research organisations
	N. of new collaborations established with other organisations (excluding research organisations)
	Changes in researchers' career path
	Changes in researchers' level of trust for citizens, other CS managers and decision-makers

Table 6 Social impact dimensions, social inclusion and research growth

Dimensions	***Indicators***
Knowledge, skills and competences	
Motivation and interest for science and the environment	N. of CS projects in which participants have been enrolled/are enrolled
	Probability to engage in CS projects in the future
	Participation in cause-oriented initiatives (see political impact)
	N. of participants considering a scientific or environmental-related carrier as a result of the project (for student only)
	N. of participants considering enrolling in life-learning educational program related to science or environmental studies (only for adults)
	Changes in the interest for the specific topic covered by the project
	Changes in the interest in science related topics and activities
Content, process and knowledge of the nature of science	Changes in the understanding of the scientific method
	Changes in the understanding of the scientific process
Skills of science inquiry	Acquisition of new skills in the research design-related activity
	Acquisition of new skills in the data gathering- related activities
	Acquisition of new skills in the data curation- related activities

	Acquisition of new skills in the data analysis- related activities
	Acquisition of new skills in the data interpretation- related activities
	Acquisition of new skills in shaping and commenting results
	Acquisition of new skills on impact assessment
	Acquisition of new skills in communicating results
	Acquisition of new skills in the valorization of project results for policy making
	Acquisition of new skills on project sustainability
	Increment in technological literacy
	Acquisition of new skills related to critical thinking
Project-specific disciplinary contents	***to be elaborated on a project-by-project base***
Soft skills	Changes in interpersonal communication related competences
	Change in the class social dynamics (only for school class-based projects)
	Changes in the capacity to collaborate (do it together)
	Changes in the capacity to collaborative discuss (think it together)
	Changes in organisational/management related competences

Table 7 Social impact dimensions, knowledge, skills and competences

Dimensions	Indicators
Changes in way of thinking, attitude and values	Changes in way of thinking related to the specific topic of the project. **Index to be selected/elaborated on a project-by-project base**
	Changes in way of thinking on environmental issues/concerns (NEPS scale)
	Changes in the way of thinking on science (MATOSS index)
	Changes at value level (post-materialistic index)
Behavioural change	Impact on green consumption behaviours
	Impact on project-specific related behaviours
	Changes in accessing green spaces and the natural world

Table 8 Social impact dimensions, thinking, attitude, values and behavioral changes

3.2.3 Community building and empowerment

The term "community empowerment" emerged during the '80 and is used in the community psychology, health promotion and liberation education sectors (Laverack, and Wallerstein, 2001). It needs to be defined from an operational point of view as it tends to be vague and difficult to measure. The concept of community empowerment is very close and, in some sense, overlapping with terms and concepts such as community capacity, community competences, social capital and community cohesiveness. However, those may lack to point out the procedural aspects of community empowerment and the dimension of power relationships and their changes (Laverack, and Wallerstein, 2001).

In fact, an empowered community is a community able to act towards a common objective and to promote the desired change. The guide for community empowerment developed by Community Development Exchange (CDX) and Changes, (http://www.iacdglobal.org/files/what_is_community_empowerment.pdf) defines an empowered community as a community, which is:

- influential,
- organised,
- confident,
- inclusive and
- co-operative.

Within this dimension we will map the community created and the number of members, the level of interaction among them and the improvement in terms of bonding, bridging and linking social capital for them. Bonding social capital, as described by Robert Putman in his book Bowling Alone (2000), refers to the relationship within a group, or better, is the social capital owned by a person when she links with persons similar to her, people that belong to the same social group, location, or which share common values and attitudes. Bridging social capital, instead, refers to the capability to get in touch with people from different social groups, communities or with different values and attitudes. Finally, scholars at the World Bank (Healy et Cote, 2001) added the concept of linking social capital to describe relationships among people or institutions at different levels of societal power hierarchy and this can be of interest when discussing community empowerment both for citizens and for citizen science managers.

Another element of social capital that will be considered is the level of trust among community members (Putnam, 2000), which is shown to have an important role in community agency and also in individual commitment in pro-environmental actions (Meyer and Liebe, 2010).

We will also analyse how participating in the CS activities might influence the perceived efficacy of participants, i.e. the perception of being able to learn a specific content, to perform a specific behaviour and to act towards a defined goal (Bandura, 1982). Self-efficacy affects individuals' decisions, behaviours, and persistence in activities (Bandura 1982, 2000; Schunk 1991; Healy et al, 2001). In this sense being able to increase citizen scientists' self-perceived efficacy can have an important impact on community empowerment and it can influence their capability to act at social level in a proactive way, in promoting sustainable changes and in continues their involvement in science and learning[4].

The aspect of inclusiveness is covered by a dedicated dimension described in the next sub-section. The organisational aspects are covered only partially by this dimension, while more attention on this is present in the political impact part (see sub-section 3.4).

3.2.4 Social inclusion

This dimension considers to what extent CS pilots contribute to reduce social exclusion at local level by engaging people belonging to category marginalised or at risk of social exclusion such as people belonging to minorities, low income families, elders and people with disabilities.

This also considers if the project is engaging people of different age groups, social and cultural background, educational level and income levels. As mentioned in the introduction to this section, inclusion of all in science is a key goal for CS and ACTION - within its accelerator - is providing specific guidance to tackle this aspect. Therefore, it is important to gather enough data on this aspect and consider how CS projects are doing with reference to diversity management considering this a crucial element for the democratisation of science. As mentioned earlier, indeed, "It is important to consider who participates in CS programs—who learns and who is supposed to learn. This may have broader social implications. If participants belong to the educated part of society, as often seems the case (e.g. Evans et al., 2005), CS may reinforce social inequalities. CS programs enrolling participants from less-educated backgrounds may help address inequalities (e.g., Gura, 2013)" Bela et al (2016:993).

Finally, we will also consider how diversified participants are in terms of values and opinions and attitudes towards science and the environment (see sub-section 3.2.5).

3.2.5 Researchers and research community growth and empowerment

Like the reasoning described above for the community building and empowerment dimension (sub-section 3.2.1), we will explore here how and to what extent CS projects help researchers in enlarging their collaboration network, in developing their research path and in acquiring new competences. We will also consider if managing or participating in a CS project can influence the level of trust between scientists, the public and project managers (Jordan et al., 2011) and we suggest adding "decision makers" in this sub-dimension as they are also relevant stakeholders of the CS process

[4] We will see in sub-section 3.24 that several authors include self-efficacy as one of the learning outcomes of CS and include this sub-dimension under the "learning" label. We prefer to have it in the Community empowerment dimension moving from an individual to a community-level analysis

both as “users” of the new knowledge developed by project and as supporters of CS through dedicated programme and funding schemas.

3.2.6 Knowledge, skills and competencies

As described already by Brossard et al. in 2005, impact on participants’ learning levels, such as gains in scientific knowledge or scientific skills are common. This is one of the social dimensions that have been discussed the most in the debate on CS impact assessment (Bonney et al, 2009; Tweddles et al., 2012; Phillips et al., 2014) and several approaches have been developed and tested.

At the same time, as stated by the U.S. Committee on Designing Citizen Science to Support Science Learning (National Academies of Sciences, Engineering, and Medicine, 2018: 17) “While the few available investigations are compelling, they do not provide enough evidence to make definitive statements about learning from citizen science”. However, the publication identifies a variety of learning outcomes and notices that “Some of these outcomes, such as developing motivation and learning new scientific skills, are relatively common within the activities and practices that are common across all citizen science projects. Others, such as encouraging the development of scientific reasoning, come only with significant supports and scaffolds that are less ubiquitous” (ivi: 120).

The same publication based on an extensive literature review, identify and discuss 6 CS learning outputs that are:

- Motivation and interest
- Use of scientific tools and practices
- Learning project-specific disciplinary contents
- Developing understanding of explanatory scientific concept
- Identity in science
- Scientific reasoning

The authors describe each output considering different CS projects and providing examples on how these outcomes can be achieved. While most of the outputs listed above are self-explanatory, “identity in science” deserves few words as it refers to how participants' socio-demographic characteristics come into play in CS projects and how they should be considered when designing CS projects. These aspects, in our framework, are covered by the dimension “inclusion” described above.

Philips at al., (2018) elaborate a framework for CS projects learning outputs which consider the following aspects:

- Interest in science and environment
- Self-efficacy for science and the environment
- Motivation for science and the environment
- Content, process and knowledge of the nature of science
- Skills of science inquiry
- Behaviour and stewardship

The Figure 8 below offers an overview of the above-mentioned aspects and related definitions.

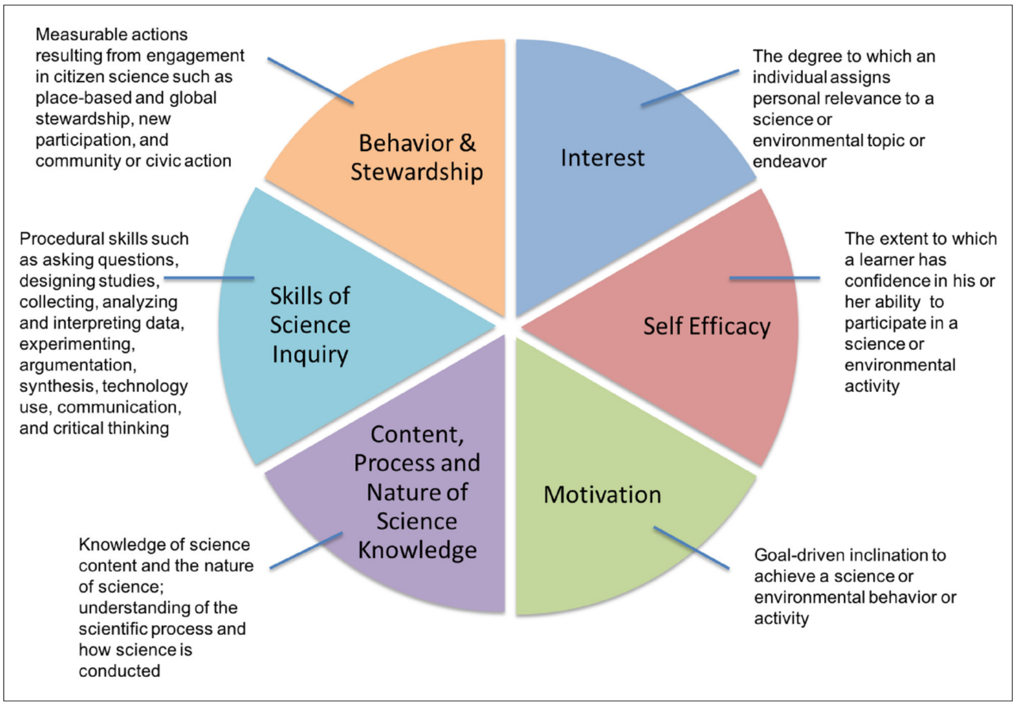


Figure 8 Framework for Articulating and Measuring Individual Learning Outcomes from Participation in Citizen Science. Source (Philips at al,. 2018)

Considering now the ACTION framework, elaborating on the two above-mentioned frameworks and considering the experience maturated in previous project and in the first 18 months of the ACTION project, we will consider the following sub-dimensions:

- Impact on motivation and interest for science and the environment
- Content, process and knowledge of the nature of science5
- Skills of science inquiry
- Project-specific disciplinary contents
- Soft skills

We will focus on "Impact" on "Motivation and interest" because our framework is not aimed at analysing the motivations and interest of citizens for the CS activities or for science and the environment in general when first engaging in the CS activities. In other terms, this framework does not wish to ask questions such as: "Why do citizens participate in CS?" "What is their interest in science and the environment?". These aspects, which are for sure crucial as an intervening variable in the learning processes (see Philips at al., 2018), are indeed covered by other research activities in ACTION (see WP5).

What we are here interested in investigating is if and to what extent the CS projects influence participants' motivation in doing CS or similar research-related activities and their interest in science and for the environment. This way of approaching "motivation and interest" is aligned with that of Kieslinger et al, 2018).

"Self-efficacy" aspects are included under the dimension "community building and empowerment" (see sub-section 3.2.1) and "stewardship" is discussed under "political impact" (see sub-section 3.4).

[5] Nature of science "refers to understanding the epistemological underpinnings of scientific knowledge and how it is generated" Philips at al., 2018

The main driving reason for having these aspects under different dimensions is related to the fact that the ACTION framework does not focus only on learning outcomes as the two frameworks considered above and that it considers impacts not only at individual level, but also at community/societal level.

With reference to “Skills of science inquiry” we operationalised this sub-dimension considering the steps of the participatory science process elaborated by ACTION in the last months (see Roman wt al., 2020) and that will form the base of the ACTION CS toolkit. Some of the steps have been aggregated in order to simplify the reasoning.

Finally, we added “learning of soft skills” because, considering the interactive and collaborative nature of CS projects, participants and CS managers can improve their interpersonal communication skills, their capability to collaborate and within a classroom setting a CS project can contribute to change the internal dynamics.

3.2.7 Changes in way of thinking, attitude and values

Under this sub-dimension we will investigate the project impact on participants’ opinions and attitude towards the specific topic of the project (i.e. water pollution), environment and towards science; then we will map participants' values.

The interest in investigating these aspects is based on, among others, Straughan and Roberts (1999) that argue that psychographic characteristics, such as citizens’ attitudes, interest and opinions, are the most important ones in predicting green and pro-environmental behaviours which are linked to the ACTION focus on pollution (this sub-dimension is linked with the following one, Impact on behavioural change and can help predicting changes in behaviours that are might be not observable at the time of the impact assessment). We are interested to see if CS participants show a pro-environmental and pro-science way of thinking before starting the CS activities (see inclusiveness dimensions, sub-section 3.2.2) or if the activities are able to influence their opinions and attitudes towards the environment and towards science. For this sub-dimension, indeed an ex-ante and ex-post assessment approach will be followed.

In investigating psychographic characteristics of participants according to their environmental concerns at operational level, we will make reference to the New Ecological Paradigm Scale Items (NEPS) (see D9.2) which propose 15 items mapping 5 hypothesized facets of an ecological worldview and ask respondents to agree or disagree on them using a 5 points Likert Scale (Dunlap et al., 2000).

In considering opinion and attitudes towards science we make reference to the (M)ATOSS approach (Brossard et al., 2005) which proposes a set of 4 items on a 5 points Likert scale and will support us in positioning respondents on a scale from anti-scientific position to pro-science positions.

When considering opinions on the specific topic covered by a CS project (i.e. water quality, air quality, etc) we will search for already-existing indexes first and, if not available, will propose an open question or elaborate an ad hoc index.

Finally, looking at values, we refer to the materialist vs post-materialistic conceptualisation (Inglehart, 1990, 1995, 1997) using the 6 items post-materialistic index of the World Value Survey (https://www.worldvaluessurvey.org/WVSContents.jsp). Such an index will support us in considering if people engaged in CS projects show more materialist values (e.g. economic growth, price stability) as opposed to post-materialistic values (freedom and self-realization). Indeed, post-materialist values showed to be positively linked to environmental concern (Franzen and Volg, 2013) and political participation and we are interested to see if ACTION pilots are influencing participants' value orientation in this sense. It is important to underline that value changes are difficult to happen in the short term but still, it is interesting in mapping these aspects of citizen scientists also in terms of group composition and group diversity (see “inclusiveness dimensions” in sub-section 3.2.4).

3.2.8 Behavioural change

In the last dimension of the social impact area we investigate if the CS projects are able to influence participants behaviours particularly looking at pro-environmental behaviours and behaviours directly linked with the CS topic (i.e. home waste management in a project working on composting). Finally, following Skirk et al. (2012) we will investigate if participating in CS projects can “deepen the contact with the natural world” (Skirk et al., 2012).

Considering changes on environmental behaviours we will build on Roberts (1996) and its Ecologically Conscious Consumer Behaviour (ECCB) items and purpose of a shorter version of it which include 30 items. We will also consider the engagement in pro-environmental groups and actions as part of the policy impact assessment and include a question on eventual increments in outside activities and engagement with the natural world. The changes related to project-specific behaviours will be investigated following a case by case approach searching for already available index first and, if not available, we will propose an open question or elaborate an ad hoc index.

3.3 Economic impact

The most difficult impact to assess in a CS project is the economic impact. In fact, CS projects have the main purpose to enhance scientific knowledge and promote, in a direct or indirect way, social and civic resilience. The economic aspect is not the principal goal of this kind of project, as confirmed by the ongoing interaction with ACTION’s pilots, but it doesn’t mean it’s not important as well, especially considering the need to foster the sustainability of the initiatives (see D7.4).

Several toolkits which assess the costs and benefits of volunteering already exist, but they are not focused on CS specifically, so that a toolkit dedicated to this domain is still missing.

Nevertheless, the report “Citizen Science and Environmental Monitoring: Towards a Methodology for Evaluating Opportunities, Costs and Benefits”, by Blaney et al. (2016), represents an important point of reference. The authors, in fact, offer support to stakeholders, especially public bodies, for evaluating the costs and benefits of CS from an economic perspective. The authors undertook a literature review to summarize and categorize existing methodologies for evaluating CS focusing on projects contribution to environmental monitoring. They found 20 relevant documents; on which basis they made a list of methods used to assess the economic impact of CS.

They consider and discuss strengths and weaknesses of 9 methods, both quantitative and qualitative including Replacement Value, Cost-Benefit Analysis (CBA), Return on Investment (ROI), Social Return on investment (SROI), multi-criteria analysis (MCA) and others. All these methods share the characteristics of expressing the economic impact of a CS project with a single value (being monetary or not) that consider various impacts, including social ones.

However, this is not the scope of the ACTION framework: we want to propose a modular framework to CS stakeholders so that each area of impact can be assessed separately. To this end, the economic impact area will consider the economic and financial benefits of CS projects, but will not “translate” social, political or environmental impacts in monetary terms. Consequently, we will not, at least at this stage, apply CBA, ROI, SROI and MCA methods even if those could be re-considered in the next stages of the ACTION project, especially when assessing the overall impact of ACTION.

In our framework we consider the following dimensions:

- Impact on employment

- Cost saving
- Income and revenue generation for leading organisations
- Economic impact on the local communities

3.3.1. Working definition of economic impact

This dimension explores if and to what extent CS can have a positive impact on CS leaders' organisations and participants in terms of employment, cost saving and financial empowerment of local communities.

3.3.2 Economic impact: ACTION dimensions and indicators

The Table 9 below provides a snapshot of all the dimensions considered when looking at economic impact and the associated indicators. The next sub-sections describe in more details each dimension.

Dimensions	Indicators
Impact on employment	Number of new job places created within the leading organisation
	Number of participants that change or get a new job place as a result of the CS project
Cost saving	Average number of hours dedicated to the project for volunteer
	Number of hours dedicated to citizens' engagement and support
Income and revenue generation	Number of new or improved product created
	Number of new services created or improved
	Revenue generated by each of the new or improved products
Economic impact on the local community	***To be elaborated on a project-by-project base***

Table 9 Indicators and variables for economic impact of citizen science

3.3.3 Impact on employment

This dimension will investigate if the CS projects are able to generate new job places within the leader organisations (for example increasing the number of employees with citizens engagement competences) or among participants as a result of new competencies and skills acquired during the CS activities (Blaney et al. 2016).

3.3.4. Cost saving

This dimension addresses the question: "to what extent does the project produce cost or time saving for local stakeholders, for example the Municipality or the research community, by carrying out activities that would be otherwise more expensive or impossible to perform?".

Taking as an example a CS project engaging citizen in measuring air quality, the work carried out by volunteers, might reduce the workload of paid employees within research organisations or in local environmental agencies and municipalities providing a financial saving to these organisations. In order to assess this financial impact of CS projects we will use, as suggested by Blaney et al. (2016), the Volunteer Investment and Value Audit (VIVA) method. This method can be considered a ROI estimating the value an organisation gains from their investment in volunteers' engagement.

From a practical point of view this method considers how much would have cost to perform the tasks carried out by volunteers if done by paid employees (Replacement Value of the volunteer work) and divide it by the total financial cost of the organisation for supporting these volunteers (i.e. the costs of the citizen science activity).

The Replacement Value of volunteer work can be accounted in different ways; considering the type of work carried out by citizens scientists in the ACTION's pilots and the willingness to limit the amount of information to be requested to them, we will use the following formula:

number of volunteer **x** *average number of hours* **x** *average hourly wage (accordingly to gross national average wages)*

3.3.5. Income and revenue generation for leading organisations

Under this dimension we will consider if and to what extent the CS project under assessment represented an opportunity to:

- Attract additional findings (may be thanks to the new collaborations established though it)
- Develop new products and/or services increasing the revenues of the organisation
- Improve the already existing products and/or services increasing the revenue of the organisation.

In assessing the impact of new or improved products and services we will consider the actual revenues and/or the potential revenues for a period of 3 years after the end of the CS project.

3.3.6. Economic impact on the local communities

This dimension will consider the direct or, most probably, indirect economic impacts on local communities. Some CS initiatives, in fact, such as conservationary projects might improve the local environment and positively impact the attractiveness of a locality; they might promote local tourism by reducing pollution and might increase leaving conditions leading to an increase of local real estate prices (for the benefits of owners).

These impacts can vary considerably from project to project so that at the present stage it is not possible to anticipate how we will measure them. A case by case project approach will be followed when analysing ACTION pilots and methods used will be reported in the next deliverables of WP6.

3.4 Political impact

Citizen science engages with political processes in several ways and can thus generate different forms of political impact (Göbel et al., 2019; Turbé et al., 2019; Roger et al., 2019; Hecker et al., 2019). Generally speaking, political impact of research occurs "when knowledge is transferred, that is, when decision-makers and/or social actors employ the published and disseminated results as the basis for their policies and/or actions" (Reale et al., 2018: 300). It is closely related to social impact, but distinct in that it specifically relates to the uptake of research results into policy processes, political decisions and activities, including the political participation and empowerment of citizens) (ibid.; Kieslinger et al., 2017; Turrini et al., 2018; Ponti and Craglia, 2020; Göbel et al., 2019).

Firstly, citizen science provides data for the development, implementation or monitoring of policies. Citizen science can expand what gets measured, how, and for what purpose – for example by tapping into distributed knowledge domains – which has helped to identify problems and promote new solutions (Turbé et al., 2019; Ponti and Craglia, 2020; Hollow et al., 2015; Nascimento et al., 2018). Specifically, citizen science enables the collection of a wide range of opinions and enhances the societal relevance and acceptance of, as well as trust in policy measures (Hecker et al., 2019; Hollow et al., 2015).

Secondly, citizen science provides scope for civic activation in political and policy-relevant debates and decision-making processes (Hecker et al., 2019; Kieslinger et al., 2017; Turrini et al., 2018). Citizen science can also empower citizens to develop and implement new solutions and prototypes, spurring new forms of self-governance (Göbel et al., 2019) and relationships between and roles of citizens and governments (Ponti and Craglia, 2020; Shanley et al., 2019).

Finally, citizen science can have an impact on how citizen science itself is supported by and connected to policy (Hecker et al., 2019; Roger et al., 2019). Hecker et al. (2019) show through a qualitative content analysis of 43 international policy documents that most documents emphasise the many benefits that citizen science may provide for science, society and policy.

(Challenges for) assessing political impact of citizen science

The political impact of citizen science can unfold at different geographical levels: from local community (e.g. neighbourhood scale), where local issues are frequently the motivation for citizen science activities, through city level, where activities are driven by coordination and collaboration between different groups, to regional, state/country level and finally to continental scale (Haklay, 2015). Additionally, there are different policy application areas, including environmental monitoring, agriculture and food, urban planning, health, humanitarian support (ibid.) according to the specific topic of the CS project.

While there is the widespread assumption that citizen science is useful in policy and political processes, there is little detail of how projects have contributed, and the potential remains largely untapped (Hollow et al., 2015; Shanley et al., 2019; Hecker et al., 2019). A survey of 503 citizen science projects by the European Commission revealed a high variety of intended and realised contributions to policy (European Commission, 2018a). A general challenge is the attribution of political impact to a specific research project given the complexity of political processes (Reale et al., 2018; Wiggins et al. 2018). Additionally, as citizen science is a relatively young field, evidence for political impact is only emerging (Hecker et al., 2019).

Another challenge related to political impact is the political nature of citizen science itself: by stimulating research on particular problems such as air pollution, projects can deflect attention of citizens and policymakers from other problems (e.g. poverty reduction) (Sauermann et al., 2020). Moreover, the solutions that are developed to address a focal problem may have negative implications for some external stakeholders (ibid.). Similarly, citizen science projects could end up engaging users that are already involved in political activities and in this way widening the gap with not-engaged (Passani at al., 2014).

The citizen science community should therefore seek to evaluate their current citizen science projects for their potential political impacts and in this way provide the scientific basis for current assumptions (Hecker et al., 2019). Political impact can be best measured through internal tracking or other forms of direct monitoring by the parties involved, including political decision-makers and citizen scientists, who are best informed about what counts as a meaningful policy or governance outcome (Wiggins et al. 2018). Evidence briefings or participation in advisory committees on legal practice and policy can help facilitate and assess political impact (Reale et al., 2018). It might also be enlightening to see how expectations are met by policy's steering activities, for instance how citizen science is framed through governmental funding schemes and in different socio-cultural contexts (Hecker et al., 2019). A systematic analysis of the political impacts of citizen science could also reveal challenges and how to address them for example through improved integration of citizen science into the policy cycle (ibid.).

3.4.1 Working definition of political impact

Political impact refers to the transfer and uptake of knowledge and results from citizen science in political processes and actions. Political processes and actions include policy processes (motivations, rationales and priorities, design, implementation and monitoring), empowerment of citizens to participate and self-organise, and political support for citizen science.

3.4.2 Political impact: ACTION dimensions and indicators/variables

We selected four dimensions for assessing the political impact of citizen science initiatives; those are reported, together with the related indicators in the table below.

Dimension	**Indicator**
Impact on policy process	Number of new/changed policies (e.g. regulatory, management or conservation actions)
	Agenda setting: number of new policy discourses and problem definitions
	Self-reported contribution to policy implementation and enforcement
	Self-reported contribution to monitoring and evaluation of policy implementation
	Number of policy recommendations produced by citizen science project
	Number of meetings/conferences organised/attended for influencing policymakers
Political participation	Political literacy: self-reported changes in the time spent by individuals in getting informed about political issues
	Self-reported changes in engagement in political groups or activities (e.g. party membership, work for candidates, protesting, lobbying)
	Self-reported changes in civic engagement (e.g. membership in voluntary associations, charities or environmental groups)

Self-governance	Active involvement in or creation of self-managed spaces for DIY-science community projects
	Active involvement in or creation of new civic society organisations and/or informal groups created at the local level
	Number of political events (e.g. rallies) organised/attended for involving wider actors
Political support for citizen science	Change in policy support and funding for citizen science
	Number of new partnerships between government decision-makers/policymakers and citizen science initiatives and organisations

Table 10 Indicators and variables for political impact of citizen science

3.4.3 Impact on policy processes

The contribution of citizen science outputs for policymaking, such as data and knowledge, has already been widely recognised and elaborated (Göbel et al., 2019; Shanley et al.,, 2019; Bela et al. 2016; Nascimento et al., 2018). Citizen science interacts with and can contribute to each step of the policy process: problem definition and agenda setting (identification of new issues or formulation of new hypothesis about known issues), policy formation, policy implementation, enforcement and compliance, and monitoring and evaluation (Turbé et al., 2019). Specifically, citizen science enables the collection of a wide range of opinions and enhances the societal relevance and acceptance of, as well as trust in policy measures (Hecker et al. 2019; Hollow et al. 2015; Ponti and Craglia, 2020).

How citizen science initiatives influence policy processes
Impact on policy processes is achieved through the mobilisation of knowledge and information for policymaking. Citizen science projects collect large amounts of data, including tapping into distributed knowledge domains and previously untapped and local or experiential knowledge (Ponti and Craglia 2020; Hollow et al. 2015) (see impact on science, in Section 3.1). This data provides policymakers and politicians with an evidence base to address (new) problems (Turbé et al. 2019; Wiggins et al. 2018). Access to citizen science generated data is often considered cost-efficient (Ponti and Craglia, 2020). Furthermore, governments often do not have the type and extent of data provided through citizen science (Ponti and Craglia, 2020).
Influencing policy processes requires linking the collected data to existing policy agendas and processes (Hecker et al., 2019; Groom et al. 2019; Ponti and Craglia 2020). Citizen science activities should iteratively and in an ongoing way link to policy-making processes, for example by involving policy makers and civil servants in the citizen science project design to communicate policy needs for data and knowledge (Göbel et al., 2019). Reports and policy briefs as outputs of citizen science initiatives can serve as instruments for policy engagement *(ibid.*).

New or changed policies
Firstly, we can assess the impact of a citizen science initiative on policy processes in terms of the likelihood that the data from the citizen science project were effectively used for new or changed policy (e.g. regulatory, management or conservation actions) (Turbé et al., 2019; Wiggins et al., 2018; Kieslinger et al., 2017). For example, Andrews et al. (2019) describe how federal managers changed regulation of the Endangered Species Act (ESA) as a result of a citizen science project that involved the recreational fishing community in Puget Sounds, Washington State, USA. Similarly, Rome and Lucero (2019) showcase how citizen scientists played a critical role in both collecting and conveying information to make the case for policy change.

Agenda setting: new policy discourses and problem definitions
Citizen science also contributes to the problem definition and agenda setting stage of the policy cycle by triggering new policy discourses and concerns regardless of the policy goals at which it was initially directed (Schade et al. 2017; Bela et al. 2016). Turbé et al. (2019) highlight how citizen science has supported the identification of new environmental problems, such as farmland birds declines, and has promoted issues such as pesticide use and intensive farming practices on the policy agenda. In another citizen science project – Botellon no me deja dormir – local residents were able to demonstrate how noise pollution was not a perception but a real problem. Thish helped to objectivise a previously considered subjective level of noise tolerance (Barcelona, Spain) (Ponti and Craglia, 2020).

Policy implementation and enforcement

Citizen science can support policy implementation and enforcement, for example by reporting breaches to relevant authorities, raising awareness and civic mobilisation for action (Turbé et al. 2019; Andrews et al. 2019; Owen and Parker 2018).

Monitoring and evaluation of policy implementation
Citizen science contributes to monitoring and evaluation of policies. Citizen science can especially address the data limitations of traditional monitoring programmes and to allow evaluation of the impacts of a policy decision (Turbé et al., 2019; Göbel et al., 2019; Nascimento et al. 2018). According to Turbé et al. (2019), there is evidence that several citizen science monitoring programmes have been instrumental in informing the designation of protected areas (e.g. eBird, Seasearch). The Common Farmland Bird Index is another example of recognised citizen science indicators for biodiversity monitoring in Europe to assess the impacts of the Rural Development Plans (Eurostat 2019).

3.4.4 Political participation

Citizen science can empower members of the public to get involved in political and policy-relevant processes and to gain interest, trust and knowledge that is needed to do so (Ballard et al., 2017; Hecker et al. 2019; Turrini et al. ,2018; Ponti and Craglia, 2020). As such, citizen science is attributed to foster political participation, which refers to activities that aim to directly or indirectly influence government action or shape the life of a community (Passani et al., 2014).

How citizen science initiatives influence political participation
Citizen science empowers citizens by involving them in decision-making processes and raising awareness and knowledge (Turrini et al., 2018; Kieslinger et al., 2017; Göbel et al., 2019). Citizen science is a form of knowledge co-production that fosters profound interaction between science, policy and society. Critical for such processes is to foster shared ownership and trust among the participants, and in this way to create a common sense of commitment (Kieslinger et al., 2017). This also requires capacity building of public authorities and science actors to engage with citizens on science and innovation, leading to better co-production and long-term public engagement activities after the end of a project (Göbel et al., 2019).

Political interest and literacy
Citizen science initiatives contribute to fostering political interest and knowledge (Turrini et al., 2018; Kieslinger et al., 2017; Hecker et al., 2019). This manifests in changes in the time spent by individuals in getting informed about political issues, as well as changes in the topics addressed (Passani et al., 2014).

Engagement in political groups or activities
Secondly, the participation in a citizen science initiative can promote engagement in political groups, activities or organisations. This engagement can be diverse, including e.g. party membership, work for candidates, taking part in demonstrations and protests, raising issues in the news media, communicating about political issues with others, initiating or signing a petition (Kieslinger et al. 2017; Passani et al., 2014).

Civic engagement

Next to political engagement, citizen science initiatives can also promote civic engagement. This can include e.g. membership in voluntary associations, charities or environmental groups to enhance the life of a community (Kieslinger et al. 2017; Passani et al. 2014; Hecker et al. 2019).

3.4.5 Self-governance

Citizen science can help experimenting with new forms of governance through which local groups self-manage environmental resources or design new solutions to deal with real world problems (Göbel et al., 2019; Ponti and Craglia, 2020). Self-governance means that a group independently exercises all necessary functions of regulation or services without intervention from an external authority (Driessen et al., 2012). It results in a decentralisation of governance towards local levels involving affected members of the public, who can directly implement changes, and can thus be a resource for political action (Göbel et al., 2019). For example, some citizen science projects have become places for communal activities and social action with potential for developing new practices around data collection, processing and use (Ponti and Craglia, 2020). Similarly, Nascimento et al. (2018) link this to the do-it-yourself movement: a 'DIY scientist' is someone who "tinkers, hacks, fixes, recreates and assembles objects and systems in creative and unexpected directions, […] doing science outside conventional university or lab settings, and instead in makerspaces, Fab Labs, Hackerspaces, techshops, innovation and community-based labs, or even in their homes, garages or schools" (Nascimento et al., 2018: p. 236). Although currently marginal, this can bring about new thinking and practices, not only enriching science and policy but also empowering citizens and communities (ibid.).

How citizen science initiatives influence self-governance
Similar to political participation, promoting self-governance relies on open interaction between actors, the creation of trust and shared ownership and empowerment of participants (Hecker et al. 2019; Göbel et al., 2019). Important is that citizen scientists are aware of the phases involved in the process and know what the end goal is (Ponti and Craglia, 2020).

Creation of organisations and spaces for DIY-science community projects or other civic society organisations and/or informal groups at the local level
We assess whether a citizen science initiative contributes to the creation of new spaces and organisations (e.g. grassroot initiatives) for DIY-science community projects, which implement innovative prototypes to solve real world problems without requiring policy involvement. This is facilitated by open source software and hardware, digital maker practices and open design that can be used by local communities to appropriate their own technological sensing tools (Nascimento et al. 2018). Göbel et al. (2019) illustrate how a citizen science workshop in Madrid involved designers and artists working together for two weeks to develop innovative prototypes to solve issues around urban mobility. Such space thus resulted in diverse prototypes that were exhibited to the public at the end, including a prototype that allows people to map potholes in their city, a bike-based pirate communication system, and a game for people to experiment with reducing air pollution. Another example for a new form of space through technology is the Public Laboratory for Open Technology and Science that includes techniques for civic mapping and water quality monitoring, which can be implemented independently by communities (Gabrys et al., 2016; Rey-Mazón et al., 2018; cf. Göbel et al., 2019).

Involvement of wider actors through public events
Often, the developed prototypes are born out of activism in the face of environmental problems and aim at civic mobilisation (Göbel et al., 2019). Applying the prototypes more widely does not require explicit approval from local authorities, scientists or the government but the active involvement of members of the public or interest groups (ibid.). Thus, we examine the extent of wider actors involved through public events (e.g. rallies).

3.4.6 Political support for citizen science

Citizen science initiatives can also have political impact by enhancing political support for citizen science itself. This addresses the regulation of citizen science as part of policies for advancing research technology and innovation (Göbel et al. 2019). Impact political support can become visible in form of supportive citizen science programmes and policies and new institutional structures within governments (Roger et al. 2019).

How citizen science initiatives influence political support for citizen science
Citizen science initiatives can engage in focused efforts to increase visibility and credibility of and to strategically position citizen science as a method for addressing policy goals and priorities, public events and policy platforms. Important for this is fostering exchange and networking between decision-makers, citizen science project leaders and practitioners (Shanley et al., 2019; Roger et al., 2019; Turbé et al., 2019; Fritz et al., 2019). In addition, citizen science initiatives need to create trust in their data quality and thus citizen science as a legitimate approach for doing research. Especially resistance to change and scepticism from government officials need to be addressed (Turbé et al., 2019; Hecker et al. 2019). Overall, it needs to be noted that changes in political support for citizen science are likely the result of pressures from multiple actors and initiatives and complex social and political negotiations (Hecker et al. 2019).

Policy support and funding for citizen science
Firstly, we assess whether the citizen science initiative achieves increased policy support and/or funding for citizen science. This includes the uptake of citizen science as a policy mechanism to achieve policy objectives, for example in funding calls or citizen science programmes (Göbel et al. 2019; Roger et al. 2019). An alignment of the citizen science initiatives with the priorities of decision-makers which will increase the likelihood of the adoption of citizen science (Fritz et al. 2019). In this reading, citizen science becomes a policy instrument that due to its many forms and functions can contribute to different policy goals and agendas (Göbel et al. 2019). Citizen science initiatives can also provide models of good practice that can be replicated in further policies and funding schemes (Fritz et al. 2019).

Partnerships between governments and citizen science initiatives and organisations
Citizen science initiatives can foster partnerships with governments. These can be lasting and formal partnerships but also more informal collaborations and policy-engagement activities to engage with policy makers who are responsible for creating and implementing laws and other rules that regulate research, science communication and science education (Shanley et al. 2019; Göbel et al. 2019). The main aim is to connect the citizen science practitioner community with decision-makers to demonstrate the validity and benefits of citizen science (Göbel et al. 2019; Hecker et al. 2018). For example, match-maker events or roundtables could be organised to foster exchange and networking between decision-makers and project leaders (Turbé et al. 2019; Göbel et al. 2019). Important is the issue of representation of professional versus volunteer practitioners, which requires considering day and time to hold such events, availability of travel cost support etc. (Göbel et al. 2019).

3.5 Environmental impact

Especially for citizen science projects on pollution, environmental impact is a very relevant area of impact. We agree with McKinley et al. (2017) when they state that "citizen science can improve conservation efforts, natural resource management, and environmental protection" (p.15). The ways in which it can do so vary from providing scientific knowledge to inspiring social and political action. In this sense, environmental impact can be achieved in tandem with most of the other dimensions in the impact assessment framework. However, because of its importance, especially in the field of pollution, we chose to give it more prominence in the ACTION framework than for example Kieslinger et al. (2017).

We did use the general distinction that Kieslinger et al. made between direct and indirect impact. With direct impact, we mean actions done in the context of the citizen science project that have an impact on the environment, such as changing policies, saving species, or convincing a company to lower their polluting activities. By indirect impact, we mean a change in behaviour, awareness, views, or responsibility of participants or other stakeholders in the project (see social impact, sub-section 3.2). Arguably, this change would also lead to an impact on the environment, for example by making people aware of the polluting nature of pesticides, they would use them less in their garden. In addition, indirect impact could come from new policies or regulations that have been instituted thanks to the project's outputs or activities (see political impact, sub-section 3.4 for more on how citizen science can impact policy).

3.5.1 Working definition

This dimension considers how the project can contribute to the conservation of natural assets, support pollution reduction or have another positive impact on the environment. This can be by directly reducing pollutants or emissions or by saving species. Alternatively, the project can have an indirect effect, by raising awareness, changing behaviours, supporting the development of new policies or strengthening community participation in environmental issues.

3.5.2 Environmental impact: ACTION dimensions and indicators

In order to do justice to the various forms of pollution and to make the environmental impact more substantial, we created six sub-dimensions, see table below. The first five were inspired by Wunder et al. (2019).

Wunder et al. (2019) developed a systematic framework for assessing the sustainability of civil society activities based on a review of scientific papers as well as 14 existing assessment systems (including e.g. the German sustainability strategy, the Sustainable Development Goals (SDGs)). The framework is targeted towards a diverse audience – including policymakers, researchers and practitioners – to (self-)evaluate the sustainability of initiatives. Despite the focus on civil society initiatives and activities, the framework was meant to be a generic and uniform starting point for sustainability assessments in different contexts. In addition, the framework is a good fit to evaluate the environmental impact of citizen science initiatives, because it is explicitly directed at actors without a thorough knowledge of sustainability evaluations and requires little data collection – it thus ensures easy application.

The assessment framework applies a broad understanding of sustainability following both the Brundtland Commission, including social, environmental and economic dimensions (WCED 1987), and the planetary boundaries (Rockström et al. 2009; Steffen et al. 2015). The latter implies that the assessment should not only consider local impacts but effects on global sustainability to account for potentially negative effects and trade-offs (Wunder et al. 2019).

For our purposes, we have only adapted the environmental assessment criteria, which include criteria on common environmental goods, climate, biodiversity, soil, water and air. The environmental criteria are already included in most of the assessment systems that were reviewed by Wunder et al. (2019). This indicates their overall relevance and applicability, also for our purposes.

Dimension	***Indicators***
Impact on ecosystem	Direct reduction emissions
	Indirect reduction emissions
Impact on biodiversity	Direct improvement biodiversity
	Indirect improvement biodiversity
Impact on soil quality	Direct improvement soil
	Indirect improvement soil
Impact on water quality	Direct improvement water
	Indirect improvement water
Impact on air quality	Direct improvement air quality
	Indirect improvement air quality
Impact on health	Direct influence health
	Indirect influence health

Table 11 Environmental impact dimensions and indicators

With impact on ecosystem we mean reducing emissions such as methane, nitrous oxide, ammonia, CFC, CO2, sulfur hexafluoride and nitrogen trifluoride. Ways of doing this would be the promotion of everyday practices with a lower ecological footprint, or active carbon storage.

Impact on biodiversity entails reducing the degradation of natural habitats, halting the loss of biodiversity or preventing the extinction of threatened species.

Impact on soil quality means to increase soil quality by reducing pollution and contamination, and/or by increasing its buffer function, filter function, habitat function, or production function.

Impact on water quality entails reducing pollution and contamination or by saving water usage.

With impact on air quality we mean reducing pollution and contamination from for example fine dust, carbon monoxide, ozone, sulphur dioxide, nitrogen, dioxide.

By the sixth dimension - impact on health - we mean increasing people's health or preventing illness. We added this dimension based on the feedback received of one citizen science project that worked with noise pollution. They do have an impact on the environment, but their impact does not fit within the other sub-dimensions. Their reduction of noise pollution has an influence on the health of the population affected by the noise, which means we have added impact on health as a sub-dimension of environmental impact.

The sub-dimensions will be measured with ad-hoc methods that fit the citizen science project in question. Most often, these measurements will be done by the citizen science projects themselves. For example, a project about air pollution will measure air quality throughout the project, which means we can compare the air quality at the start of the project to the air quality at the end to see whether there have been any improvements.

3.6 Transformative potential

This dimension assesses the transformative potential of a project in its context, i.e. the degree to which the project can help to challenge, alter, or replace dominant institutions and structures. A project has transformative potential by being radical, iconic, catalysing, timely, and by allowing for learning. Improving these aspects would increase the chance that this project will have long-term and long-lasting effects on society.

This dimension is different from the other five, in that it concerns a much longer-term impact – something that we would only be able to measure years after the project. For the other dimensions, there will be short-term outcomes and long-term impacts, but transformative impact would only be visible in the very long-term, as it is about system change. In order to have an idea of the potential now, we have developed a metrics and an associated tool. The concept of transformative potential has its roots in the field of sustainability transitions (Loorbach et al. 2017), and more specifically, strategic niche management (Kemp et al. 1998, Schot et al. 2008), the technological innovation systems approach (Markard and Truffer 2008, Smith and Raven 2012), and transformation research (Hölscher et al. - under review).

Transformative potential reflects the extent to which we expect that the project contributes to changing the regime. By the regime we mean business as usual, or the current system. For example: cars as the main mode of transport, and gas and oil as the main sources of energy. A niche, on the other hand, is a space for radical innovation that challenges the status quo. For example: bike sharing and public transport, renewable energy, etc. As Hölscher et al. (2020) put it, the transformative potential of a niche innovation "is visible in the extent to which it questions, changes or challenges (elements of) dominant regimes (e.g. user behaviour, technical components, market structures)" (p.25).

We see citizen science as a niche activity that has the potential to change how science is currently practiced. At the moment, the institutional context of science is that universities are the main or only place where science happens, and it is common practice that scientists do science and then tell their results to policy makers and other citizens. Citizen science challenges this regime by showing how science can be done by both scientists and citizens and there is participation from citizens from the beginning. As Turrini et al. put it: "the development of more citizen science formats that involve the public into the whole scientific process could foster innovation at a systemic level" (2018 p.184, see also Fernandez-Gimenez et al. 2008, Jordan et al. 2012, Bela et al. 2016).

This potential to change the scientific system is linked to the scientific impact indicators, especially those that focus on changing the institutional structures of academia. But citizen science also has the potential to transform other systems, such as the energy system, mobility system, or problem complexes such as biodiversity, because of the participatory way that citizen science is set up. For example, citizen science could change how we govern environmental issues through environmental democracy. Environmental democracy[6] is the idea that "meaningful participation by the public is critical to ensuring that land and natural resource decisions adequately and equitably address

[6] https://www.wri.org/blog/2014/07/what-does-environmental-democracy-look

citizens' interests". This is similar for energy systems and mobility systems, in the sense that radical civic participation can contribute to system change[7].

In order to exploit and assess this potential, we use a framework from the SIC Public Sector Innovation Blog[8] that focuses on five subdimensions, see Figure 9 and Table 12 below

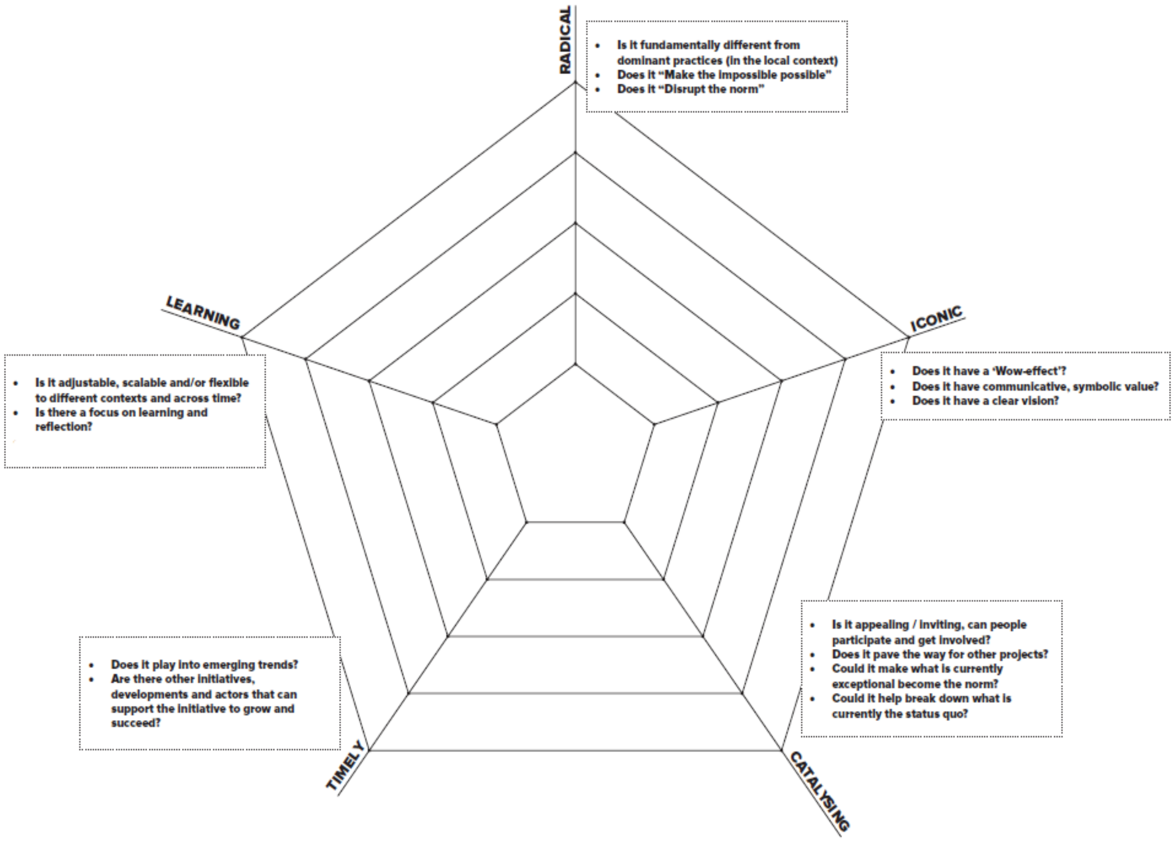


Figure 9 Framework to assess transformative potential, SIC Public Sector Innovation Blog

[7] https://proseu.eu/
[8] https://www.silearning.eu/wp-content/uploads/2017/04/6.transformative-impact-tool.pdf

Subdimensions	Questions regarding the project
Radical	Is it fundamentally different from dominant practices (in the local context)? Does it "make the impossible possible"? Does it "disrupt the norm"?
Iconic	Does it have a "wow effect"? Does it have a communicative, symbolic value? Does it have a clear vision?
Catalysing	Is it appealing/inviting, can people participate and get involved? Does it pave the way for other projects? Could it help break down what is currently the status quo?
Timely	Does it play into emerging trends? Are there other initiatives, developments, and actors that can support the project to grow and succeed?
Learning	Is it adjustable, scalable and/or flexible to different contexts and across time? Is there a focus on learning and reflection?

Table 12 Subdimensions framework to assess transformative potential

In this table we also see the questions that allow us to assess these sub-dimensions. These questions are also part of the transformative impact tool, which is designed to stimulate learning and critical reflection and in doing so, helps to identify actions and interventions that can increase the transformative impact (see D6.2).

3.7 How the framework will be applied to the ACTION project

As we mentioned in the previous sections of this document, the impact of ACTION as a project is constituted by the sum of the impacts of its pilots, plus the impact generated by its outputs. Here below we report the impact value chain of the ACTION project, already presented in sub-section 2.4.

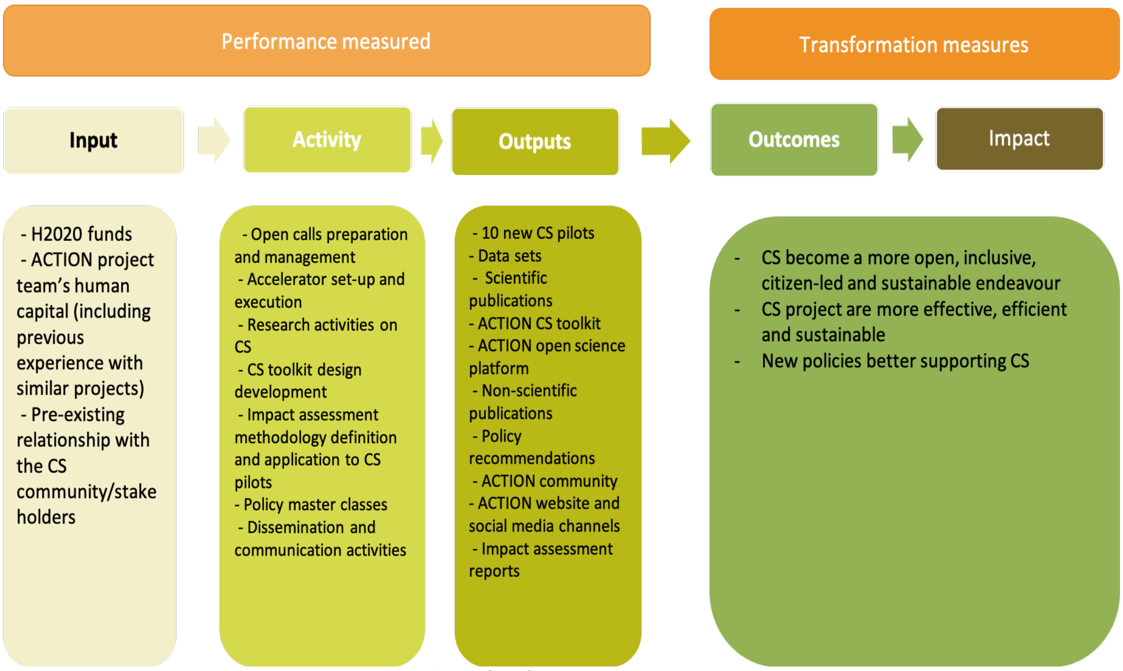


Figure 10 ACTION impact value chain

Considering the project output and expected outcomes, we will aggregate the impacts of the ACTION pilots for each of the five areas of impact considered. Then we will consider achievements and benefits generated by outputs other than the CS pilots and we will apply the relevant indicators.

More specifically we will:

- Apply the indicators of the scientific impact area to the scientific production of ACTION for evaluating the new knowledge generated, its openness and the interdisciplinary work conducted.
- Apply the indicators of the dimension "Impact on policy process" and "political support for CS" for evaluating the political impact of ACTION.
- Apply the indicators of the dimension "community building and empowerment" for evaluating the capability of the project to create and provide "value" to the CS and research community engaged by the project.

Some of the indicators will need some adjustment in its operationalisation but, overall, changes should be basically on the wording of the related data gathering tools (see D6.2).

Finally, we will consider the impact of the ACTION project on RRI through the application of the MORRI indicator (see next section).

Project impact will be assessed in January 2021 and in January 2022

4. Impact on SDGs and on RRI

In this section we will discuss how to link and enrich our impact assessment methodology with references to the United Nation Sustainable Development Goals and how to investigate ACTION achievements on Responsible Research and Innovation by referring to the MORRI indicators.

Both the approaches are more and more used worldwide and especially by the European Commission so that carrying out these additional analyses could be useful for ACTION reporting and for better communicating our project and pilots' achievements to a wider audience.

However, both the approaches refer to national-level goals and achievements so that the challenge is to find a suitable way to link pilots and project-level achievements to these macro/country-level analyses.

4.1 CS contribution to SDGs

The United National Sustainable Development Goals (SDGs) represent a framework for monitoring the achievements at national and global level in the alleviation of key issues such as poverty, hunger, and environmental degradation. The progress towards the 17 goals are assessed through 169 targets and 232 indicators.

Fritz et al. (2019) show that CS projects can be of help in measuring progress towards the targets of the SGS by providing data not available from official statistics, complementing them and enriching them. Also, Campbell et al, (2020) stress the potentialities of using data coming from CS for filling the data gap related to UN SDGs and Fraisl et al. (2020) show how CS is already contributing by providing data to several of the environmental-related targets.

This is for sure an interesting example on how CS can relate to SDGs, indeed providing data and filling data gaps is an enabling input: without reliable and timely data it is impossible to know the situation in a given territory and develop the needed actions for its improvement.

Within ACTION, however, we are also interested in describing how each pilot can help a territory in improving its performance on specific SDGs targets. Lämmerhirt et al. (2018) mention, for example that CS can develop several actions relevant for the achievements of the SDGs such as education, community engagement, community-based problem solving, as well as improvement to public services.

For tackling this dimension, we will consider if the ACTION pilots provide direct inputs to one or more of the SDGs at local level and if they promote an innovation (including policy innovation) able to contribute to SDGs target at regional, country or international level.

Summarising, for each of the ACTION pilot we will describe:

- The targets they address by providing useful data
- The targets they address with dedicated actions at local level
- The targets they address by providing innovation capable to provide an impact at regional/national or international level

4.2 ACTON contribution to MoRRI indicators

MoRRI indicators have been developed by the MoRRI project[9] in the 2014-2018 period and represent the first RRI monitoring system in Europe. MoRRI approach includes more than 36 indicators of RRI and considers six key areas of Responsible Research and Innovation: gender

[9] https://www.technopolis-group.com/morri/

equality, science literacy and education, public engagement, ethics, open access, and governance. The MoRRI system was meant to be a tool for monitoring European national R&I systems and the indicators selected consider mainly formally recognised national research institutions. The first challenge for ACTION, indeed, is to apply the MORRI indicators to an EU project, which does not work as an R&I organisation, being constituted by multiple partners, in several countries and being temporary in nature.

It is important to notice that the MoRRI indicators are currently under revision, thought a dedicated EU project called SUPER MoRRI which goals are to:

- “ensure continuation of cross-European data collection on the evolution and benefits of Responsible Research and Innovation (RRI);
- to advance beyond the MoRRI project by developing a proper scientific understanding of the complex and diverse relationships between RRI policies and practices and their societal, democratic, economic, and scientific benefits;
- and to significantly improve the properties of the RRI monitoring system”. (https://www.super-morri.eu/super-morri/)

The SUPER MoRRI project is also working on the challenge of linking the indicators to citizen science and this topic was discussed in the recent annual event. In that event the diversity in nature and scope of CS project was mentioned

And it was highlighter that “From the perspective of the SUPER MoRRI project, it is necessary to reflect upon what kinds of citizen science work the framework which is developed should aim to support. A framework to support ‘investigation projects’ may be irrelevant for, or even oppositional to the needs of ‘action-oriented’ projects and vice versa”. Further the discussion recognised that “the picture painted of citizen science is complex, deeply normative, and requires careful consideration”.

Considering the ongoing debate within SUPER MoRRI, we can attentive say that we will carry out a qualitative analysis on how ACTION can contribute to the MoRRI indicators but we will, more importantly, follow the evolution of the indicators by reinforcing our communication exchange with the SUPER MoRRI project and take on board any advice or new/revised metrics especially developed for CS projects. Another important point of reference for the ongoing debate on MoRRI application to CS is the MICS project (Wenh et a., 2020b): the communication with them is ongoing and the synergy on this aspect of the impact assessment could be very beneficial to ACTION.

ACTION

5. Data gathering and analysis

The methodology here described is operationalised through several data gathering instruments, mainly questionnaires. They are administered to CS managers and, for certain dimensions, to citizen scientists. The questionnaires developed and applied so by the impact assessment team (D6.2) are uploaded on the ACTION open data portal and regularly updated (https://zenodo.org/record/3968460#.XyQRCB1S-u5).

The process of data gathering varies for each pilot, indeed we engage with ACTION's project partners and accelerator pilots in co-designing this process to assure that the data gathering process and related tools are tailored to their needs.

5.1 Data gathering process

5.1.1 Canvas

Our first stage of data gathering is through the impact assessment canvas (see section 2 for a full description, and Annex 2 for the canvas). We ask the pilot coordinator (CS project manager) to fill out what areas of impact they expect from their project to be relevant and to provide the impact value chain-related parts if the information is not already available to us from other sources (pilots activity plan, monthly reports, etc).

5.1.2 One-to-one calls

The second stage is to have a one-to-one call with the pilot coordinator. The aim of this one-to-one call is two-fold: to gather feedback on the impact methodology, to look at the areas of impact to see if any should be changed or added. In the same call we plan the data gathering process with them, looking at the timeline of their activities and how to best engage the citizen scientists in the process.

5.1.3 Questionnaires and interviews

Third, we develop the questionnaires and other methods of data gathering (focus group guidelines, data gathering matrix, etc.) for the ACTION pilots (see D6.2 for the questionnaires that we have developed thus far). The general set-up for these questionnaires is that we do an ex-ante questionnaire at the start of the project and an ex-post questionnaire at the end of the project for the dimensions for which this approach is relevant. Depending on the areas of impact that are relevant for a specific pilot, they can do data gathering among project coordinators or with their citizen scientists. For example, the number of publications can be assessed by the pilot coordinators, while data about political participation has to be gathered from the citizens themselves.

The pilot coordinators are able to adapt the questionnaires to suit their project needs, for example by shortening it or by adding other relevant questions.

In planning the data gathering activities one of the guiding principles is that of reducing the burden for both pilot coordinators and citizen scientists so we try to merge our questionnaires with others (if present) as much as possible and pre-fill the answer if information is available from other sources.

The questionnaires for citizen scientists are usually translated in the local language by the pilot coordinator and are administered face to face or online according to the specific need of each pilot. The ACTION impact assessment team supports the process by developing paper-based surveys or online surveys as requested and in the languages needed.

The questionnaire and data gathering spreadsheet targeting pilot coordinators are in English: they are digital documents that the coordinators fill in in an autonomous way and send to the ACTION impact assessment team.

5.1.4 Final interview with pilot coordinators

At the end of each pilot, a final impact assessment interview with the pilot coordinator is organised in order to gather eventual missing information and for deeper understanding on specific aspects, if needed. This will be also the occasion for discussing further the impact assessment methodology and gathering feedback for its further improvement.

The data analysis is carried out by the ACTION impact assessment team and is described in the next subsections.

5.1.5 Transformative impact diamond

The Transformative Impact tool follows a slightly different logic from the questionnaires. Indeed, it is designed to stimulate learning and critical reflection, whereas the questionnaires' main aim is to measure impact. Nevertheless, the tool can and will be used in order to gain a better understanding of the transformative impact of the project in relation to its context. The tool also helps to identify actions and interventions that can increase the transformative impact, i.e. the degree to which the initiative can help to challenge, alter, or replace dominant institutions and structures.

This tool will be used in the ex-post impact assessment phase; we will ask the pilot coordinator to fill it in and then the content will be discussed in the final impact assessment interview mentioned above.

5.2 Data analysis

As mentioned in the previous sections, the ACTION impact assessment methodology is a quali-quantitative one so that we follow a mixed-methods approach in the data analysis (Cresswell, 2008).

Data will be analysed at pilot level first and then aggregated as indicated in subsection 5.2 in order to evaluate the impact of ACTION as a project.

At the pilot level we will carry out a descriptive, mono-variate analysis for the quantitative data and interpretative analysis for the qualitative ones: both will be done for each of the areas of impact separately. We assess the impact of all the pilots that join our accelerator and that are part of the ACTION consortium using an ex-ante/ex-post approach on several dimensions, which means that we will be able to assess the added value provided by ACTION.

At the project level, we will conduct a descriptive analysis first. More specifically, the overall dataset (including project and pilots' data) will be analysed by a process of thematic analysis based on the emerging themes considered to be relevant for describing and interpreting the investigated topic (Fereday and Muir-Cochrane, 2006). The process for the identification of the emerging themes will be based, first of all, on the five dimensions of our impact assessment methodology. We will also analyse - data allowing - correlations between demographic and psychographic variables and observed outcomes by comparing the results of the various pilots. The data gathered during the impact assessment activities will be enriched by the information gathered as part of the accelerator evaluation activities that will help us in understanding the impact of ACTION activities on the different pilots.

5.3 Expected results

The results that we gather will show the impact of each of the CS pilots as well as the impact of ACTION.

For each pilot a short impact report will be developed: it will follow a storytelling approach describing project input, activities, outputs and the qualitative results of the impact assessment. Each report will also include a visualisation of the impact of the pilots in more quantitative terms on the different areas and dimensions considered. This report will have a communicative nature so that pilots will be able to use it for their communication activities and, possibly, for presenting the benefit generated by their project to potential investors and other stakeholders.

Our first impact assessment report (D6.3) will be delivered in January 2021. This report will contain all impacts from the pilots in the first round of the ACTION accelerator in the above-mentioned form. It will also include a project-level impact assessment analysis.

At the end of the ACTION project, in January 2022 we will publish an updated report of the results (D6.4) which will include the impacts from the pilots in the second round of the ACTION accelerator and the final impact assessment of ACTION as a project.

Last, the results of the impact assessment will also feed into the development of the policy masterclasses (Task 6.4) as well as the policy brief on citizen science mainstreaming (D6.5), especially the impact results that concern the political impact dimension.

6. Conclusions

This report presented the ACTION impact assessment methodological framework, how it has been designed, its theoretical foundation and a plan for its implementation in the upcoming months.

It is important to underline that *we do not consider the framework presented in this report as final.* Indeed, in the next months we will apply it to different ACTION CS pilots: this will give us the possibility to understand if and where improvements are needed. Updates of the methodology will be presented in the next WP6 deliverables (D6.3 and D6.4 and in the ACTION CS toolkit).

This deliverable is complementary to D6.2 which includes the data gathering instruments developed so far and is constantly updated in order to make this methodology not only operational, but also modular and flexible. In fact, present and future CS pilots will be able to select the impact dimensions most relevant to them and to collect the data which is necessary for the impact assessment using the tools developed and tested by the ACTION team.

Finally, it is worth mentioning that the impact assessment activities that will take place in the upcoming months will support the whole ACTION consortium and the CS pilots in improving their work and will provide useful information on the overall project achievements. With this they will also serve as an input to the project dissemination work and to inform the sustainability plan, both part of WP7.

ACTION

Annex 1 - ACTION impact assessment canvas

ACTION

ACTION citizen science impact assessment canvas

Key problem you want to address	Key research question
What social, economic, environmental problem are you trying to (contribute) to solve? *Example: Air pollution, especially that is generated by private mobility, in Turin (Italy)*	What is the main research question addressed by your CS project? *Example: how does private mobility traffic impact on air quality in specific areas of the city and on specific moments of the day?*

Key stakeholders	To what category does your CS project belong?
• **Researchers** *Representing which disciplines? Junior or senior?* • **Citizen scientists** *Do you foresee engaging any specific social group? Is your project working towards inclusiveness? What is the gender distribution in your group of citizens: female/male/not disclosed/other?* • **Policy/decision makers** *Are you targeting local/national or international policy/decision makers?* • **Business actors** *Will your project provide input to business actors? Are you collaborating with business actors as part of your project?* • **Other organisations** *Will you collaborate with other organisations? What kind of organisation can benefit from the project's activities/results?* • **General public** *Do you foresee reaching local, national or international audiences?*	❑ Contributory project ❑ Collaborative project ❑ Conservation project ❑ Co-created project ❑ Education project ❑ Action project

1

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ACTION

Input	Activities
• Where are you starting from? • What was there before the beginning of the project? • What are the economic/technical and human resources you will use besides the one provided by ACTION? How much do they cost? *Example: this project is the continuation of a previous one, we already have 200 CS engaged and 5 lead researchers*	• What will you do? • What do you do to engage your stakeholders? *Example: Air quality monitoring with low cost DIY sensors. 5 events. 3 training workshops*
Outputs	**Short-terms and long-term impacts**
• What are the tangible results you expect to deliver? • How many people do you aim to engage? • How many people do you aim to reach through communication? • How many policy makers? *Example: a new version of our air quality measurement sensor; a curated dataset; 3 publications. 500 CS engaged. 1k reached*	• What positive change do you expect for your stakeholders? • Which areas of impact are more relevant? (see ACTION impact assessment framework in the next page and described in the PPT attached) • Which dimensions are more relevant? (see ACTION impact assessment framework in the next page and described in the PPT attached) *Example: citizens will be more aware of air quality, better informed on how to reduce exposure, 10% will change their moving behaviours. Policy makers will change mobility policies. Papers deeply up taken by researchers in the field.*

2

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Assign a value from 1 to 5 to each areas of impact and to the related dimensions
(1 is not relevant/we do not aspect impacts. - 5 is very relevant/will be a crucial impact)
Definitions of the areas of impact and related dimensions are in the PPT that accompany this canvas

Scientific impact	Value
Scientific knowledge	
New research fields and interdisciplinarity	
New knowledge resources	

Economic impact	Value
Impact on employment	
Cost saving	
Income and revenue generation for leading organisations	
Economic impact on the local communities	

Social impact	Value
Community building and empowerment	
Social inclusion	
Researchers and research community growth and empowerment	
Knowledge, skills and competences	
Changes in way of thinking, attitude and values	
Behavioural change	

Political impact	Value
Impact on policy process	
Political participation	
Self-governance	
Political support for citizen science	

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Environmental	Value
Impact on ecosystem	
Impact on biodiversity	
Impact on soil quality	
Impact on water quality	
Impact on air quality	
Impact on health	

Other impacts	Value
Please specify.....	
Please specify.....	
Please specify.....	

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Passani, A., Janssen, A.L., Hoelscher, K. (2020)

ACTION

Annex 2 - ACTION areas of impact, dimension, indicators, variables and references

Scientific impact	
Dimension	***Indicators***
Scientific knowledge	Quantity of new data created (N. of data points)
	Quality of data in datasets
	Research outputs' visibility on social media and research platforms (Academia, Research.edu, etc)
	Research outputs' compliance with FAIR principles of open data.
	Citizen scientists' participation and recognition in the scientific output.
	N. of published articles/books/book chapters (multiplier for peer-reviewed articles, impact factor)
	N. of other scientific outputs (new specimen collections, conservation outcomes, GitHub entries, etc)
	N. of non-scientific publications
	N. of theses
	Citizen scientists' participation and recognition in the scientific output.
New research fields and interdisciplinarity	Self-reported level of interdisciplinarity
	N. of new research groups created
	Sub-disciplines emerging
New knowledge resources	Ease access to knowledge that is otherwise hard to access
	Facilitate knowledge creation among societal actors and groups
	Development of new data-gathering tools
Innovation in education	Innovation in academic or school curricula
	Innovation in (other) educational/training methods

Social impact	
Dimensions	***Indicators***
Social Inclusion	Percentage of participants belonging to under represented social groups
	Ration among age groups of participants
	Male/female share among participants
	Diversity of participants in terms of education level
	Diversity of participants in terms of income
	Diversity of participants in terms of cultural differences
	Diversity of participants in terms of value orientation (materialistic/post materialistic)
	Presence and description of a dedicated strategy for social inclusion and diversity management

Researchers and research community growth and empowerment	N. of new collaborations established with other researchers/research organisations
	N. of new collaborations established with other organisations (excluding research organisations)
	Changes in researchers' career path
	Changes in researchers' level of trust for citizens, other CS managers and decision-makers

Knowledge, skills and competences	
Motivation and interest for science and the environment	N. of CS projects in which participants have been enrolled/are enrolled
	Probability to engage in CS projects in the future
	Participation in cause-oriented initiatives (see political impact)
	N. of participants considering a scientific or environmental-related carrier as a result of the project (for student only)
	N. of participants considering enrolling in life-learning educational program related to science or environmental studies (only for adults)
	Changes in the interest for the specific topic covered by the project
	Changes in the interest in science related topics and activities
Content, process and knowledge of the nature of science	Changes in the understanding of the scientific method
	Changes in the understanding of the scientific process
Skills of science inquiry	Acquisition of new skills in the research design-related activity
	Acquisition of new skills in the data gathering- related activities
	Acquisition of new skills in the data curation- related activities
	Acquisition of new skills in the data analysis- related activities
	Acquisition of new skills in the data interpretation- related activities
	Acquisition of new skills in shaping and commenting results
	Acquisition of new skills on impact assessment
	Acquisition of new skills in communicating results
	Acquisition of new skills in the valorization of project results for policy making
	Acquisition of new skills on project sustainability
	Increment in technological literacy
	Acquisition of new skills related to critical thinking
Project-specific disciplinary contents	***to be elaborated on a project-by-project base***

Soft skills	Changes in interpersonal communication related competences
	Change in the class social dynamics (only for school class-based projects)
	Changes in the capacity to collaborate (do it together)
	Changes in the capacity to collaborative discuss (think it together)
	Changes in organisational/management related competences

Changes in way of thinking, attitude and values	Changes in way of thinking related to the specific topic of the project. **Index to be selected/elaborated on a project-by-project base**
	Changes in way of thinking on environmental issues/concerns (NEPS scale)
	Changes in the way of thinking on science (MATOSS index)
	Changes at value level (post-materialistic index)
Behavioural change	Impact on green consumption behaviours
	Impact on project-specific related behaviours
	Changes in accessing green spaces and the natural world

Economic impact	
Dimensions	**Indicators**
Impact on employment	Number of new job places created within the leading organisation
	Number of participants that change or get a new job place as a results of the CS project
Cost saving	Average number of hours dedicated to the project for volunteer
	Number of hours dedicated to citizens' engagement and support
Income and revenue generation	Number of new or improved product created
	Number of new services created or improved
	Revenue generated by each of the new or improved products
Economic impact on the local community	***To be elaborated on a project-by-project base***

Political impact	
Dimension	***Indicator***
Impact on policy process	Number of new/changed policies (e.g. regulatory, management or conservation actions)

	Agenda setting: number of new policy discourses and problem definitions
	Self-reported contribution to policy implementation and enforcement
	Self-reported contribution to monitoring and evaluation of policy implementation
	Number of policy recommendations produced by citizen science project
	Number of meetings/conferences organised/attended for influencing policymakers
Political participation	Political literacy: self-reported changes in the time spent by individuals in getting informed about political issues
	Self-reported changes in engagement in political groups or activities (e.g. party membership, work for candidates, protesting, lobbying)
	Self-reported changes in civic engagement (e.g. membership in voluntary associations, charities or environmental groups)
Self-governance	Active involvement in or creation of self-managed spaces for DIY-science community projects
	Active involvement in or creation of new civic society organisations and/or informal groups created at the local level
	Number of political events (e.g. rallies) organised/attended for involving wider actors
Political support for citizen science	Change in policy support and funding for citizen science
	Number of new partnerships between government decision-makers/policymakers and citizen science initiatives and organisations

Environmental impact	
Dimension	***Indicators***
Impact on ecosystem	Direct reduction emissions
	Indirect reduction emissions
Impact on biodiversity	Direct improvement biodiversity
	Indirect improvement biodiversity
Impact on soil quality	Direct improvement soil
	Indirect improvement soil

Impact on water quality	Direct improvement water
	Indirect improvement water
Impact on air quality	Direct improvement air quality
	Indirect improvement air quality
Impact on health	Direct influence health
	Indirect influence health

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REFERENCES

Andrews, K.,, Nichols, K., Harvey, C., Tolimieri, N., Obaza, A., Garner, R., Tonnes, D., (2019). All Hands on Deck: Local Ecological Knowledge and Expert Volunteers Contribute to the First Delisting of a Marine Fish Species Under the Endangered Species Act. *Citizen Science: Theory and Practice, 4(1): 37*, pp. 1–14. DOI: https://doi.org/10.5334/cstp.221;

Ballard, H.L., Dixon, C. G. H., Harris, E. M., (2017). Youth-focused citizen science: examining the role of environmental science learning and agency for conservation. *Biol. Conserv. 208*, 65–75;

Bandura, A., (1982). Self-efficacy mechanism in human agency. *American Psychologist. 37 (2):* 122–147. DOI:10.1037/0003-066X.37.2.122;

Bandura, A., (2000). Exercise of human agency through collective efficacy. *Current directions in psychological science, vol. 9, issue 3,* pp. 75-78;

Bela, G., Peltola, T., Young, J. C., Balász, B., Arpin, I., Pataki, G., Hauck, J., Kelemen, E., Kopperoinen, L., Van Herzele, A., Keune, H., Hecker, S., Suškevičs, M., Roy, H. E., Itkonen, P., Külvik, M., László, M., Basnou, C., Pino, J., Bonn, A.,(2016). Learning and the transformative potential of citizen science. *Conservation Biology, 30 (5)*: 990–999. DOI: 10.1111/cobi.12762;

Blaney, R. J. P., Jones, G. D., Philippe, A. C. V., Pocock, M. J. O., (2016). Citizen Science and Environmental Monitoring: Towards a Methodology for Evaluating Opportunities, Costs and Benefits. Final Report on behalf of UKEOF. *WRc, Fera Science, Centre for Ecology & Hydrology*;

Bollen, J., Van de Sompel, H., Hagberg, A., & Chute, R., (2009). A principal component analysis of 39 scientific impact measures. *PloS one, 4(6), e6022*;

Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., Wilderman, C. C., (2009). Public participation in scientific research: defining the field and assessing its potential for informal science education. A CAISE Inquiry Group Report, Washington D. C.: Center for Advancement of informal Science Education (CAISE);

Bonney, R., Shirk, J. L., Phillips, T. B., Wiggins, A., Ballard, H. L., Miller-Rushing, A. J., Parrish, J. K., (2009). Next step for Citizen Science. *Science 343 (6178),* 1436-1437. DOI:10.1126/science.1251554;

Bonney, T., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., Shirk, J., (2009). Citizen science: a developing tool for expanding science knowledge and scientific literacy. *BioScience 59:* 977–984. ISSN 0006-3568, electronic ISSN 1525-3244. by American Institute of Biological Sciences;

Brossard, D., Lewenstein, B. V., Bonney, R., (2005). Scientific knowledge and attitude change: the impact of a citizen science project. *International Journal Science Education, vol. 27, n° 9*, pp. 1099-1121;

Chandler, M., Rullman, S., Cousins, J., Esmail, N., Begin, E., Venicx, G., Eisenberg, C., Studer, M., (2016). Contributions to publications and management plans from 7 years of citizen science: use a novel evaluation tool on Eartwatch-supported projects. *Elsevier Ltd, 0006-3207*. DOI:http://dx.doi.org/10.1016/j.biocon.2016.09.024;

Chase, S. K., Levine, A., (2016). A framework for evaluating and designing citizen science programs for natural resources monitoring: Resource-Based Framework for Citizen Science. *Biology, Volume 00, No. 0*, 1–11. DOI:10.1111/cobi.12697;

Crain, R., Cooper, C., & Dickinson, J. L., (2014). Citizen science: a tool for integrating studies of human and natural systems. Annual Review of Environment and Resources, 39;

Cresswell, J. W., (2008), Research Design: Qualitative, Quantitative and Mixed Methods Approaches, 3rd ed., Sage, Thousand Oaks;

Dickinson, J. C., Shirk, J., Bonter, D., Bonney, R., Crain, R. L., Martin, J., Phillips, T., Purcell, K., (2012). The current state of citizen science as a tool for ecological research and public engagement. *Frontiers in Ecology and the Environment, 10(6)*: 291–297. DOI:10.1890/110236;

Driessen, P.P.J., Dieperink, C., van Laerhoven, F., Runhaar, H.A.C., Vermeulen, W. J. V., (2012). Towards a Conceptual Framework for The Study of Shifts in Modes of Environmental Governance – Experiences From The Netherlands. *Environmental Policy and Governance, 22(3):* 143-160. DOI: https://doi.org/10.1002/eet.1580;

European Commission, (2018a). An inventory of citizen science activities for environmental policies. European Commission. Italy: Bio Innovation Service, Directorate- General for Environment; European Commission, Joint Research Centre. [Dataset] PID: http://data.europa. eu/89h/jrc-citsci-10004

European Commission, (2018, b), Monitoring the evolution and benefits of responsible Research and Innovation, Luxemburg. Available at: https://op.europa.eu/en/publication-detail/-/publication/2c5a0fb6-c070-11e8-9893-01aa75ed71a1/language-en

Fauver, B., (2015). Is Citizen Science Worth It: Identifying Natural Resource Managers' Values Through Cost-Benefit Analysis. Paper presented at the Citizen Science 2015 Conference; February 11-12 2015, San Jose, California, USA;

Fereday, J., & Muir-Cochrane, E., (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. International journal of qualitative methods, 5(1), 80-92.

Fernandez-Gimenez, M. E., Ballard, H. L., & Sturtevant, V. E., (2008). Adaptive management and social learning in collaborative and community-based monitoring: a study of five community-based forestry organizations in the western USA. *Ecology and Society, 13(2)*;

Fraisl, D., Campbell, J., See, L. et al. (2020), Mapping citizen science contributions to the UN sustainable development goals. *Sustain Sci* (2020). https://doi.org/10.1007/s11625-020-00833-7

Franzen, A., Vogl, D., (2013). Acquiescence and the willingness to pay for environmental protection: A comparison of the ISSP, WVS, and EVS. *Social Science Quarterly 94:* 637- 659;

Friedman, A. J., See, L., Carlson, T., Haklay, M., Oliver, J. L., Fraisl, D., Mondardini, R., Brocklehurst, M., Stanley, L. A., Schade, S., Wehn, U., Abrate, T., Anstee, J., Arnold, S., Billot, M., Campbell, J., Espey, J., Gold, M., Hager, G., He, S., Hepburn, L., Hsa, A., Long, D., Masó, J., McCallum, I., Muniafu, M., Moorthy, I., Obersteiner, M., Parker, A. J., Weisspflug, M., West, S., (2008). Framework for evaluating impacts of informal science education projects. Report from a National Science Foundation workshop;

Fritz, S., See, L., Carlson, T. et al. (2019). Citizen science and the United Nations Sustainable Development Goals. *Nature sustainability, 2*: 922-930. DOI: https://doi.org/10.1038/s41893-019-0390-3;

Garfield,, E., (1999). Journal impact factor: a brief review. *CMAJ 161 (8)* 979-980;

Göbel, C., (2019). How does citizen science "do" governance? Reflection from DITO's project. *Theory and Practice, 4(1): 31*, pp. 1–13. DOI: https://doi.org/10.5334/cstp.204;

Gijsel, L., Huyse, T., & Van Hoyweghen, I., (2019). Citizen science: hoe burgers de wetenschap uitdagen. *Pelckmans Pro*;

Groom, Q., Strubbe, D., Adriaens, T., Davis, A. J. S., Desmet, P., Oldoni, D., Reyserhove, L., Roy, H. E., Vanderhoeven, S., (2019). Empowering Citizens to Inform Decision-Making as a Way Forward to Support Invasive Alien Species Policy. *Citizen Science: Theory and Practice, 4(1): 33*, pp. 1–11. DOI: https://doi.org/10.5334/cstp.238;

Haklay, M., (2015). Citizen Science and Policy: A European Perspective. *Washington, DC: Woodrow Wilson International Center for Scholars.* https://www.wilsoncenter.org/sites/default/files/media/documents/publication/Citizen_Science_Policy_European_Perspective_Haklay.pdf (Accessed: June 20, 2020);

Haywood, B. K., Besley, J. C., (2014). Education, outreach, and inclusive engagement: Towards integrated indicators of successful program outcomes in participatory science. *Public Understanding of Science, Vol. 23(1),* 92–106, DOI: 10.1177/0963662513494560;

Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J. & Bonn, A., (2018). Citizen Science: Innovation in Open Science, Society and Policy. *London: UCL Press.* DOI: https://doi.org/10.14324/111.9781787352339;

Healy, T., and Cote, S., (2001). The Well-Being of Nations : The Role of Human and Social Capital. *Organisation for Economic Co-operation and Development*;

Hecker, S., Wicke, N., Haklay, M., Bonn, A., (2019). How Does Policy Conceptualise Citizen Science? A Qualitative Content Analysis of International Policy Documents. *Citizen Science: Theory and Practice, 4(1): 32*, pp. 1–16. DOI: https://doi.org/10.5334/cstp.230;

Hollow, B., Roetman, P. E. J., Walter, M., Daniels, C. B., (2015). Citizen science for policy development: the case of koala management in South Australia. *Environmental Science & Policy, 47:* 126-136. DOI: http://dx.doi.org/10.1016/j.envsci.2014.10.007;

Hölscher, K., Wittmayer, J. M., Hirschnitz-Garbers, M., Olfert, A., Walther, J., Schiller, G., (under review). Transforming science and society? Methodological lessons from and for transformation research. *Research Evaluation*;

Hölscher, K., Wittmayer, J., Olfert, A., Hirschnitz-Garbers, M., Walther, J., Brunnow, B., Schiller, G., Hinzmann, M., Langsdorf, S., (2020). Infrastrukturkopplungen als Beiträge zur Nachhaltigkeitstransformation: Einflussfaktoren und Handlungsmöglichkeiten. Teilbericht des Vorhabens: „Transformation hin zu nachhaltigen, gekoppelten Infrastrukturen". *Texte 100/2010. Umweltbundesamt, Dessau.* https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/texte_100-2020_infrastrukturkopplungen_als_beitraege_zur_nachhaltigkeitstransformation.pdf;

International Association for Impact Assessment (IAIA), 2011. International Association for Impact Assessment (online). Fargo, ND: IAIA. Available at: www.iaia.org.

IMWG, (2014), *Measuring Impact.* Subject paper of the Impact Measurement Working Group. Available at: http://www.evaluatingimpactinvesting.org/wp-content/uploads/Measuring-Impact-IMWG-paper.pdf

Inglehart, R., (1990). *Culture shift in advanced industrial societies*, Princeton University Press. ISBN: 9780691022963;

Inglehart, R., Abramson, P. R., (1995). *Value change in global perspective*, University of Michigan Press. DOI: 10.3998/mpub.23627;

Inglehart, R., (1997). *Modernization and postmodernization*. Princeton University Press. ISBN: 9780691011806

Jordan, R. C., Gray, S. A., Howe, D. V., Brooks, W. R., Ehrenfeld, J. G., (2011). Knowledge gain and behavioural change in Citizen Science programs. *Conservation Biology, Volume 25, No. 6*, 1148–1154;

Jordan, R. C., Ballard, H. L., Phillips, T. B., (2012). Key issues and new approaches for evaluating citizen-science learning outcomes. *Front Ecol Environ; 10(6):* 307–309. DOI:10.1890/110280;

Kemp, R., Schot, J., & Hoogma, R., (1998). Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management. *Technology analysis & strategic management, 10(2),* 175-198;

Kieslinger, B., Schäfer, T., Heigl, F., Dörler, D., Richter, A., Bonn, A., (2017). The Challenge of Evaluation: An Open Framework for Evaluating Citizen Science Activities. *ResearchGate.* DOI:10.17605/OSF.IO/ENZC9;

Kosmala, M., Wiggins, A., Swanson, A., & Simmons, B., (2016). Assessing data quality in citizen science. *Frontiers in Ecology and the Environment, 14(10),* 551-560;

Lämmerhirt D., Gray J., Venturini T., Meunier A., (2018), Advancing sustainability together? Citizen-generated Data and the sustainable development goals. Available at: https://www.data4sdgs.org/sites/default/files/services_files/Advancing%2520Sustainability%2520Together%2520CGD%2520Report_1.pdf

Laverack G., Wallerstein, N., (2001). Measuring community empowerment: a fresh look at organizational domains. *Health promotion international, 16(2),* 179-185;

Loorbach, D., Frantzeskaki, N., & Avelino, F., (2017). Sustainability transitions research: transforming science and practice for societal change. Annual Review of Environment and Resources, 42;

Markard, J., & Truffer, B., (2008). Technological innovation systems and the multi-level perspective: Towards an integrated framework. *Research policy, 37(4),* 596-615;

McKinley, D. C., Miller-Rushing, A. J., Ballard, H. L., Bonney, R., Brown, H., Cook-Patton, S. C., ... & Ryan, S. F. (2017). Citizen science can improve conservation science, natural resource management, and environmental protection. *Biological Conservation, 208*, 15-28;

Meyer, R., Liebe, U., (2010). Are the affluent prepared to pay for the planet? Explaining willingness to pay for public and quasi-private environmental goods in Switzerland. *Popul environ, 32:42-65.* DOI: 10.1007/s11111-010-0116-y;

Nascimento, S., Iglesias, J. M. R., Owen, R., Schade, S., Shanley, L., (2018). Citizen science for policy formulation and implementation. In: Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., Bonn, A. (eds.) Citizen Science. Innovation in Open Science, Society and Policy. *UCL Press: London*, pp. 219-240;

National Academies of Sciences, Engineering, and Medicine, (2018). Learning Through Citizen Science: Enhancing Opportunities by Design. *Washington, DC: The National Academies Press*. doi: https://doi.org/10.17226/2518

Nurmi, V., Votsis, A., Prampolini, A., Passani, A., Mägdefrau, N., (2017), *Report on iSCAPE socio-economic impact assessment methodology*, project deliverable available at https://www.iscapeproject.eu/wp-content/uploads/2018/03/D5.6-Report-on-iSCAPE-socio-economic-assessment-methodology.pdf

Owen, R. P. and Parker, A. J., (2018). Citizen science in environmental protection agencies. In: Hecker, S, Haklay, M, Bowser, A, Makuch, Z, Vogel, J and Bonn, A (eds.), Citizen Science: Innovation in Open Science, Society and Policy, 284–300. *London: UCL Press*. DOI: https://doi.org/10.14324/111.9781787352339;

Passani, A., Schäfer, T., Heigl, F., Dörler, D., Richter, A., Bonn, A., (2014). The Challenge of Evaluation: An Open Framework for Evaluating Citizen Science Activities. *ResearchGate*.DOI:10.17605/OSF.IO/ENZC9;

Passani, A., Spagnoli, F., Prampolini, A., Firus, K., Van Der Graaf, S., Vanobberghen, W. (2014). IA4SI Methodological framework – First version. Update. A deliverable of the project "IA4SI – Impact assessment for Social Innovation", European Commission – 7th Framework Programme;

Phillips, T., Ferguson, M., Minarchek, M., Porticella, N., Bonney, R., (2014). Users guide for evaluating learning outcomes in Citizen Science. *Ithaca, NY: Cornell Lab of Ornithology*;

Ponti, M., Craglia, M. (2020). Citizen-generated data for public policy. European Commission, Ispra, JRC120231. https://ec.europa.eu/jrc/communities/sites/jrccties/files/jrc120231_citizen-generated_data_for_public_policy.pdf (Accessed: June 20, 2020);

Putnam, R. D.. (2000). Bowling alone : the collapse and revival of American community. *New York: Simon & Schuster*

Ratto, Nielsen, J., (2017), Creating Impact Canvas: a tool for planning and design of your learning mobility project, available at: https://epale.ec.europa.eu/en/resource-centre/content/creating-impact-canvas-tool-planning-and-design-your-learning-mobility

Reale, E., Avramov, D., Canhial, K., Donovan, C., Flecha, R., Holm, P., Larkin, C., Lepori, B., Mosoni-Fried, J., Oliver, E., Primeri, E., Puigvert, L., Scharnhorst, A., Schubert, A., Soler, M., Soòs, S., Sordé, T., Travis, C., Van Horik, R., (2018). A review of literature on evaluating the scientific, social and political impact of social sciences and humanities research. *Research Evaluation, 27(4):* 298–308. DOI:10.1093/reseval/rvx025;

Rey-Mazon, P., Keysar, H., Dosemagen, S., D'Ignazio, C. and Blair, D., (2018). Public Lab: Community-Based Approaches to Urban and Environmental Health and Justice. *Sci Eng Ethics, 24(3):* 971–997. DOI: https:// doi.org/10.1007/s11948-018-0059-8;

Roberts, J. A., (1996b). Green consumers in the 1990s: profile and implications for advertising'. *Journal of Business Research, Vol. 36 No. 3*, pp. 217-31 ,

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S. III, Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H., Nykvist, B., De Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R. W., Fabry, V. J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., and Foley, J., (2009). Planetary boundaries:exploring the safe operating space for humanity. *Ecology and Society 14(2): 32.* [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art32;

Roger, E, Turak, E, Tegart, P. (2019). Adopting Citizen Science as a Tool to Enhance Monitoring for an Environment Agency. *Citizen Science: Theory and Practice, 4(1): 35*, pp. 1–9. DOI: https://doi.org/10.5334/cstp.231;

Roman, D.; El Kader, S. A.; Thuermer, G.; Gonzalez, E.; Celino, I.; Calegari, G.; Scandolari, D. (2020), ACTION Deliverable D4.1 Conceptual architecture and delivery plan.

Rome, C, and Lucero, C. (2019). Wild Carrot (Daucus carota) Management in the Dungeness Valley, Washington, United States: The Power of Citizen Scientists to Leverage Policy Change. *Citizen Science: Theory and Practice, 4(1): 36*, pp. 1–9. DOI: https://doi.org/10.5334/cstp.201;

Sauermann, H. and Franzoni, C., (2014). Crowd science user contribution patterns and their implications. *Edited by Adrian E. Raftery, University of Washington, Seattle, WA*;

Sauermann, H. Vohland, K., Antoniou, V., Balázs, B., Göbel, C., Karatzas, K., Mooney, P., Perelló, J., Ponti, M., Samson, R., Winter, S., (2020). Citizen science and sustainability transitions. *Research Policy, 49: 103978.* DOI: https://doi.org/10.1016/j.respol.2020.103978;

Schade, S, Manzoni-Brusati, M, Tsinaraki, C, Kotsev, A, Fullerton, K, Sgnaolin, R, Spinelli, F and Mitton, I., (2017). Using new data sources for policymaking. *Luxembourg: Publications Office of the European Union.* DOI: https://doi.org/10.2760/739266;

Schaefer, T., Kieslinger B., (2016), Supporting emerging forms of citizen science: a plea for diversity, creativity and social innovation. *JCOM* 15(02), Y02

Schaefer, T., Kieslinger, B., Fabian, C. M., (2020). Citizen-Based Air Quality Monitoring: The Impact on Individual Citizen Scientists and How to Leverage the Benefits to Affect Whole Regions. *Citizen Science: Theory and Practice, 5(1): 6,* pp. 1–12. DOI: https://doi.org/10.5334/cstp.245;

Schot, J., & Geels, F. W., (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology analysis & strategic management, 20(5),* 537-554;

Schunk, D. H., (1991). Self-efficacy and academic motivation. *Educational Psychologist, 26*, 207-231;

Shanley, L.A., Parker, A., Schade, S., Bonn, A., (2019). Policy Perspectives on Citizen Science and Crowdsourcing. *Citizen Science: Theory and Practice, 4(1): 30,* pp. 1–5. DOI: https://doi.org/10.5334/cstp.293;

Shirk, L. J., Ballard, H. L., Wilderman C. C., Phillips, T., Wiggins, A., Jordan, R., McCallie, E., Minarchek, M., Lewenstein, B. V., Krasny, M. E., Bonney, R., (2012). Public participation for scientific research: a framework for deliberate design. *Ecology and Society 17(2):29*. DOI: http://dx.doi.org/10.5751/ES-04705-170229;

Skrip M.M., (2015). Crafting and evaluating Broader Impact activities: a theory-based guide for scientists. *Frontiers in Ecology and the Environment, 13:* 273–279. DOI: http://dx.doi.org/10.1890/140209;

Smith, A., and Raven, R., (2012). What is protective space? Reconsidering niches in transitions to sustainability. *Research policy, 41(6),* 1025-1036;

Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E. I. M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B. und Sörlin, S., (2015). Planetary Boundaries: Guiding human development on a changing planet. *Science, 347(6223)*;

Straughan, R. D., Roberts, J. A., (1999). Environmental segmentation alternatives: a look at green consumer behavior in the new millennium. *Journal of consumer marketing, vol. 16 n. 6,* pp. 558-575. MCB University Press, 0736-3761. DOI: 10.1108/07363769910297506;

Theobald, E. J., Ettinger, A. K., Burgess, H. K., DeBey, L. B., Schmidt, N. R., Froehlich, H. E., Wagner, C., HilleRisLambers, J., Tewksbury, J., Harsch, M. A., Parrish, J. K., (2015). Global change and local solutions: Tapping the unrealized potential of citizen science for biodiversity research. *Biological Conservation, 181*, 236–244. DOI:10.1016/j.biocon.2014.10.021;

Tredick, C. A., Lewinson, L. R., Deutschman, D. H., Hunt, T. A., Gordon, K. L., Von Hendy, P., (2017). A rubric to evaluate citizen-science programs for long-term ecological monitoring. *Bioscience, vol 67, n° 9*;

Tulloch, A. I., Possingham, H. P., Joseph, L. N., Szabo, J., & Martin, T. G., (2013). Realising the full potential of citizen science monitoring programs. Biological Conservation, 165, 128-138

Turbè, A., Barba, J., Pelacho, M., Mudgal, S., Robinson, L. D., Serrano-Sanz, F., Sanz, F., Tsinaraki, C., Rubio, J. M., Schade, S., (2019). Understanding the Citizen Science Landscape for European Environmental Policy: An Assessment and Recommendations. *Citizen Science: Theory and Practice, 4(1): 34*, pp. 1–16. DOI: https://doi.org/10.5334/cstp.239;

Turrini, T., Dörler D., Richter, A., Heigl, F., Bonn, A., (2018). The threefold potential of environmental citizen science - Generating knowledge, creating learning opportunities and enabling civic participation. *Biological conservation 225:* 176-186. DOI: https://doi.org/10.1016/j.biocon.2018.03.024;

Tweddle, J. C., Robinson, L. D., Pocock, M. J. O., Roy, H. E., (2012). Guide to Citizen Science: developing, implementing and evaluating citizen science to study biodiversity and the environment in the UK. *Natural History Museum and NERC Centre for Ecology & Hydrology for UK-EOF.* Retrieved on 29.06.2016;

United Nations (UN), (2015), UN general Assembly Transforming our World: The 2030 Agenda for Sustainable Development A/RES/70/1

WCED, World Commission on Environment and Development (1987). Our common future. http://www.un-documents.net/our-common-future.pdf. Accessed: October 4, 2018;

Wehn, U., Gharesifard, M. and Bilbao, A. (2020a) D2.2: Report detailing impact-assessment methods adapted to citizen science. Deliverable report of project H2020 MICS (grant agreement No 824711)

Wehn, U., Gharesifard, M. and Ceccaroni, L. (2020b). D2.3: Impact-assessment methods adapted to citizen science. Deliverable report of project H2020 MICS (grant agreement No 824711).

Weiss, C. H., (1998). Evaluation. Methods for Studying Programs and Policies. Second Edition. *Prentice Hall, New Jersey*;

Wickson, F., Carew, A. L., (2014). Quality criteria and indicators for responsible research and innovation: learning from transdisciplinarity. *Journal of Responsible Innovation, Vol.1, No 3,* 254 – 273. DOI: 10.1080/23299460.2014.963004;

Wiggins, A.,Crowston, K., (2011). From conservation to Crowdsourcing: A Typology of Citizen Science. In: Proceeding of 44th Hawaii International Conference on System Science (HICSS), pp.1-10: DOI: 10.1109/HICSS.2011.207

Wiggins, A., Bonney, R., LeBuhn, G., Parrish, J.K., Weltzin, J.F., (2018), A science product inventory for citizen science planning and evaluation. BioScience 68: 436–444. *Published by Oxford University Press on behalf of the American Institute of Biological Sciences.* Doi: 10.1093/biosci/biy028;

Wunderm, S., Albrecht, S., Porsch, L., Öhler, L., (2019). Kriterien zur Bewertung des Transformationspotentials von Nachhaltigkeitsinitiativen. *Texte 33/2019. Umweltbundesamt: Dessau-Roßlau*.