This project is co-financed by the European Union

Grant Agreement No.: 824603
Call: H2020-SwafS-2018-1
Type of action: RIA
Starting date: 1/02/2019

D6.3 Impact Assessment Report V1

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Deliverable nature	R
Dissemination level	PU
Work package and Task	WP6, Task 6.3
Contractual delivery date	M24
Actual delivery date	29/01/2021

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Abstract	This document reports the results of the intermediate impact assessment of the ACTION project. It focuses on the results achieved by the ACTION pilots in the first half of the project. Following the ACTION impact assessment methodology, the main areas of impact considered are: scientific, social, economic, political and environmental. The transformative potential of the pilots is also considered together with their potential contribution to UN Sustainable Development Goals (SDGs). The report describes the impact analysis of nine pilots at aggregated level firs and then one by one. Averall ACTIOn and its pilot reported many and interesting results and the perspective in terms of impact are positive. The areas of impact that score highest are the scientific and the social ones and promising results are observable also in terms of political impact.
Keywords	Impact assessment, impact of CS projects, social impact, economic impact, scientific impact, environmental impact, policy impact, transformative potential of CS projects

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How to quote this document

Passani, A. Janssen, A., Di Lisio, G. (2021), D6.3 Impact assessment report v1.

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EXECUTIVE SUMMARY

This report describes the scientific, social, economic, political and environmental impacts of ACTION, and especially of nine of its CS pilots.

Overall, the mapped impacts are aligned with the expectations: many projects have a strong scientific and/or social impact, a high transformative potential, and promising political impacts. Environmental and economic impact emerged as more difficult to measure in a relatively short timeframe as the one considered.

Out of nine pilots considered, four deal with light pollution, three with soil pollution, one with noise pollution and one with air pollution.

Altogether, the pilots reached more than **36.000 persons** through events and dissemination activities and engaged more than **660 persons** in citizen science (CS) activities. All the pilots engaged citizens in data collection, four of them also in data analysis and two also in data gathering tool development and in data curation.

The UN Sustainable Development Goals (SDGs) more relevant for ACTION pilots are: 3 – Good health and wellbeing, 4 – Quality education, 5 - Gender equality, 6- Clean water and sanitation, 11 - Sustainable cities and communities, 12 - Responsible production and consumption and 13- Climate action.

All ACTION pilots show a positive **scientific impact**. In total, pilots gathered more than 45.000 datapoints. Furthermore, ACTION produced 9 peer reviewed articles, 5 non-peer reviewed articles, and 21 non-scientific publications (such as blog post, videos, articles on magazines, etc.). For almost all the project data quality is very high and most pilots are following well Open Science and Open data principle.

Considering **social impacts**, it is possible to say that all the pilots report a positive social impact in terms of knowledge, skills and competencies acquisition by engaged citizens. Some of the pilots report positive results in changing participants' opinions and way of thinking, especially on the specific topic covered by the pilots. Changes in opinions on more general aspects such as environmental sustainability or trust in science didn't emerge so well, because, in many cases participants showed a pro-environmental and pro-science value orientation already at the beginning of the pilots. Nevertheless, the pilots engaging students show a positive impact on this aspect by increasing participants' interest for science and for nature and for the specific topic addressed by the pilot such as air and light pollution.

The situation for *behavioral change* is similar, but it is positive so see that some pilots are able to report behavioral changes already during the time life of the pilots since usually this kind of impact takes longer to become visible.

With reference to the *social inclusion* dimension, it is fair to say that the covid-19 situation got a negative impact on the capability of pilots to engage citizens belonging to categories at risk of social exclusion. Indeed, the need to avoid face to face activities and the intensification of online activities made their engagement more difficult. In some cases, the pandemic situation reduced also the overall number of volunteers engaged, and the possibility to support participants in enlarging and

strengthening their social links. Higher impacts on social capital, for example, would have been probably reported if the activities would have been carried out in a face-to-face way.

Economic impact was not an expected impact by the majority of the ACTION pilots: on this more should be done is better support CS project managers in considering also this aspect of their work. However, there are promising achievements. Indeed, at least one pilot is in a good position for linking CS and social entrepreneurship and the activities carried out provided the pilot team the need information for developing a clear vision on how creating new jobs, especially for disadvantaged youths, in the green sector. For others, participating in ACTION was an occasion for creating new collaborations that are and might lead to new projects and additional funding. Finally, there is at least one project that show potentialities in generating positive economic impacts for the local community engaged in the CS activities.

Political impact is a long-term impact that is generally achieved toward the end of the projects or, more often, after. Some of the ACTION pilots saw this area of impact as relevant since the planning phases and is important to say that some of them already succussed in engaging decision makers, in providing them with the results of their pilots and in opening up an informed dialogue between citizens and local administration on pollution-related topics. It is reasonable to say that effective political impacts will emerge in the upcoming months.

Finally, considering **environmental impact**, at least for the period under analysis, it appears to be mainly an indirect impact for most of the pilots and it can be achieved through policy impact or by succeeding in spreading more sustainable behaviours among a relatively high number of citizens. Indeed, CS can be one of the contributing factors for environmental impact, by collecting the necessary knowledge leading to individual, policy and social changes.

This report is, at the same time, a research output and an informative report interesting for both internal as well as external to the ACTION consortium readers.

From a research perspective this report represents the testing of the ACTION impact assessment methodology presented in Passani, Jenssen and Hölscher, K. (2020). In this sense, it can be useful to CS projects and social science researchers dealing with CS impact assessment and interesting in better understand what kind of information can be gathered with the ACTION methodology and how to analyse them. From the impact assessment results here presented, as well as the feedback received from the projects during the assessment, is it possible to say that the methodology responds to the needs of citizen science pilots and support the analysis at project as well at aggregated level. Indeed, the modular and flexible structure makes sure that a diverse range of projects can show their impact, while allowing for some comparisons across projects.

Considering now the reporting aspect of this report, it is useful for the ACTION consortium as a reflexivity instrument, able to inform the activities for the last year of the project looking at impact maximisation. For external readers it can be interesting for learning more about the ACTION project and about nine of its CS pilots.

1. INTRODUCTION

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.

Some attempts have been made to create guidelines for supporting CS projects' managers such as the Citizen Science White Paper (Socientize, 2014) and the Green Paper on the Citizen Science Strategy 2020 for Germany (Hecker et al., 2016). A process-based approach, linking evaluation and impact has been developed by Kieslinger, et al. (2017) and there is also a project dedicated to developing a online self-assessment tool for CS (MICS[1]), but the research in the field is still ongoing.

Indeed, even in a very recent meeting among 16 CS projects financed by the SWAFS programme, held in the January 2020, impact assessment emerged as one of the areas in which more research and training to CS managers is needed. 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" (Haywood B. K., Besley J. C., 2014 and Haywood B. K., Besley J. C., 2014).

The ACTION impact assessment framework (Passani, Janssen and Hoelscher, 2020) aims to fill this gap and offers a standardized, yet flexible, impact assessment framework - including relative indicators and operational tools. This report is the first occasion in which the ACTION impact assessment methodology has been applied and represents, therefore, its first testing.

By applying the above-mentioned methodology (summarized in section 2), this document describes the main achievements of nine ACTION pilots in terms of scientific, social, economic, political and environmental impacts. It also considers their transformative potential.

This document is the third deliverable of WP 6 - Enhancing reflexivity, impact assessment and policy roadmapping. More specifically, it is the first deliverable of Task 6.3 - Social, economic, policy and environmental impact assessment and analyses the data gathered as part of Task 6.2 - Data gathering.

The analysis included here is related to the first 22 months of the project activities. Another round of data gathering will start in March 2021 and will lead the impact assessment team to the final impact assessment of the ACTION project which will be finalised by January 2022.

This document is organised as follows: section two summarizes the ACTION impact assessment methodology and describes the data gathering activities performed so far. Section 3 reports the aggregated data analysis of the impact of all pilots, and section 4 outlines the impact per project. Section 5 closes the document by reporting the main lesson learned from a methodological and data

[1] https://mics.tools/about-mics

gathering point of view, drafts recommendations on how to maximize the ACTION's impact in the last year of the project and describes the next activities for the impact assessment analysis.

2. IMPACT ASSESSMENT METHODOLOGY, DATA GATHERING AND ANALYSIS

The following analysis of the pilots' impact is based on the ACTION impact assessment methodology described in D6.1 (Passani, Janssen and Hoelscher, 2020), which presents a first version of the methodology. Indeed, it has been developed and will be further refined following a co-design approach, engaging the ACTION consortium partners and the other citizen science pilots participating in the ACTION accelerator. Its final version will be available at the end of the ACTION project, in January 2022.

The ACTION impact assessment framework considers five areas of impact: scientific, social, economic, political and environmental, which are articulated in several dimensions each, with a total of 24 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 (Figure 1).

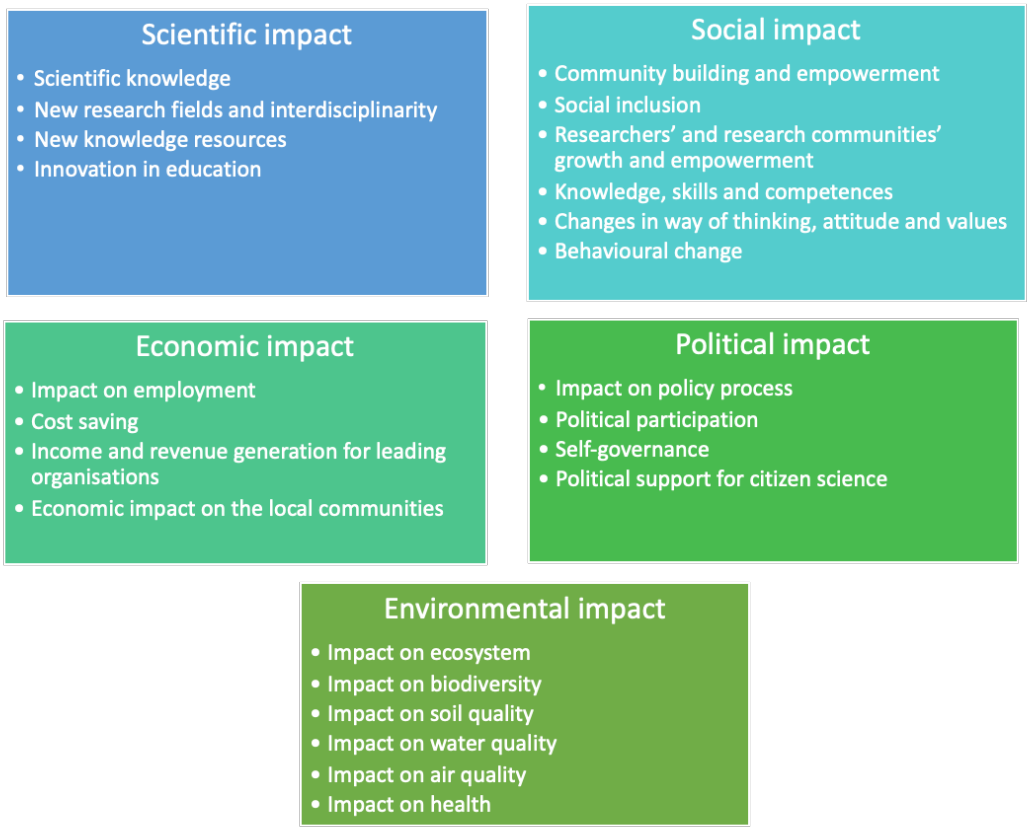


Figure 1: ACTION impact assessment areas and dimensions

Besides these five areas of impact, the methodology also considers the transformative potential of the CS pilots, i.e., the degree to which a 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.

The methodology is quali-quantitative and is designed to be modular and flexible in order to be adaptable to the specific characteristics of each CS pilot but, at the same time, assuring a cross-pilot and cumulative analysis. Indeed, not all the dimensions are (equally) relevant for all CS pilots, depending on their nature, their specific focus and the level of citizen engagement.

The specific needs of each pilot in terms of impact assessment and the relevance of the various dimensions were collected and presented by help of an impact assessment canvas. The impact assessment canvas (Passani, Janssen and Hoelscher, 2020), is a four pages graphic form that supports CS pilots in mapping their stakeholders, their main outputs and the relevance of the impact dimensions (see Annex A)[2].

Then, for each pilot, an ad hoc impact assessment process has been defined, accompanied by the development of the necessary data gathering instruments (questionnaires, online interviews, focus group guidelines, data recording matrixes, etc.). In the next seb-section a more precise description of the data gathering process followed for each of the pilots under analysis in this deliverable is provided.

2.1 Data gathering process

Moving from the information gathered through the impact assessment canvas, one to one online meetings were organised with all the pilots described hereafter in order to co-design the data gathering process and related instruments. Information to be gathered was related to the areas of impact and dimensions emerging as more relevant for each pilot as per the impact assessment canvas, but for all pilot's information on the number and profile of the citizens scientists engaged, scientific and technological outputs and dissemination activities were gathered.

For the pilots engaged through the ACTION first open call, data were gathered mostly by interviewing the pilot coordinators. Online interviews lasted one hour and half approximately and were recorded. For the pilots that are ACTION partners since the beginning of the project, data were gathered mainly through semi-structured questionnaires anticipated and followed by email exchange and ad hoc online meetings for clarifying specific topics.

For most pilots it was not possible to gather information directly from the citizen scientists/volunteers. In some cases, the reasons were related to opportunity (asking information directly from them would

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

have requested too much effort for them or would have undermined the engagement process) or time-related. With reference to the latter, more data gathering for some of the pilots is planned for the last year of the project and results will be included in the final impact assessment report due January 2022.

Besides questionnaires and interviews, data were gathered by publicly available online resources and by considering the report developed by the pilots as part of their activities. The table below summarizes the data gathering channels used for each pilot.

Pilots	**Impact assessment canvas**	**Online interview with project manager**	**Self-administered questionnaire to project manager**	**Survey to volunteers (i.e., citizens scientists, students, teachers)**	**Analysis of available documents (internal-to-ACTION reports, blog posts, pilot websites, etc.)**
Students, air pollution and DIY sensing	*		*	*	
Citizen scientists, dragonflies and pesticides	*		*		
Tatort street light	*	*			*
Loss of the night	*	*			*
Street spectra	*		*		
Sonic Kayaks	*	*			*
NOISE MAPS	*	*			*
CitiComPlastic	*	*			*
In my backyard	*	*			*

Table 1: Data gathering channels used

The ACTION impact assessment canvas proved to be a useful and effective tool and positive feedbacks from the pilots have been collected. Indeed, the canvas helped the impact assessment team in providing a focused impact assessment analysis and supported the CS managers in thinking in a more structured way about their impacts and, in some cases, also in adjusting the planning of their activities in order to cover desired impacts mentioned in the canvas but not considered before.

3 AGGREGATED DATA ANALYSIS

This section aggregates the analysis of nine ACTION pilots. Given the diversity among pilots and also the different level of details available among them, we only report those dimensions and information for which data aggregation is more meaningful/doable.

As said, we assessed the impacts of nine pilots. Four of them - the ones engaged in the first edition of the ACTION accelerator - are closed at the time of writing, while the others are ongoing (some even at an early stage) so that their impact assessment will be updated in the final impact assessment deliverable[3] due at the end of the ACTION project in January 2022.

3.1 Overview

Out of the nine ACTION pilots carried out in the first half of the project, four deal with light pollution, three with soil pollution, one with noise pollution and one with air pollution (some pilot consider more than one pollution typology at the same time).

Considered altogether, the pilots reached more than 36.000 persons through events and dissemination activities (see Figure 2). It is important to notice that due to the Covid-19 situation, online dissemination and engagement has been crucial for all of them while face-to-face events have been strongly reduced in number and reach.

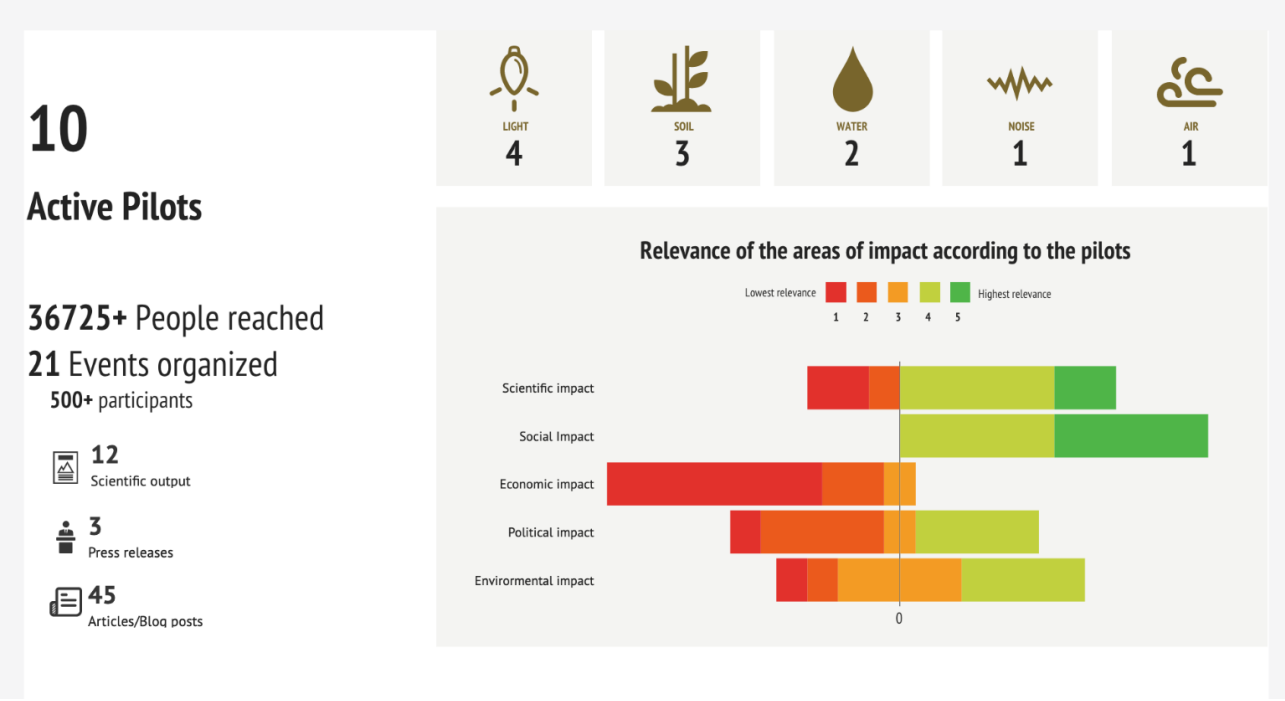


Figure 2: Overview of the ACTION pilots' impacts as illustrated by the ACTION dashboard (Scandolari, et al., 2021[4])

[3]It is possible that some additional data will be gathered also for the pilots of the first edition of ACTION accelerator.

[4]The figure reports 10 pilots as it considers also Color Spectra, a pilot not analysed in the impact assessment as the activities with citizens didn't start yet due to the covid-19 situation. However, this does not impact on the other information included in this and the following figures if not in relation to the typology of pollution consider which is, for this pilot, light pollution.

Looking at citizens engagement in CS activities (see Figure 3) the pilots involved more than 660 persons: all the pilots engaged citizens in data collection, four of them also in data analysis and two also in data gathering tool development and in data curation.

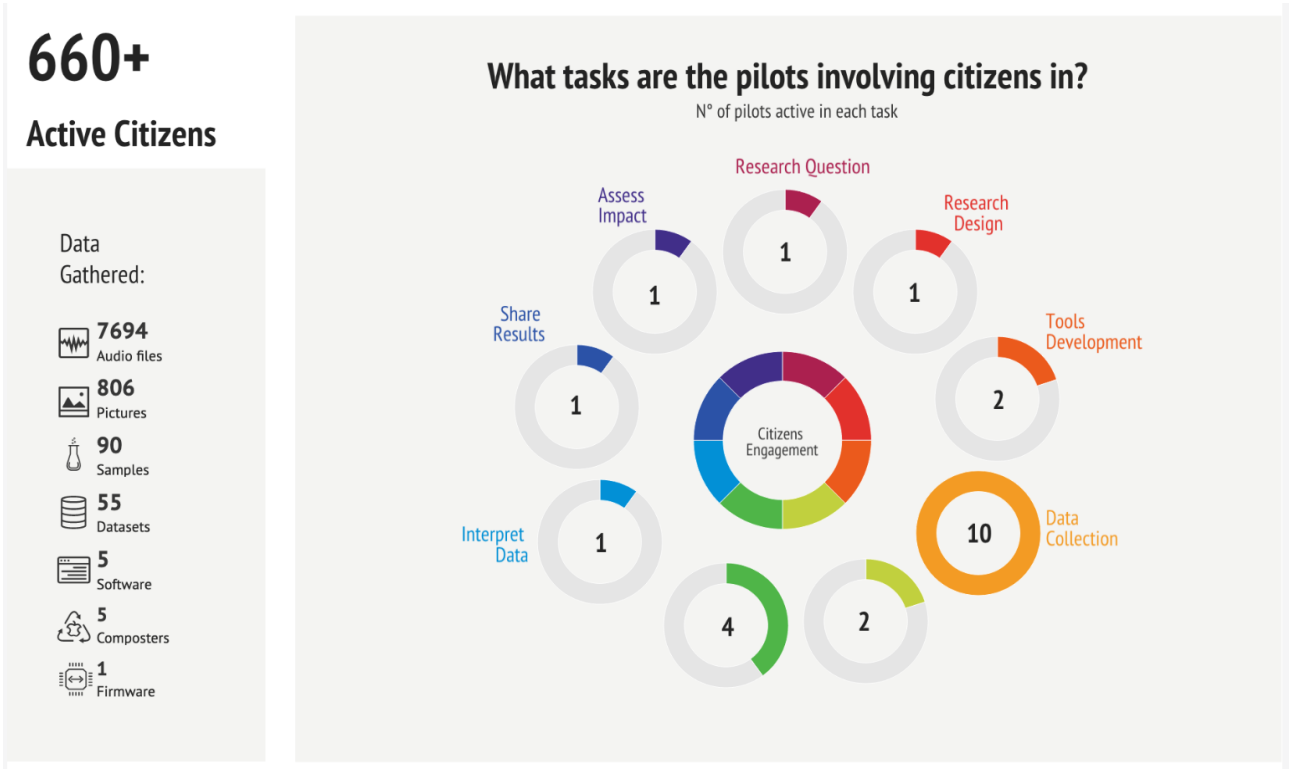


Figure 3: Overview of the ACTION pilots' citizen engagement outputs as illustrated by the ACTION dashboard

Considering the potential contribution of the ACTION pilots to UN sustainable Development Goals (SDGs), Figure 4 visualises the goals on which a positive impact can be expected.

Figure 4: Relevance of SDGs goals for the ACTION pilots as illustrated by the ACTION dashboard

Going more into details, Table 2 shows the targets that are more relevant for the ACTION pilots and how pilots are expected to contribute to their improvement/achievement. The levels to which they might contribute are the following:

- The target is addressed by providing useful data
- The target is address with dedicated actions at local level
- The target is address by providing innovation capable to provide an impact at

regional/national or international level

SDG goals/targets	*Data provision*	*Local level*	*National/international level*
Goal 3. Target:3.9		*	
Goal 4. Target: 4.7		*	
Goal 6. Targets: 6.1, 6.3	* (for 6.3)	*	
Goal 10. Target: 10.2		*	
Goal 11. Target: 11.4, 11.6		*	
Goal 12. Target:12.8		*	*
Goal 13. Target: 13.3		*	

Table 2: ACTION pilots and relevant SDGs/targets

As we will see in the next subsections, social and scientific impacts are the ones considered as most relevant by the majority of the pilots and on which mapped impact results as more relevant. Some of the pilots indicated environmental and political impacts as relevant too, while for the vast majority economic impact was considered as not relevant (see subsection 3.4).

3.2 Scientific impact

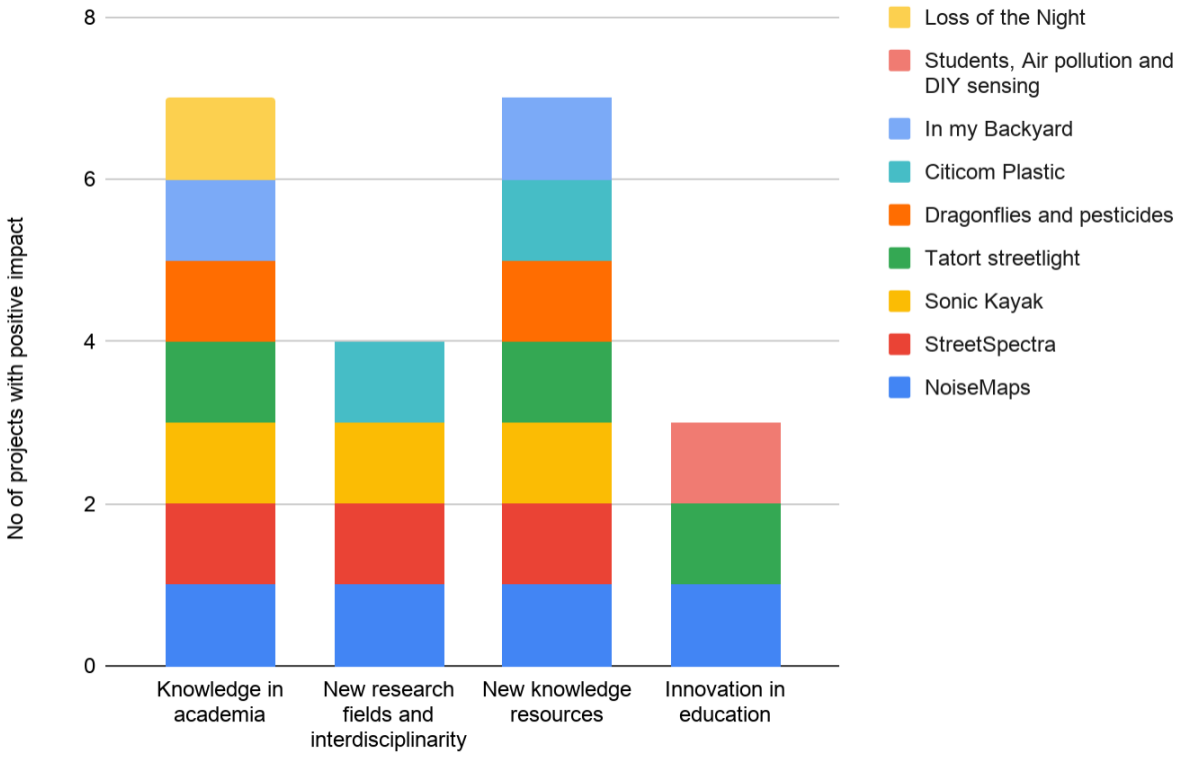


Figure 5: Aggregate scientific impact per sub dimension

All ACTION projects have had a positive scientific impact, many of which had a high scientific impact. All subdimensions are represented in the pilots (see Figure 5) for an overview. We can see that most projects (7) have a positive impact on **knowledge in academia,** and that **new knowledge resources** have been delivered by most of the projects (7). A substantial number of projects have created **new research fields** and/or are highly **interdisciplinary** (4). Some projects have contributed to **innovation in education** (3).

The scientific impact is more or less in line with the expected scientific impact as indicated on the canvas (see Figure 6). For the first sub dimension - Knowledge in academia - impact is in fact higher than expected. For the second sub dimension - interdisciplinarity and new research fields - impact has been somewhat lower than expected.

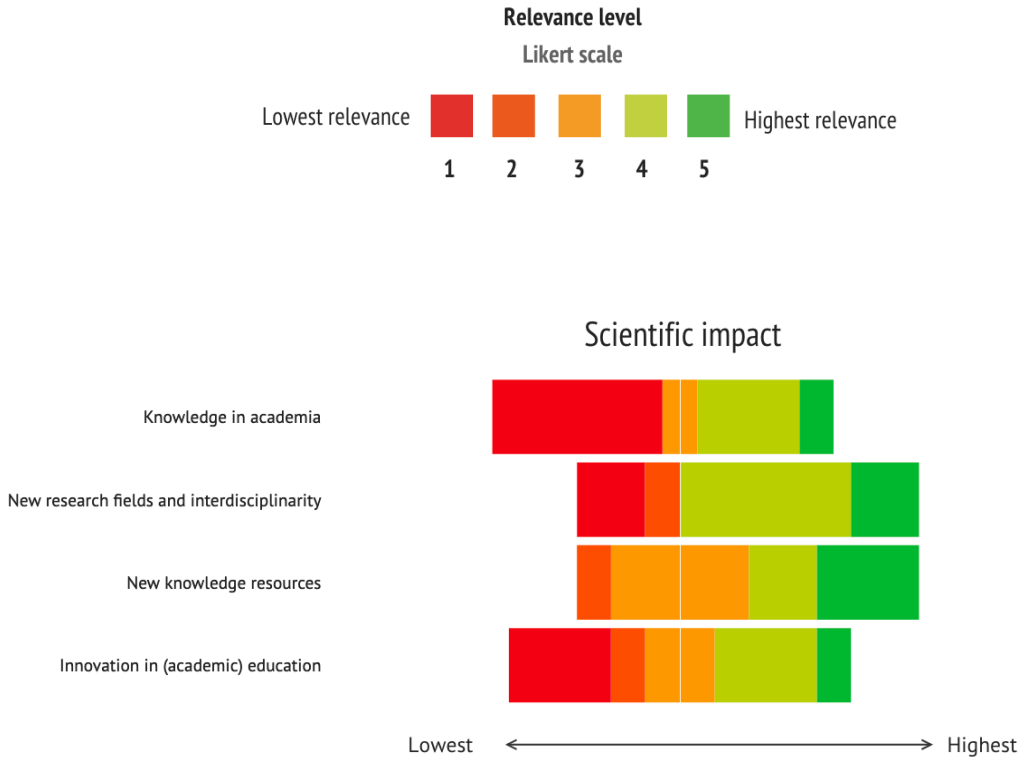


Figure 6: Aggregate relevance ofscientific impact per sub dimension as described in pilots' canvas

Below we go into more detail about the Knowledge in Academia sub dimension, because there are several variables that determine this impact.

Knowledge in Academia

In total, pilots gathered more than 45.000 datapoints. Furthermore, ACTION produced 9 peer reviewed articles, 5 non-peer reviewed articles, and 21 non-scientific publications (see

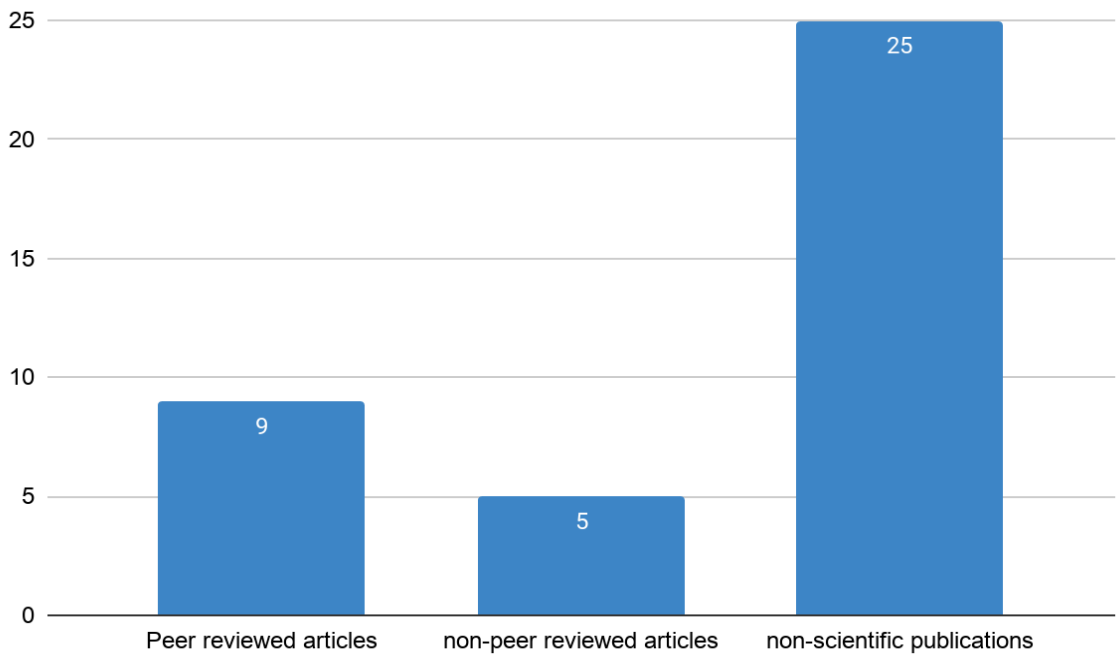


Figure 7, and appendix B for a full list of those publications). In these numbers we included 3 scientific publications that were made by the ACTION consortium, separate from the pilots.

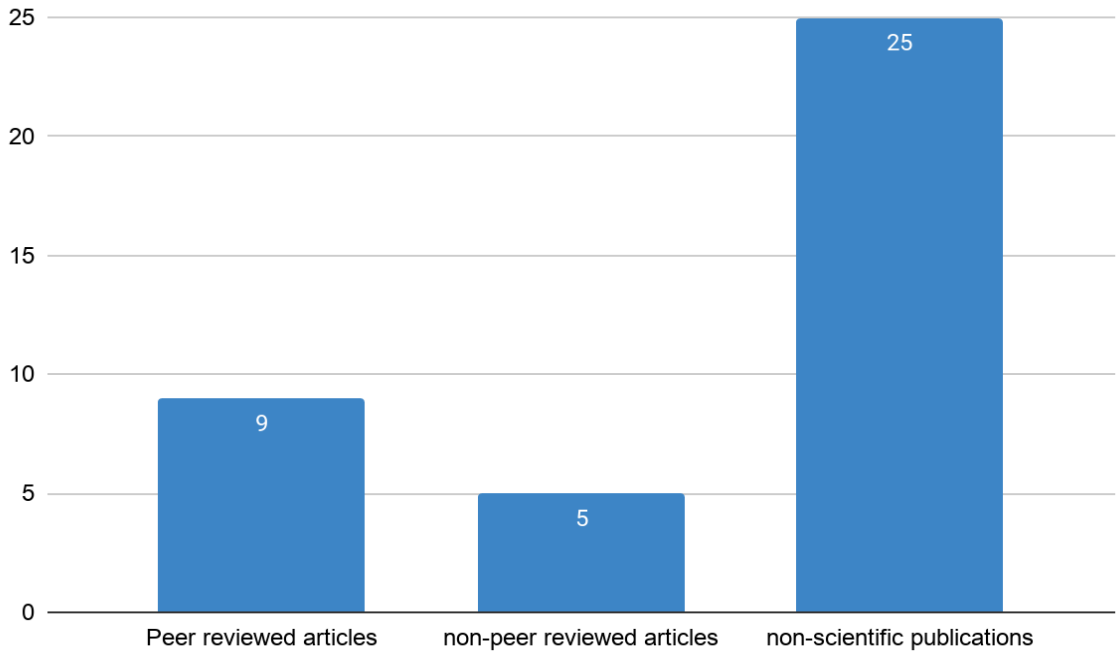


Figure 7: ACTION total number of publications

Data quality

For almost all projects for whom data collection was important, data quality is very high, scoring 4 or 5 out of 5. (see Figure 8). One project scored 2. This score can partly be explained by the adaptations

made to the project due to the pandemic, and partly because there was a shift of focus. Figure 9 shows which indicators were positive for how many of those projects. This shows us that the projects scored very well on most indicators, but that we should focus more on implementing a procedure for adapting the process of data collection based on feedback, before data collection is fully rolled out.

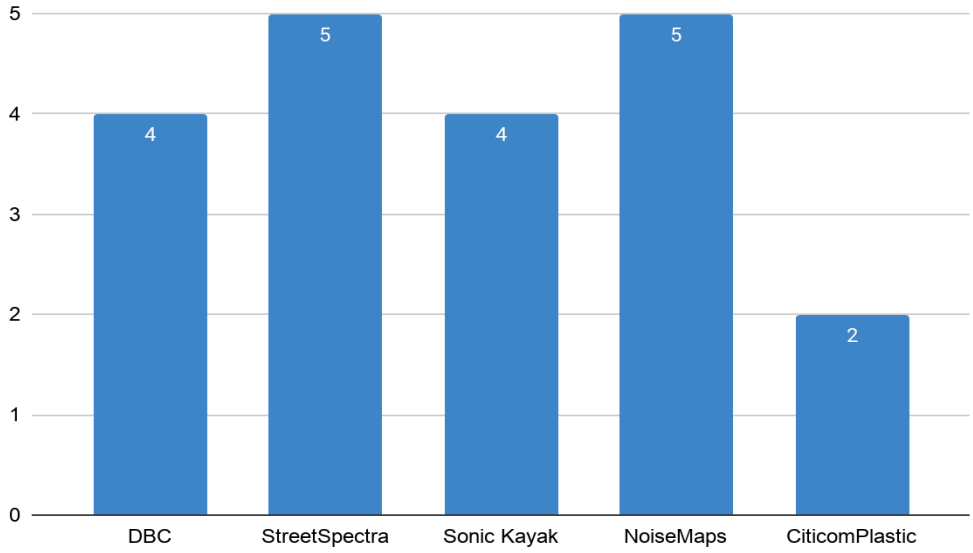


Figure 8: Overall data quality score (out of 5)

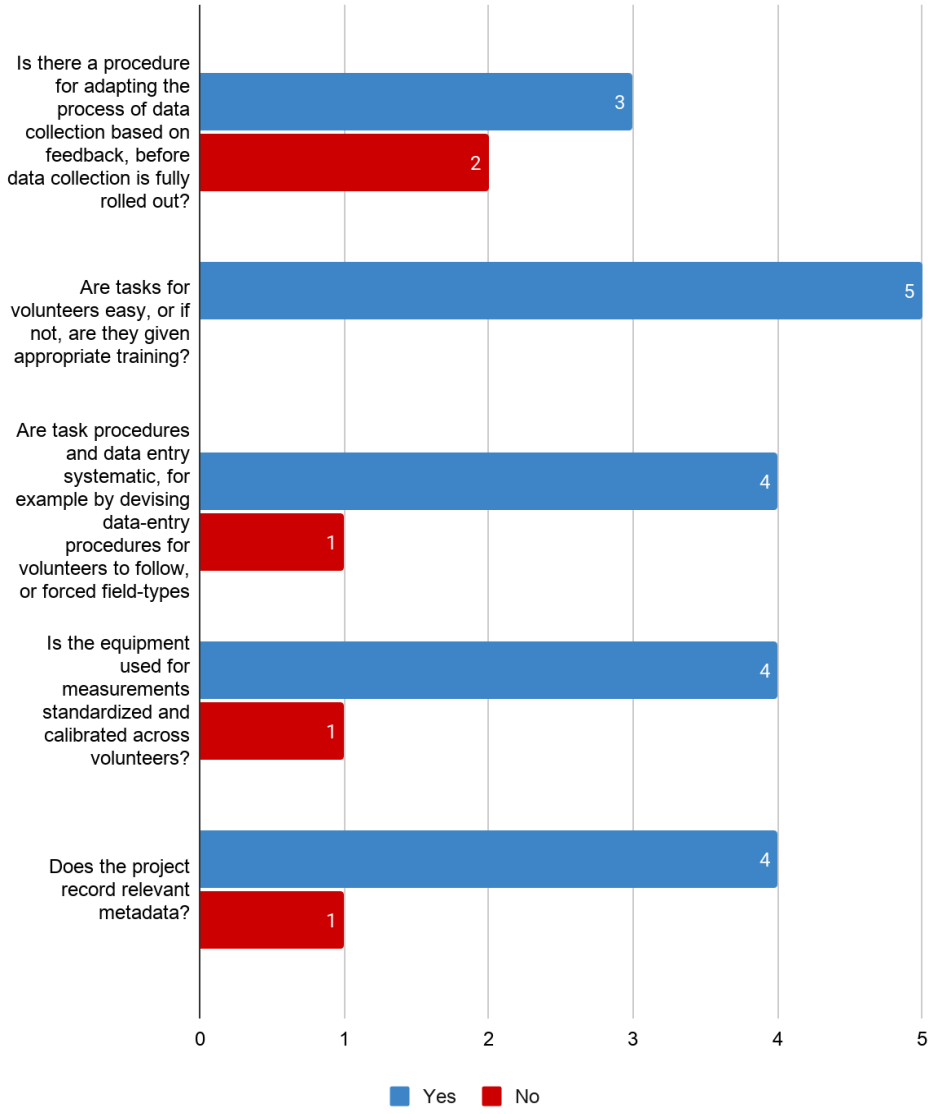


Figure 9: Aggregated data quality score (out of 5) per indicator

Openness

Most projects for whom data collection was a priority score well on the openness of their data, see Figure 10.

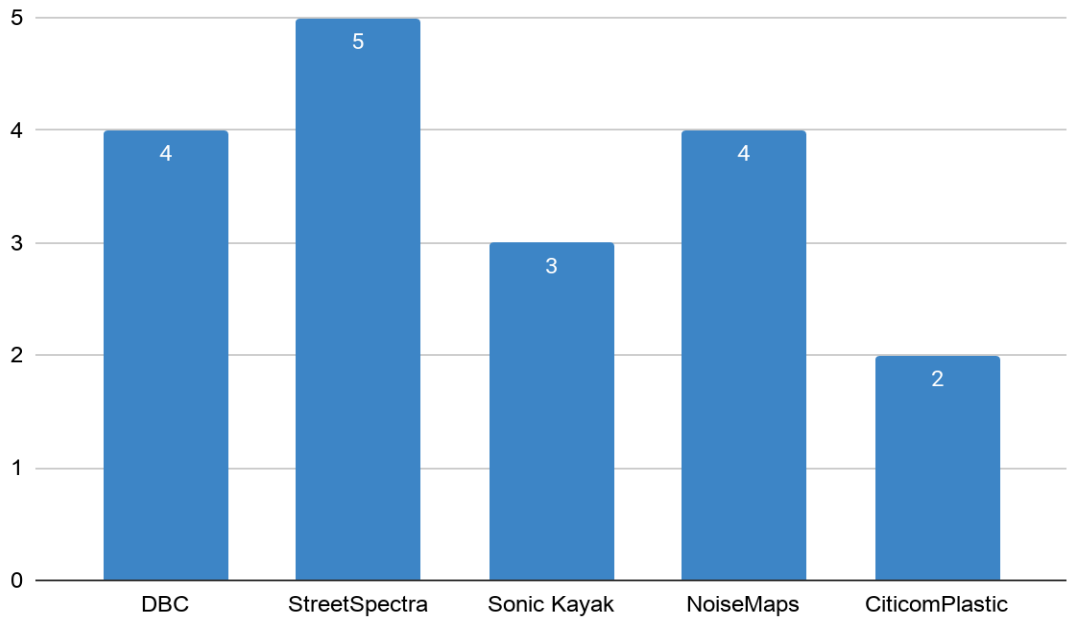


Figure 10: Aggregated openness of data score (out of 5)

In Figure 11 we can see that many indicators for the openness of data are positive, but that the projects could improve by following standards from for example W3C and by linking to other datasets for context.

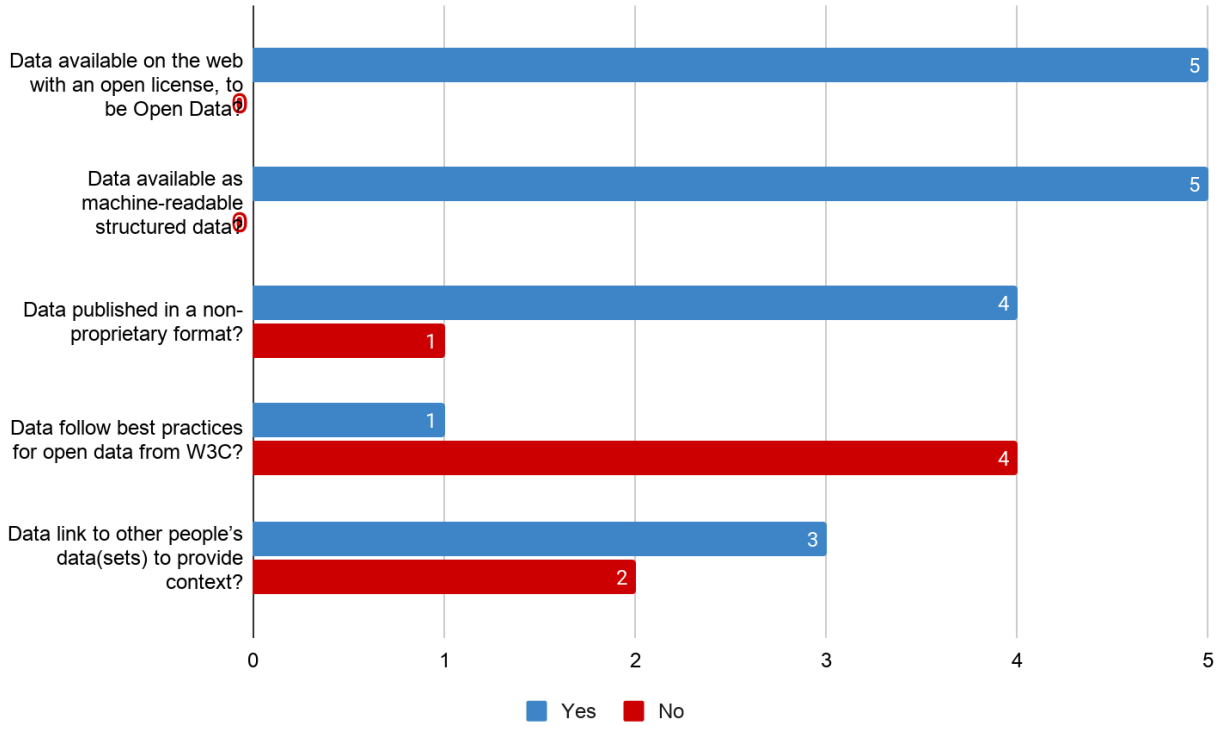


Figure 11: Aggregated openness of data score (out of 5) per indicator

3.3 Social impact

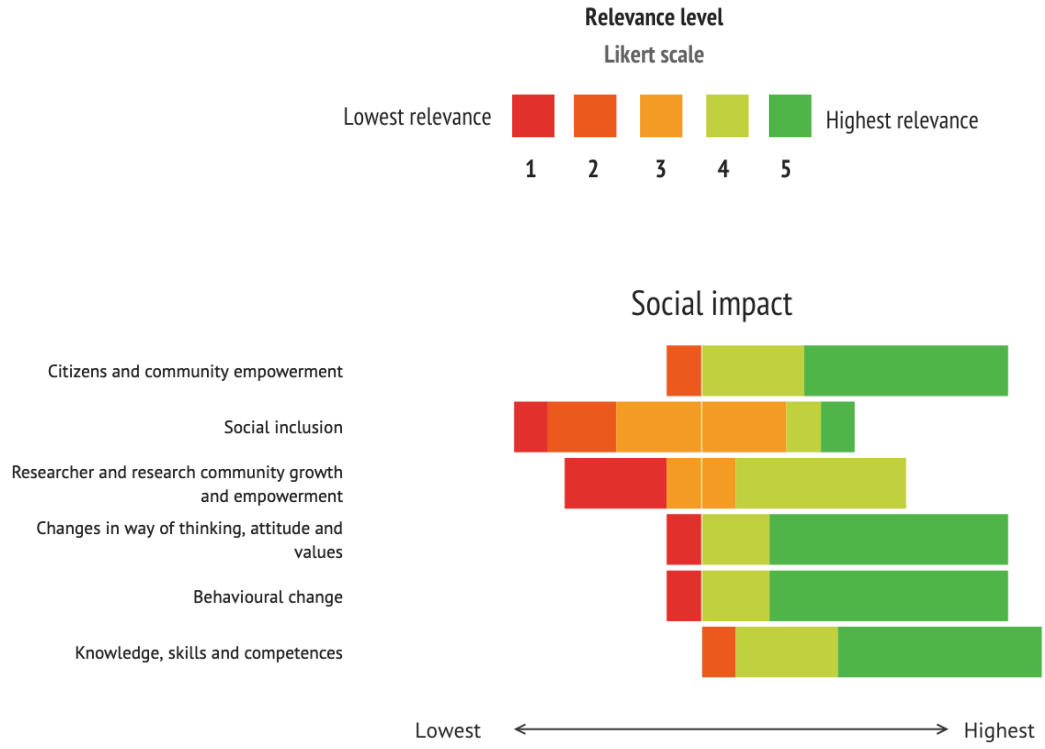


Figure 12: Aggregated relevance of social impact dimensions accordingly to the pilots' canvas

Figure 12 shows the relevance of the social impact dimensions from the pilots' point of view at the beginning of their journey, when filling in the impact assessment canvas. From the analysis that we carried out so far it is possible to say that all the pilots have a positive impact on *knowledge, skills and competencies*. In all the cases this is true with reference to the topic directly tackled by the pilots, while for others the engaged volunteers also improved their understanding of scientific processes.

Change in *way of thinking* happened for some pilots, again more with reference to the specific topic covered by the pilot than on other more general aspects such as environmental sustainability or trust in science. In many cases this is due to the fact that participants were already interested in environmental issues, showing a pro-environmental and pro-science value orientation. However, this kind of information has been mainly reported by pilot managers and more will be understood on these aspects in the final impact assessment report where more direct information from volunteers will be available. It is interesting to notice that pilots working with students show a positive impact in terms of participants' interest on science and on the specific topic addressed by the pilot. This is especially positive as it could lead participants to be further engaged in CS and in continuing learning in an autonomous way after the end of the pilot on topic such as environmental sustainability, air pollution, light pollution, etc.

The situation for *behavioral change* is similar, but it is positive so see that many projects are able to report behavioral changes already during the time life of the pilots since usually this kind of impact takes longer to become visible. Behavioral changes are reported especially by pilots that engage citizens in activities and topics directly linked with their personal behaviors such as purchasing choices or gardening practices.

With reference to the *social inclusion* dimension, it is fair to say that the covid-19 situation got a negative impact on the capability of pilots to engage citizens belonging to categories at risk of social exclusion such as migrants, persons with handicap and low-income families and individuals. Indeed, the need to avoid face to face activities and the moving of the engagement in the “online sphere” made their engagement more difficult. This is for various reasons, among which the fact that digital divide and lack of digital skills goes, sometimes, hands in hands with other risk factors. Another reason is linked to the need to invest more time and develop collaboration with other associations for engaging these communities and gaining their trust, activities that were planned in at least three pilots and that could happen or happened in a more limited way during the covid-19 period.

In some cases, the pandemic situation reduced also the number of volunteers engaged, and the possibility to support participants in enlarging and strengthening their social links. Higher impacts on social capital, for example, would have been probably reported if the activities would have been carried out in a face-to-face way. Indeed, in the pilots that were able to do so (at least for a brief period or partially), we reported improvement in the social relationships among participants and the creation of new social links.

Nevertheless, the pilots did important work in spreading their work to a large audience and support awareness raising at local level and beyond.

3.4 Economic impact

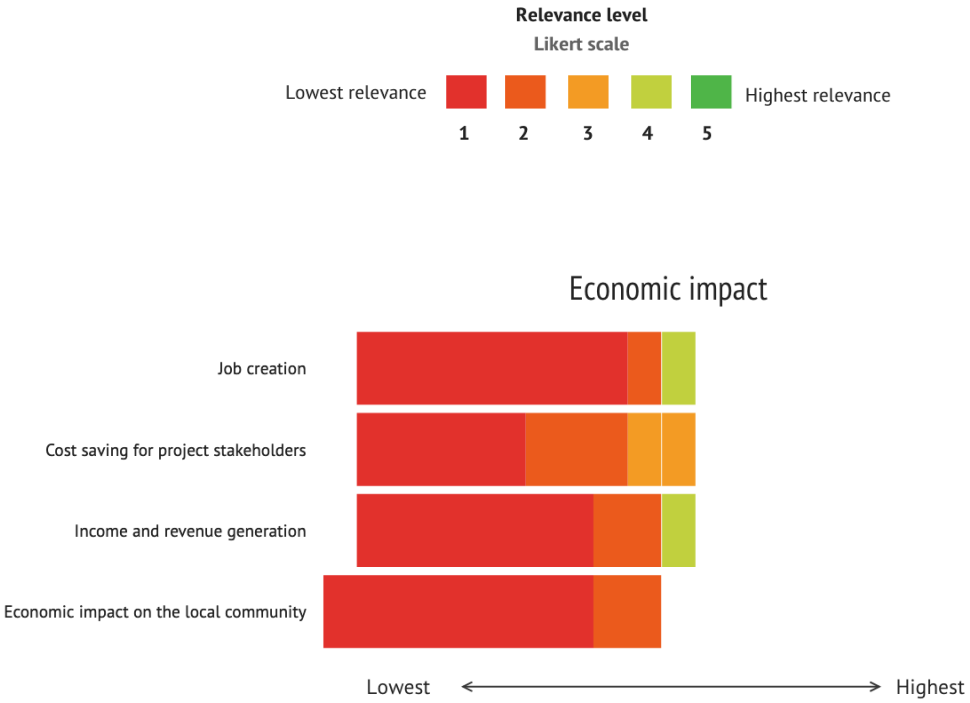


Figure 13: Aggregated relevance of economic impact dimensions accordingly to the pilot's canvas

As Figure 13 shows, economic impact was not seen as an expected impact by the majority of the ACTION pilots. Economic impacts are often underestimated when analysing citizen science. In the final impact assessment report, we will investigate deeper one of the main economic impacts of CS which is linked with the capacity of CS projects to gather data that is otherwise impossible to gather. Indeed, the time invested by citizens in gathering data and, sometimes, in analysing them has an economic value. Paying professional researchers for doing so would be unsustainable from an economic point of view, but also from a management point of view considering that, in pilots like Loss of the Night and Street spectra, there is the need to gather data for a decade or longer. At the same time, engaging citizens in science and support them while working is also a cost that need to be properly accounted for.

Beside this, some projects like Tatort Street Light are expected to have a positive economic impact on the local community by safeguarding the target territories and promoting them for their reservation characteristics. Indeed, this pilot is expecting to support the local community in attracting visitors willing to take advantage of dark skies and to support, in this way, a twist towards sustainable tourism.

CitiComPlastic seems in a good position to link citizen science with social entrepreneurship and support job creation for marginalized youth as a result of the pilot.

In addition, some of the pilots show a potential in terms of revenue generation for the leading organisation, most of the time through public funds but in some cases, like Sonic Kayaks, also through the offering of consultancy service and training on the project results and outputs.

Finally, sustainability is a relevant topic for all the pilots and most of them declare to be interested in having dedicated support on this aspect. From the interviews with pilot managers, it emerged that, when planning a project, thinking about long term sustainability is crucial, especially when Apps are involved. In some cases, indeed, the team could be able to support follow-up research activities or engagement activities on a voluntary basis or with a low budget, but costs for App updates and adaptations can be high so that they should be considered upfront in order to avoid risk of project interruption and community disintegration.

3.5 Political impact

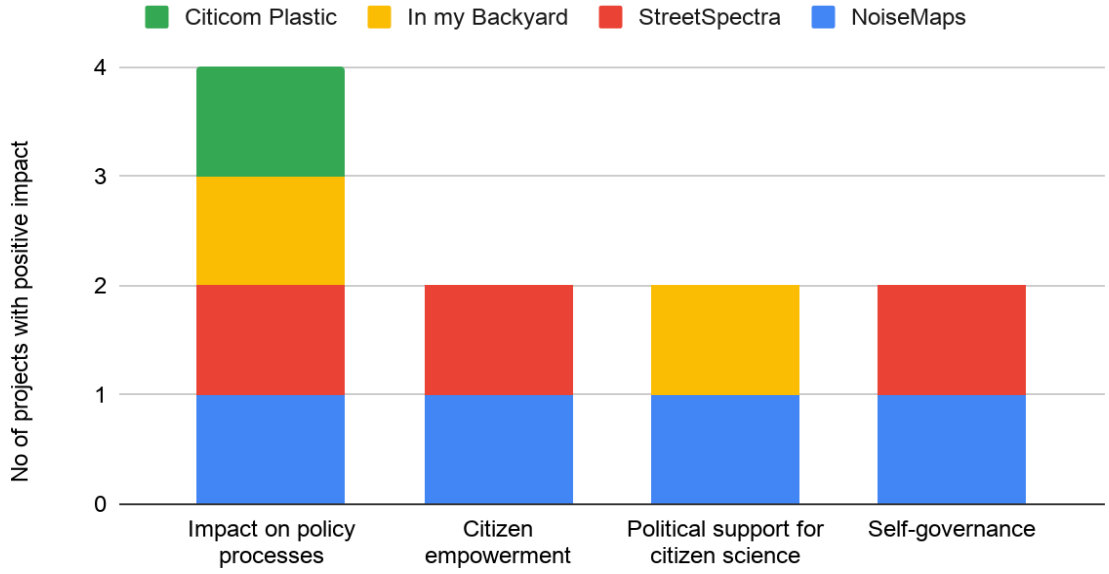


Figure 14: Aggregate political impact per sub dimension

Four pilot show important output in terms of political impact and have made important achievements in engaging policy makers on the specific topic addressed by the pilot (Figure 14). All sub dimensions are represented in two or more projects, with **impact on policy processes** being the most important sub dimension (relevant for four projects). For this sub dimension, as well as self-governance, impact is in line with the expected political impact (see Figure 15). For the other two sub dimensions - citizen empowerment and political support for citizen science - impact is somewhat lower than expected. The (proposed) reasons for this are explained in the next chapter for the relevant pilots, but in general we believe that political impact is often a longer-term impact. For example, an increase in political support for citizen science might only happen sometime after the project has ended, when policy makers hear of the project's successes. All in all, we believe that the results of the pilots in terms of political impact are promising and show us that citizen science can have a political impact.

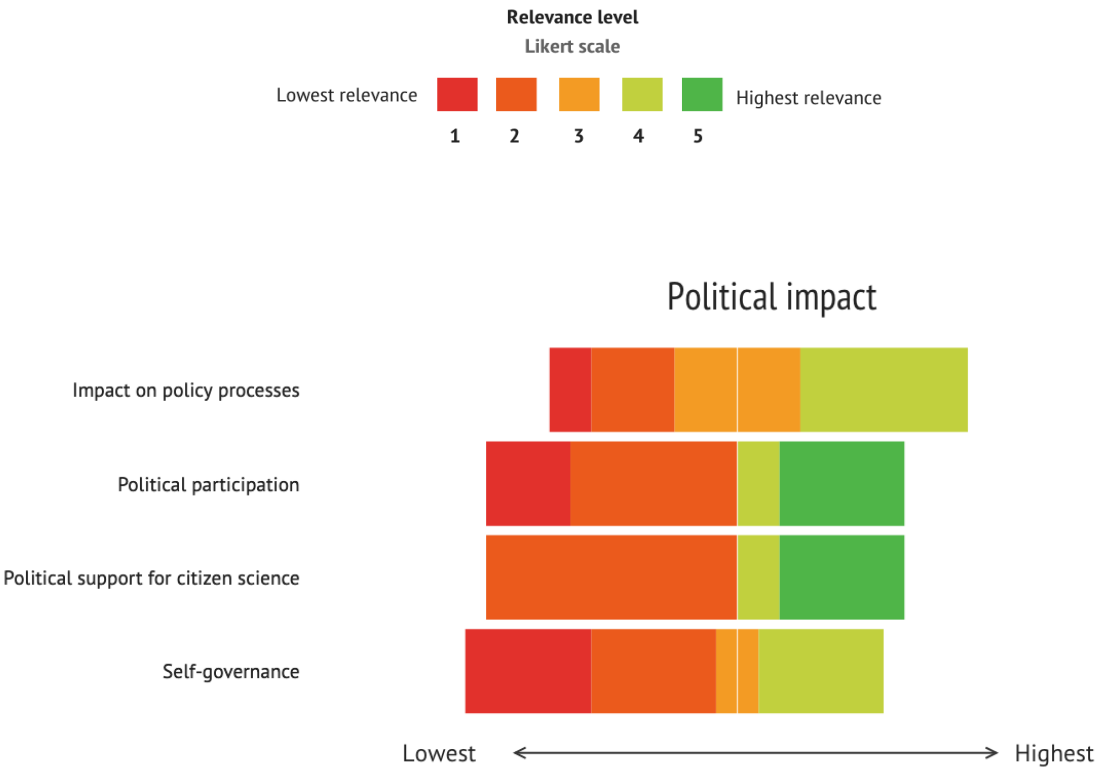


Figure 15: Aggregate relevance of political impact per sub dimension as per pilot canvas

3.6 Environmental impact

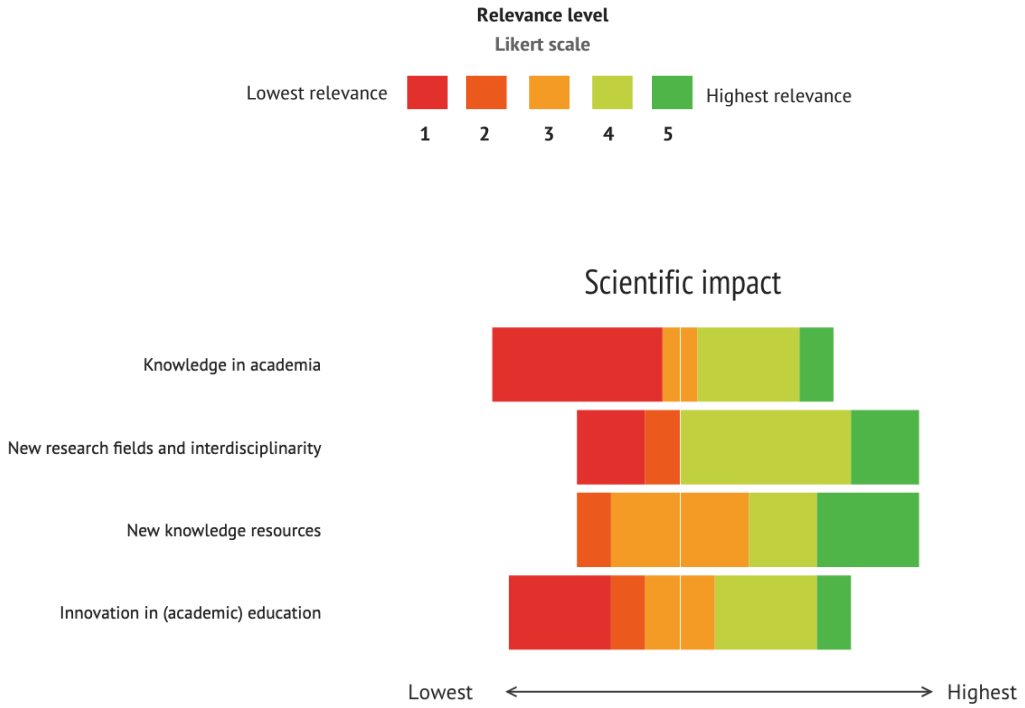


Figure 16: Aggregate relevance of environmental impact per sub dimension as per pilots' canvas

While for many projects, environmental impact seemed important (see Figure 16), we were unable to measure actual environmental impact. We believe this is due to the fact that environmental impact usually only becomes apparent after a long time, such as long-term behavioural change of a group of citizens, or after a big-scale intervention, such as closing down a polluting factory. Both the scale and the duration of citizen science projects does not lend itself to environmental impact that is measurable at the present stage.

This does not mean that the citizen science projects did not impact the environment positively. Citizen science can be one of the contributing factors for environmental impact, by collecting the necessary knowledge or support for changing policy or behaviour. For example, the analysis of the correlation between Dragonflies presence and pesticides in DBC's project has environmental impact in the sense that knowing about the threats for biodiversity will help reduce those threats. This means that the project does cover a vital step in achieving environmental impact but does not generate a direct impact on the environment. Another example comes from the Street Spectra project: while the project has not decreased light pollution directly, it increases light pollution awareness, which will hopefully have an impact in the long-term.

3.7 Transformative impact

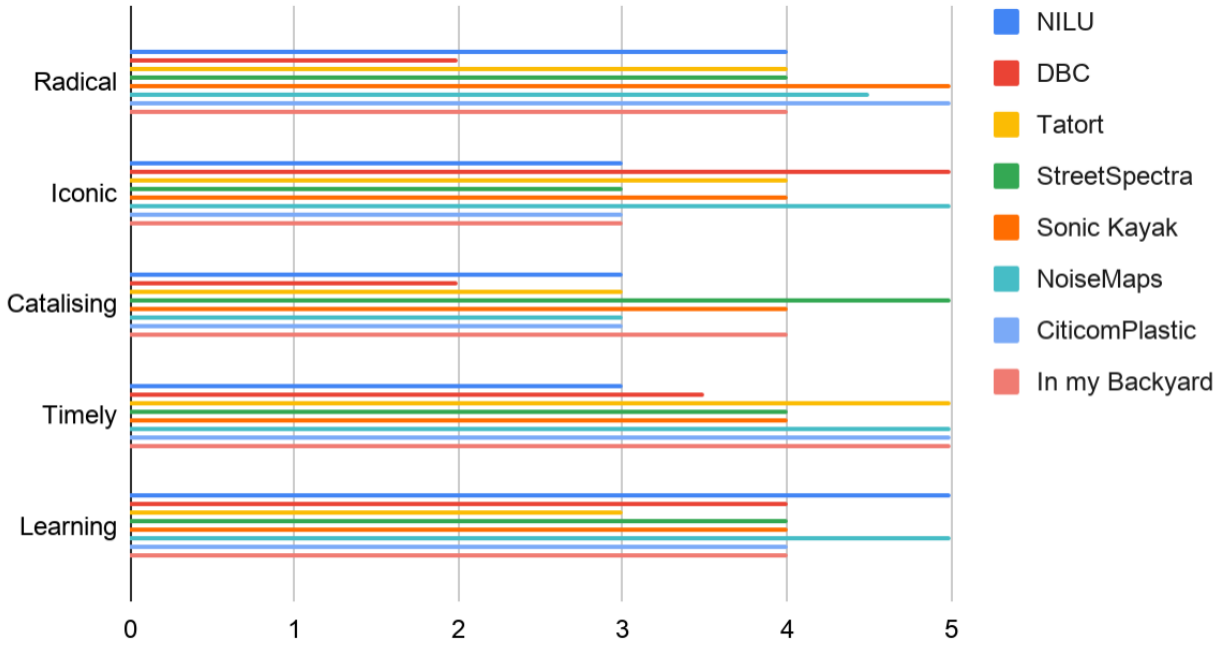


Figure 17: Transformative impact scores (out of 5), overview

Most projects have a high transformative impact. Figure 17 shows all scores. The average scores per sub dimension are as follows: Radical 4,06; Iconic 3,75; Catalysing 3,38; Timely 4,31; Learning 4,13. We can see that all average scores are above 3, with Timely being the highest, and Catalysing the lowest.

4 RESULTS OF ACTION'S PILOTS

This section reports the results of the intermediate impact assessment activity of the following ACTION pilots:

- Students, air pollution and DIY sensing
- Citizen scientists, dragonflies and pesticides
- TATORT STREET LIGHT
- LOSS OF THE NIGHT
- STREET SPECTRA
- Sonic Kayaks
- NOISE MAPS
- CitiComPlastic
- In my backyard

Each of the following subsections is dedicated to a specific pilot. Each pilot is first described with reference to its main activities and characteristics, then the relevance to the impact assessment'areas is reported in a radar chart. *It is important to note* that this chart reports the relevance of the areas of impact according to the pilot project managers as resulted in the impact assessment canvas and does not indicate, therefore, the actual achieved impacts.

The relevance of the various areas of impact is important because the impact assessment data gathering, and analysis activities were performed only for those areas of impact and dimensions that scored 3 or higher in the impact assessment canvas. The radar chart is followed by thematic subsections that describe the outputs/impacts achieved on the areas of impact and dimensions considered as most relevant by the pilots' project managers.

4.1 Students, air pollution and DIY sensing[5]

Territorial coverage: Oslo and larger Oslo area (Norwey)	**Type of pollution considered:** Air pollution
Revant SDGs 3 - Good health and wellbeing, 4 - Quality education, 5 - Gender equality 11 - Sustainable cities and communities, 13 - Climate action	

In this pilot, high-school students in Oslo and the greater Oslo area had the opportunity to carry out their own air quality projects - from data gathering to analysis and results presentations (in some of the schools engaged this implied the definition of research questions too, while in others the research question was assigned by the teachers).

For carrying out measurements and collecting data, the students used an Arduino-based air quality sensor platform, equipped with a Nova SDS011 sensor to measure $PM_{2.5}$ and PM_{10} pollution levels. They could add additional components for measuring e.g., relative humidity, temperature, noise or CO2. The results were presented by the students themselves at a joint student conference. The two rounds of project activities were planned for spring 2019 and 2020. The project activities in 2019 engaged 7 school classes, while in 2020, due to Covid-19 only three school classes completed the activities. For more detailed information about how the project was planned and carried out, see D2.7. Furthermore, D2.8 is an evaluation report of the students' learning outcomes.

4.1.1 Impact areas' relevance

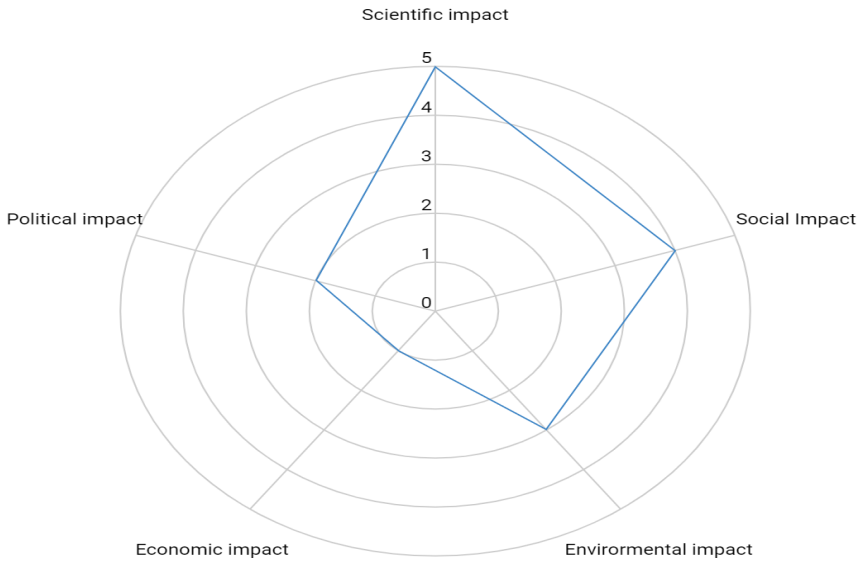
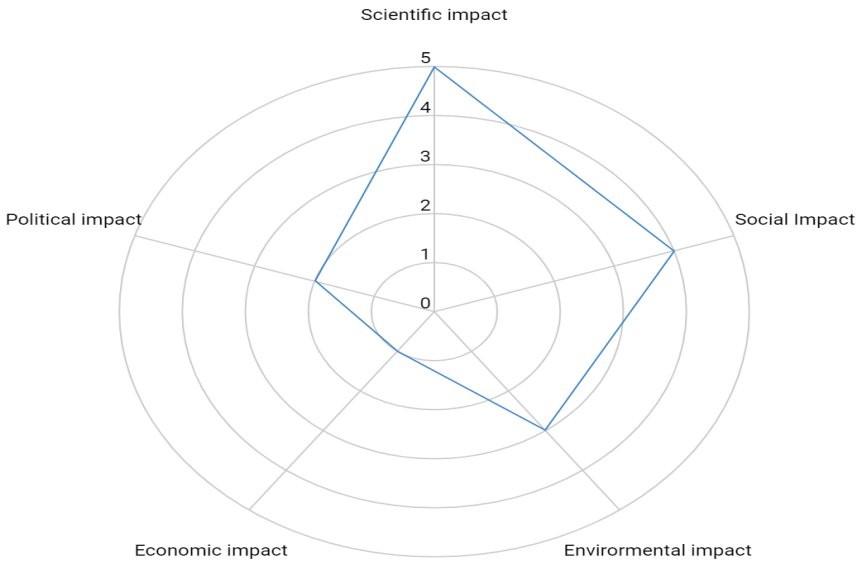


Figure 18: Impact areas relevance for Students, air pollution and DIY sensing as described in the pilot canvas

[5]This part borrows heavily from D2.8: *Passani, A., Janssen, A., Di Lisio, G. Grossberndt, S. (2020), Evaluation report of learning outcomes of high school students after participating in air quality projects*



As we can see in

Figure 18, the most relevant impact areas for this pilot are the scientific impact, the social impact and the environmental impact. We'll discuss the scientific and social impact in more detail in the following subsections. As we discussed in chapter 3, we were not able to measure environmental impact.

4.1.1 Scientific impact

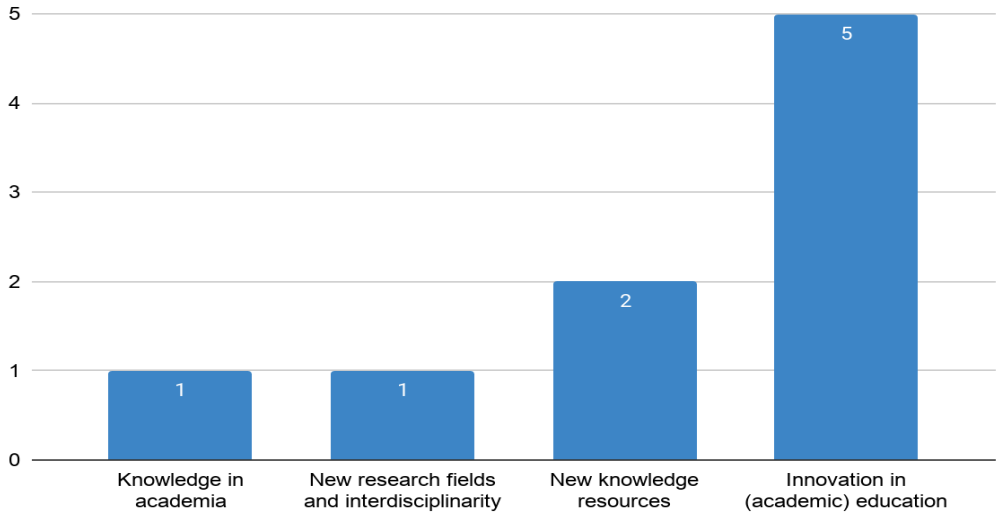


Figure 19: Relevance of scientific impact dimensions for Students, air pollution and DIY sensing as described in the Canvas

Innovation in academic or school curricula

Most of the scientific impact of the project *Students, air pollution and DIY sensing* were foreseen in terms of innovation in education (3,5 out of 5 - project manager's scoring). This is less than expected

compared to the canvas scoring (see Figure 19), but does not depart radically from the expectations, especially given the adaptations to the pandemic and the fact that the project is still ongoing.

The project is an innovative way of implementing the current school curriculum, which states that students should learn how to work scientifically. Rather than assigning the students another paper, the project is an immersive way of teaching scientific skills. Also, the project has been highly appreciated by the teachers because of its interdisciplinary character and the students' independence.

Producing project output in terms of datasets or publications has not been the aim of this project. This means that impact on the other subdimensions of scientific impact - knowledge in academia, new research fields and interdisciplinarity, and new knowledge resources - is minimal.

4.1.2 Social impact

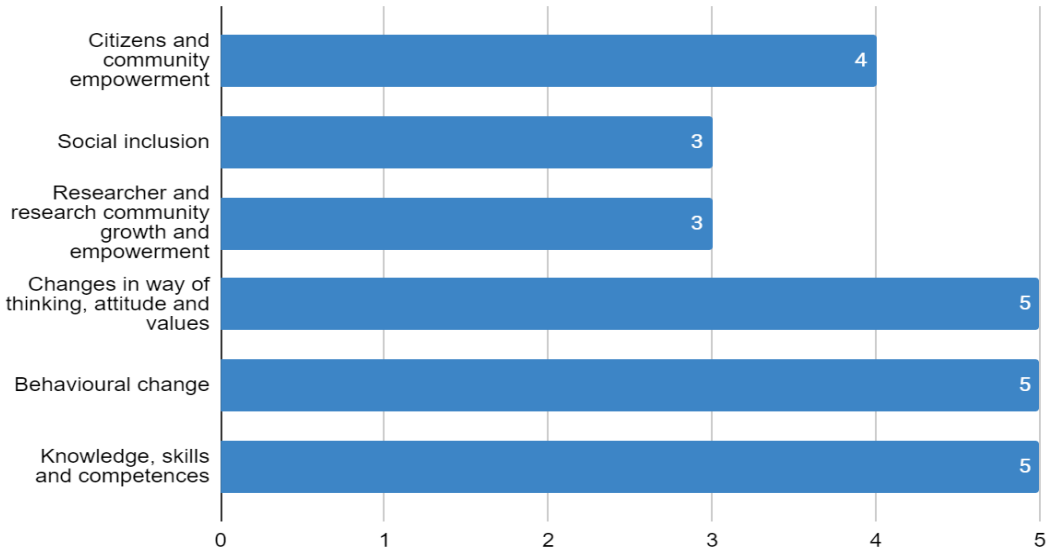


Figure 20: Relevance of social impact dimensions of Students, air pollution and DIY sensing according to the pilot' canvas

The social impact is the most relevant area of impact for the pilot, especially for the following subdimensions (Figure 20):

- increase of knowledge, skills and competences;
- changes in way of thinking, attitudes and values;
- behavioural changes.

We have valued the social impact through the analysis of questionnaires submitted to both teachers and students, at the end (and, for the students, also at the beginning) of each round of the project. In this section we have summarized the results that are more extensively described in D2.8 (Passani, A. et al., 2020).

For what concerns the impacts on teachers in the first round, we have the responses of four of them.

All the teachers affirmed that the project's activities contributed to *increasing students' awareness on air quality issues*, provided both students and teachers with *new skills and competences* and influenced the *way in which students view and value science*. Three out of four of the teachers think that the engagement with the ACTION project team has increased their awareness on air quality issues and that, thanks to the knowledge gained with the activities, they will now have a more pro-environmental behaviour. Two out of four of them think that also students will have a more pro-environmental behaviour.

With reference to the second round, we have collected answers from three teachers out of the four engaged.

All three of them affirmed that the activities of the project:

- positively influenced students' attitude towards science;
- provided students with new competences in the use of scientific tools (e.g. sensors);
- improved students' scientific competences (including data gathering and data analysis), students' interest in scientific related careers, students' attitude towards environmental issues and air quality issues, and the relationships within the class.

Two out of three of them think that the activity carried out improved students' scientific reasoning skill and their critical thinking attitude. Only one of them thinks that the activities have improved students' motivation and self-esteem.

Moreover, to measure the impact on teachers, we designed two questions where they had to answer "yes" or "no". Firstly, we asked teachers if the activity and the engagement with the ACTION project team contribute to increase their awareness on air quality issues. Then, we asked them if the activity and the engagement with the ACTION project team provid

ed them with new skills and competences. All three teachers answered positively to both questions.

For the students of the first round, we have measured the impact that the pilot activities had on students through specific questions. Figure 21 below shows both questions and answers. We used a 5-point Likert scale.

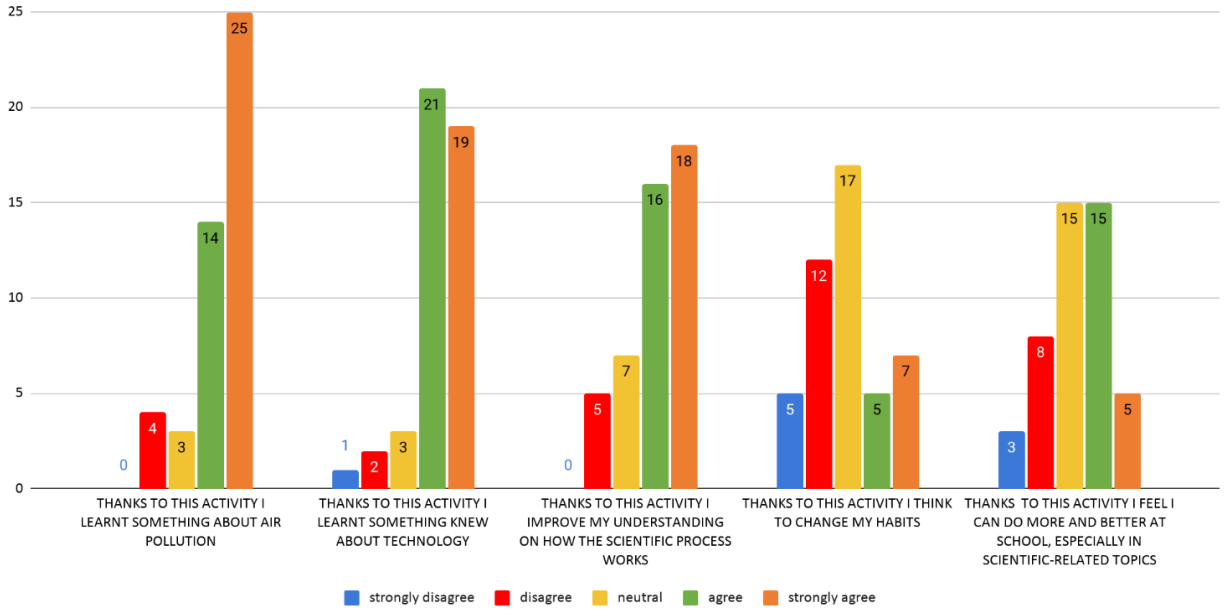


Figure 21: Students, air pollution and DIY sensing impact on learning (students' survey - first round)

As can be seen, the strongest impact that we have registered is on the learning aspect. 39 out of 47 respondents declare that they learned something about air pollution, 39 that they learned about technology, 43 that they improved their understanding of scientific processes. Only 12 said that they are thinking of changing their behaviours and 20 declared to see a positive impact on how they can do at school in general and especially in scientific topics.

There were 38 students in the second round. For this round, we implemented an ex-ante/ex-post questionnaire. In the ex-ante questionnaire, we measured students' opinion and behaviour towards science and environment. We submitted the same questions in the ex-post questionnaires, to check possible changes, plus we used a series of questions to evaluate the overall impact of the project. For example, we used simple questions, to which we applied a dichotomic type of answers ("yes" and "no"). In Figure 22we can see the results.

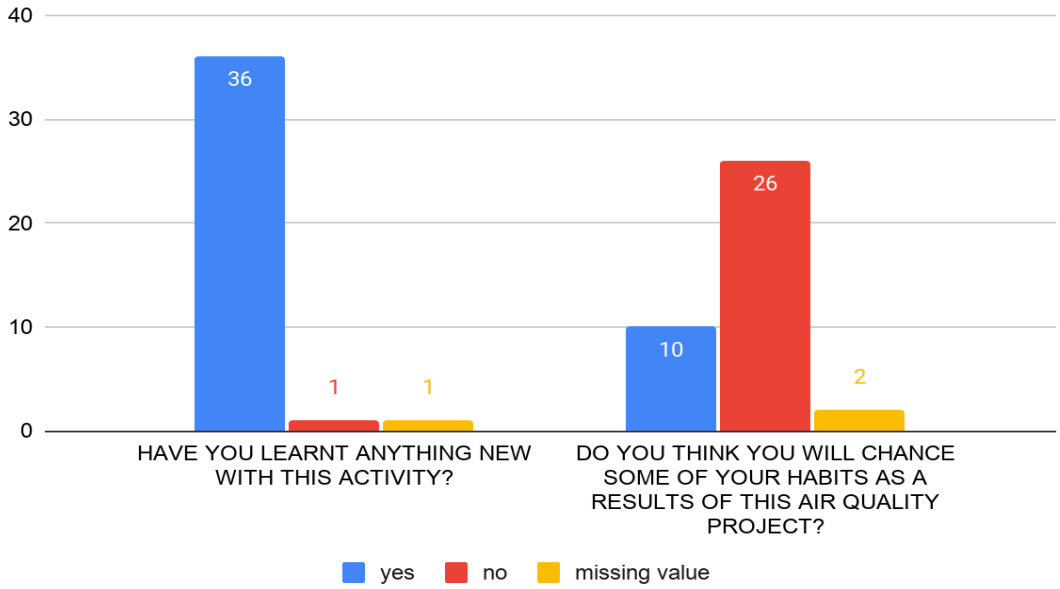


Figure 22: Students, air pollution and DIY sensing impact on learning (students' survey, second round)

We can see a positive impact with regard to the learning aspect, but a less positive impact regarding behavioral changes; 36 out of 38 of them answered positively. However, only 10 of them affirmed that they would change some of their habits as a result of the engagement in the project.

To better understand the impact with regard to the learning aspect of the project, we asked the students whether their interest in air quality and in science in general had changed. Figure 23 and Figure 24 show the results.

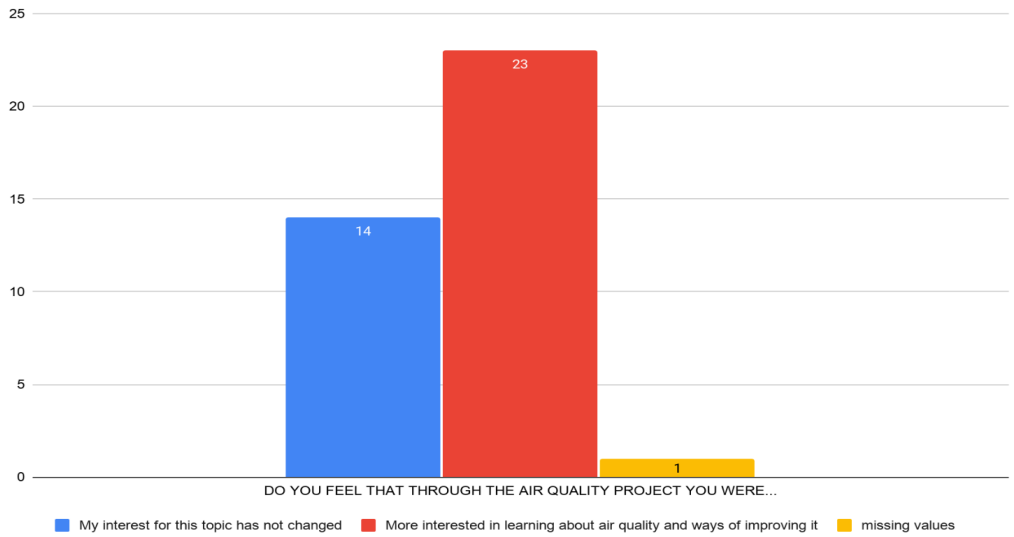


Figure 23 Students, air pollution and DIY sensing impact on interest for the topic (students' survey, second round)

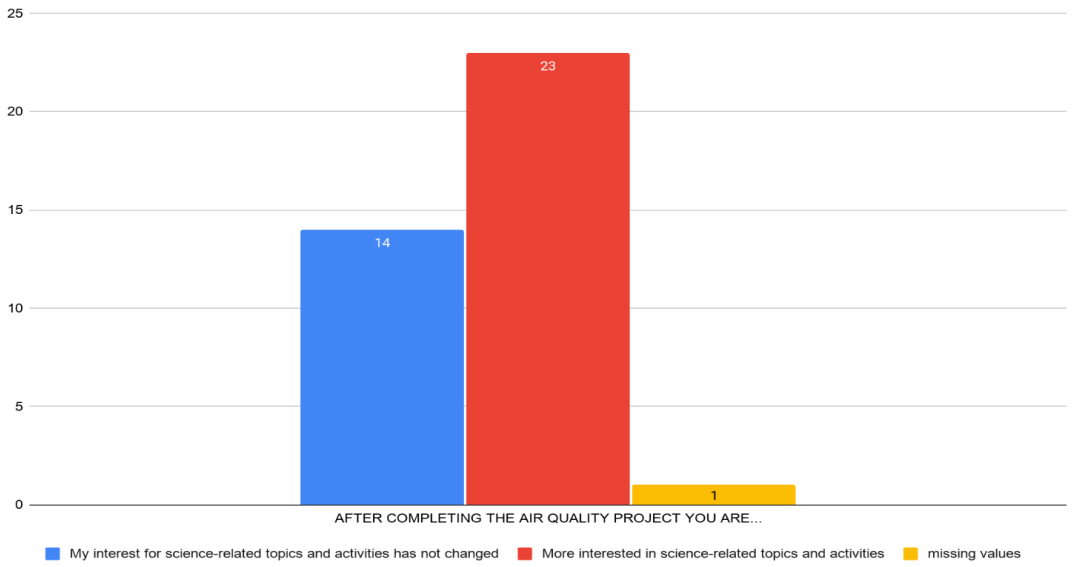


Figure 24: Students, air pollution and DIY sensing impact on interest in science (students' survey, second round)

As we can see, 23 out of 38 of the students stated that, after completing ACTION project activities, they are more interested in learning about air quality and ways of improving it, and in science related topics and activities.

Social inclusion

Looking now at the diversity among participants, of the 46 students participating in the first round of the pilot activities (2019), the majority were male and ranged between 14 and 19 years old. We haven't any students' cultural background information for this first wave of the pilot project.

For the second round of the pilot (2020), 46 students completed the questionnaires. Again, the majority of them were male. Their ages varied from 16 to 19 years old. In order to understand the cultural background of students without asking about their nationality and without mentioning (for ethical purposes) the status of migrant/refugees they might belong to, we asked - as a proxy for nationality - the language used at home. The obtained data show that the large majority of the students (80,43%) speak Norwegian at home, and there is a minority that come from families whose cultural background is different from Norwegian.

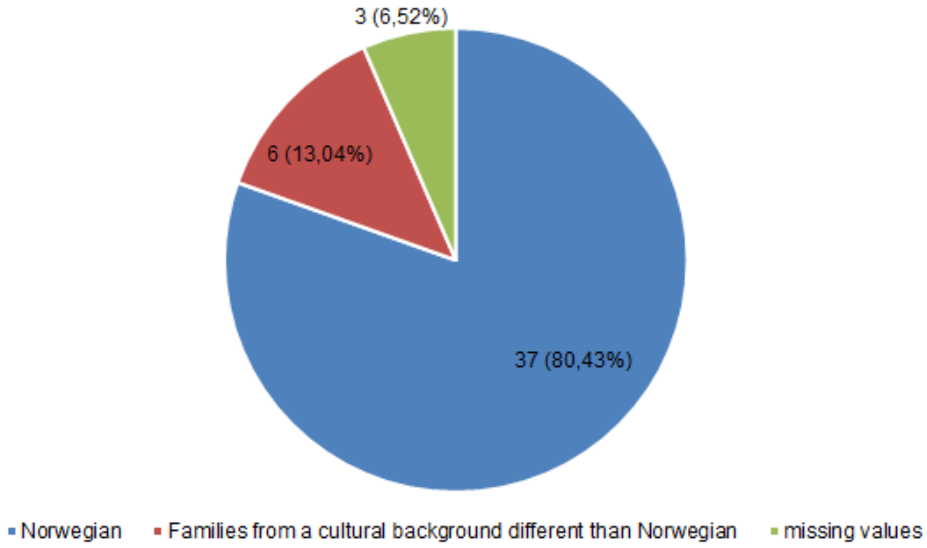


Figure 25 - Students, air pollution and DIY sensing cultural diversity among participants (students' survey, second round)

4.1.3 Transformative impact

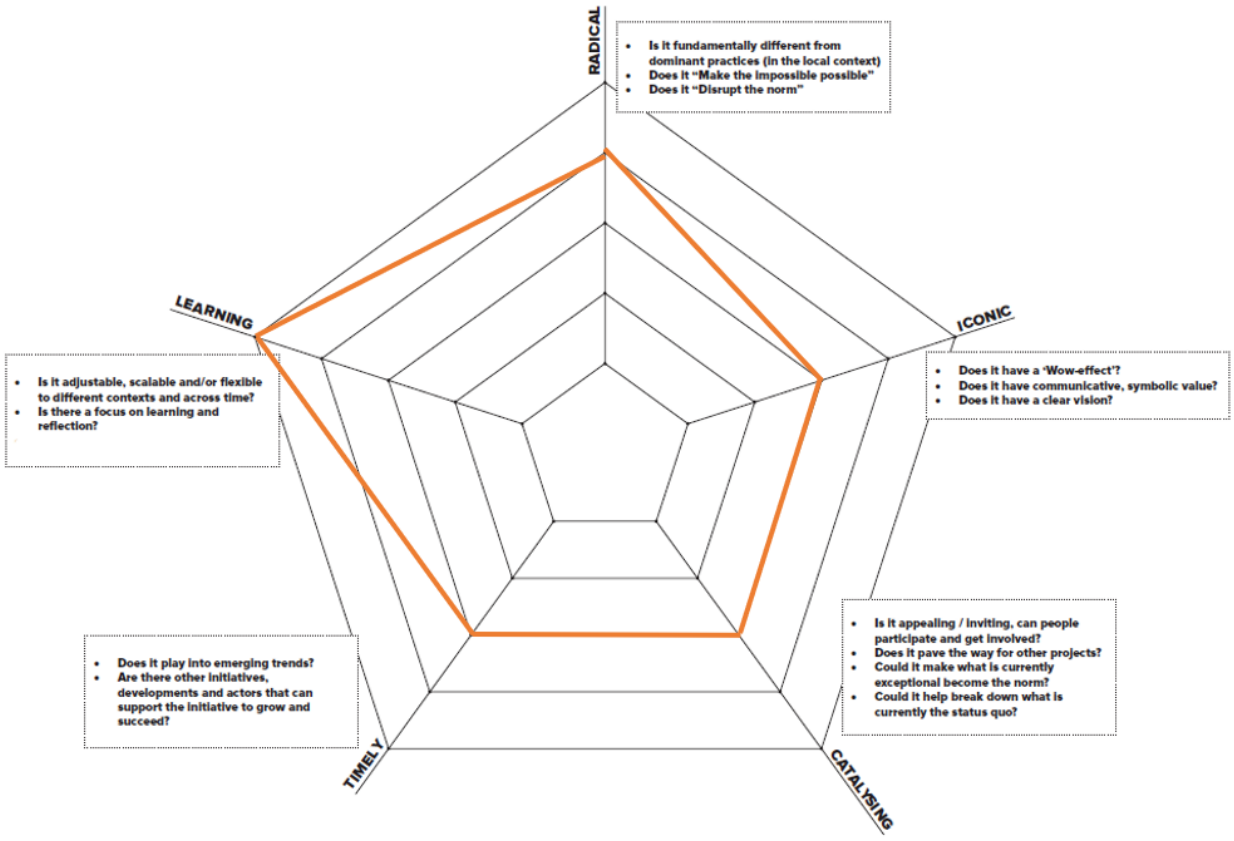


Figure 26**: **Transformative impact of Students, air pollution and DIY sensing project according to project manager

In terms of transformative impact, the project scores 4 out of 5 on **Radical**, because it provides a new education format, away from the traditional front-of-class teaching (see Figure 26). The interdisciplinary activities cover different topics, from computer science to technology, science and society. Designing their own research project and presenting the results in a scientific manner to professional scientists was highly appreciated by the students and brought them closer to science and scientific thinking. Dealing with the topic of air pollution in a self-exploratory manner will foster a holistic view of a scientific and technological topic with relevance for both, the students themselves and society.

The project scores 3 out of 5 on **Iconic**. While the project does not have an enormous "Wow-effect", the activities have been taken up by the teachers positively and also feedback from the students was positive.

With a score of 3 on **Catalysing**, there are some ways in which the project can inspire other activities that can break down the status quo. The activities have appealed to several teachers who participated with their school classes. The project might not directly "pave the way for other projects", but it might give teachers new ideas for future education topics, to contact researchers from other disciplines to carry out other projects. This, however, requires much own initiative by the teachers. The activities will probably also not directly "break down the status quo". This would require changes in the curriculum, which is not always easy to implement. But it might have been inspirational for teachers to find ways to carry out similar projects within the given frameworks.

The project is quite **Timely**, scoring 3 out of 5. Focus on the environment is increasing everywhere, also amongst the students. The activities tie in with this development and may foster more pro-environmental behaviour. They might also contribute to engage more female students in technology and research topics/activities.

The highest score is given to the aspect of **Learning** (5 out of 5). The activities cover different topics and students can learn a lot (programming; building sensors; how do sensors work – technology; air pollution – sources, effects on the human body, what can be done to reduce pollution; what are the effects on society, what can we do to avoid emissions to the air; scientific work – also through the poster for the student conference; working independently/exploring topics independently; …). The activities can be adjusted/upscaled/downsized according to the needs of the students and the frameworks given by the curriculum.

All in all, the project scores medium to high on transformative impact, which means the project contributes to changing business-as-usual towards a more sustainable world.

4.2 Citizen scientists, dragonflies and pesticides

Territorial coverage: The Netherlands	**Type of pollution considered:** Water pollution

Relevant SDGs: 3 - Good health and wellbeing, 6 - Clean water and sanitation, 12 - Responsible consumption and production

Water quality has improved quite a lot in the second half of the last century and dragonflies, as aquatic insects, have recovered in this period. However recently numbers have started declining again and this seems to be mostly the case with the common species outside of nature reserves. Within the ACTION pilot “dragonflies and pesticides” DBC, the organisation learning this pilot, wants to figure out if pesticides play a role in this decline, using dragonflies as the flagship species.

In this project DBC selects suitable transects from the Dutch Dragonfly Monitoring Scheme to study the impact of pesticides on dragonflies. Since 1999 Dutch Butterfly Conservation has run a monitoring program for dragonflies where dragonflies are counted along transects by citizen scientists following a protocol. This is done on more than 500 transects a year and allows us to calculate trends in the abundance of dragonflies in the Netherlands. In the pilot project, DBC combines this data with new measurements of pesticides on locations where dragonflies are being monitored, in order to research whether there is a correlation between pesticide presence in water and dragonfly prevalence.

Samples of water are collected from these sites by the same citizen scientists who count the dragonflies. Testing of the samples for pesticides requires sophisticated laboratory equipment and is carried out by students at the University of Applied Sciences in Leiden. Together this will give insight into what extent pesticides are a threat to dragonflies and which pesticides are most harmful.

4.2.1 Impact areas’ relevance

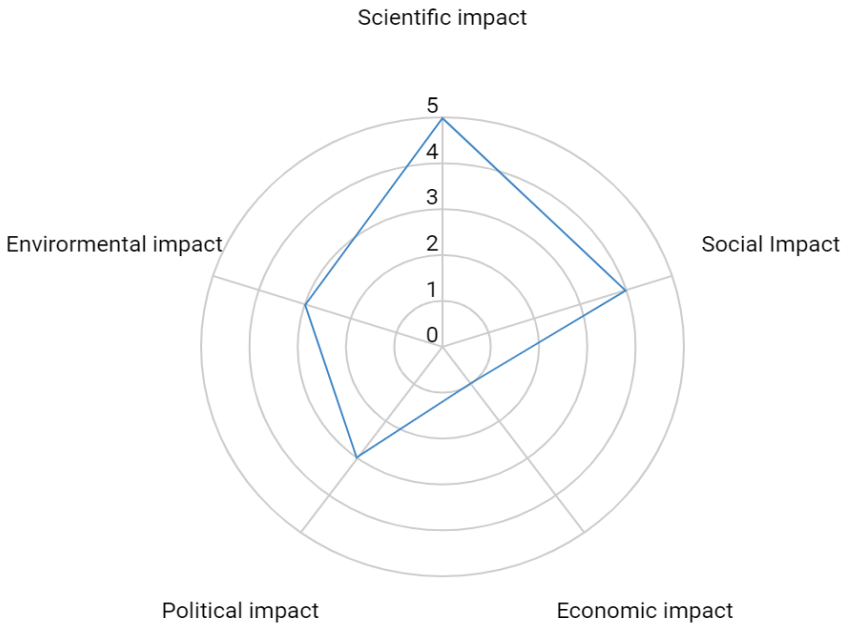


Figure 27: Impact areas relevance self-assessment as described in the canvas

As we can see in Figure 27, the most relevant impact areas for this pilot are the scientific impact, social impact, environmental impact, and political impact. We'll discuss scientific impact, social impact, and political impact in the following subsections. As we discussed in chapter 3, it was not possible to measure environmental impact.

4.2.2 Scientific impact

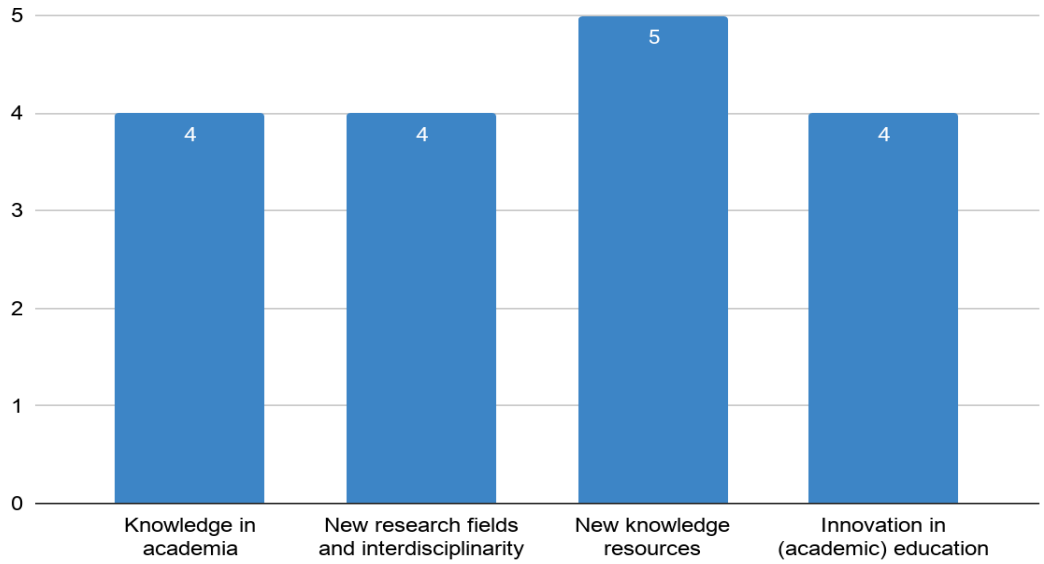


Figure 28: Expected scientific impact Dragonflies and pesticides as described in the Canvas

In terms of scientific impact, the most important subdimensions are innovation in academia, new research fields and interdisciplinarity, and new knowledge resources. This is in line with the expected scientific impact (Figure 28), except for innovation in (academic) education. As the project is still ongoing, the impact on this dimension might still grow.

Knowledge in academia

The project Dragonflies and pesticides already has a clear scientific impact. There are 40 datapoints collected by citizen scientists. The data have a high quality (4 out of 5 indicators), because the task procedures are systematic, and easy for volunteers. The equipment used for measurements is standardised and calibrated across volunteers, and the project records relevant metadata. The project already produced a peer-reviewed article in the Journal of applied ecology, titled "Environmental levels of neonicotinoids reduce prey consumption, mobility and emergence of the damselfly Ischnura elegans", published in 2019 and written by Barmentlo et al (see Appendix B).

In terms of the openness of the data, the project also scores high, with 4 out of 5 indicators. The data are available as machine-readable structure, in non-proprietary format, they link to other datasets to provide context, and will be available on Zenodo and GBIF.

The data has medium to high compliance with the FAIR principles, see Figure 29. The dragonfly data is highly findable, because it will be in the National database, where all Dutch data on flora and fauna is collected and in GBIF. Water quality data is less easy to find if you do not know it exists.

Water quality data will be fully open, dragonfly data in a limited form. That metadata is lacking in the

database. Furthermore, the detailed data is not publicly available. This means the data has medium accessibility.

Both datasets are highly interoperable. Dragonfly data will be included in the other analyses for trend calculations and follows standard formatting. Measurements of water quality will use universal coding for compounds and coordinates for locations.

Dragonfly data is very reusable and will be reused regularly. Water quality data is more difficult as the meta data is limited and it is unlikely to often fit the criteria needed for other questions.

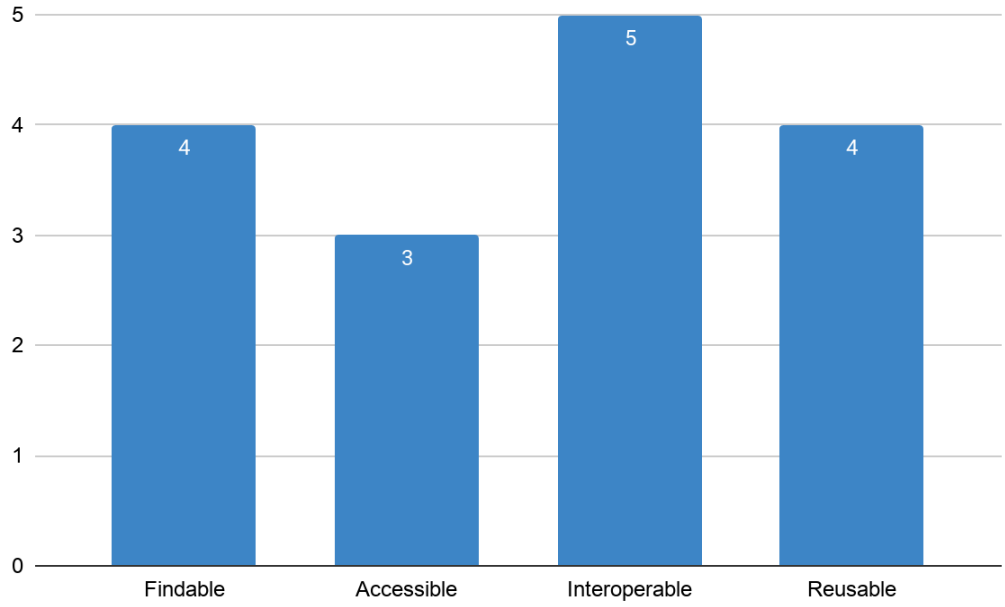


Figure 29: FAIRness of the Dragonfly and Pesticides data

The DBC sees some opportunities for increasing the FAIRness of the data. However, one of the problems is that the details of the monitoring transects will not be openly available, this is only on request. The records of the dragonflies will be in the national database but that is currently poorly accessible without a contract with the organization behind it. This will change in the future (although some parts, especially rare species, will not be visible for the general public).

New research fields and interdisciplinarity

The project Dragonflies and pesticides has pioneered some new methods and fields of study: there will likely be a follow up on chemical fingerprinting of ecosystems, and a technique to measure pesticides in water samples has been developed in the project.

New knowledge resources

The project generated knowledge that was impossible to generate without citizen science; monitoring of biodiversity is done by volunteers, because there is no capacity for this in academia.

4.2.3 Social impact

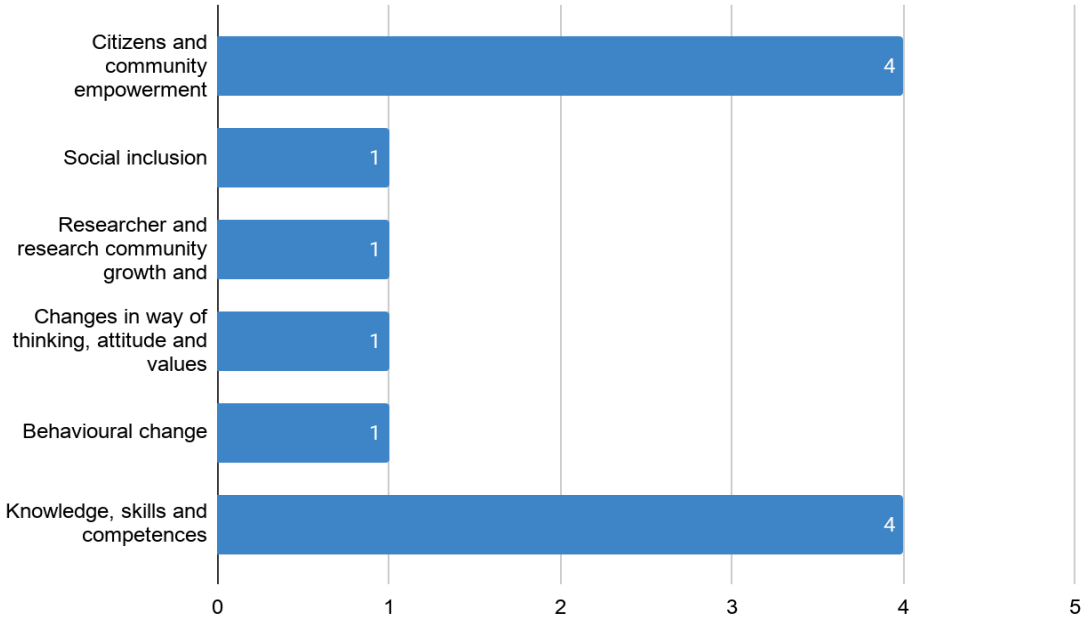


Figure 30: Social impact Dragonflies and pesticides

The pilot, in the period under evaluation, engaged 40 volunteers in sampling and monitoring dragonflies and they were not interacting with each other during the activities. So far one dissemination event has been organised at the national level, but more will be done in the future once the covid-related restrictions will be removed. The project also participated in the European Week of Region and Cities, an important event of the EC targeting decision makers and experts.

With reference to the social impact, the most relevant dimensions, accordingly to the canvas, are:

- Citizens and community empowerment
- Knowledge skills and competences

Citizens and community empowerment

With reference to this dimension, the empowerment relies on the fact that, thanks to the activities carried out, participants are more aware that the data they gather helps protect biodiversity. However, impact on aspects such as social capital, community growth and self-perceived efficacy results are difficult to evaluate at this stage. In order to better consider these dimensions, we plan to gather data directly from the volunteers in the next stages of the pilot.

Knowledge skills and competences

At the present stage the main impact on this dimension is related to awareness, more specifically awareness of the possible impact of pesticides and the omnipresence of them in the environment. At the time of the data gathering it was difficult to describe other or more precise impacts but, as for the previous dimension, we plan to gather data from the volunteers in the next stages of the pilot.

4.2.4 Political impact

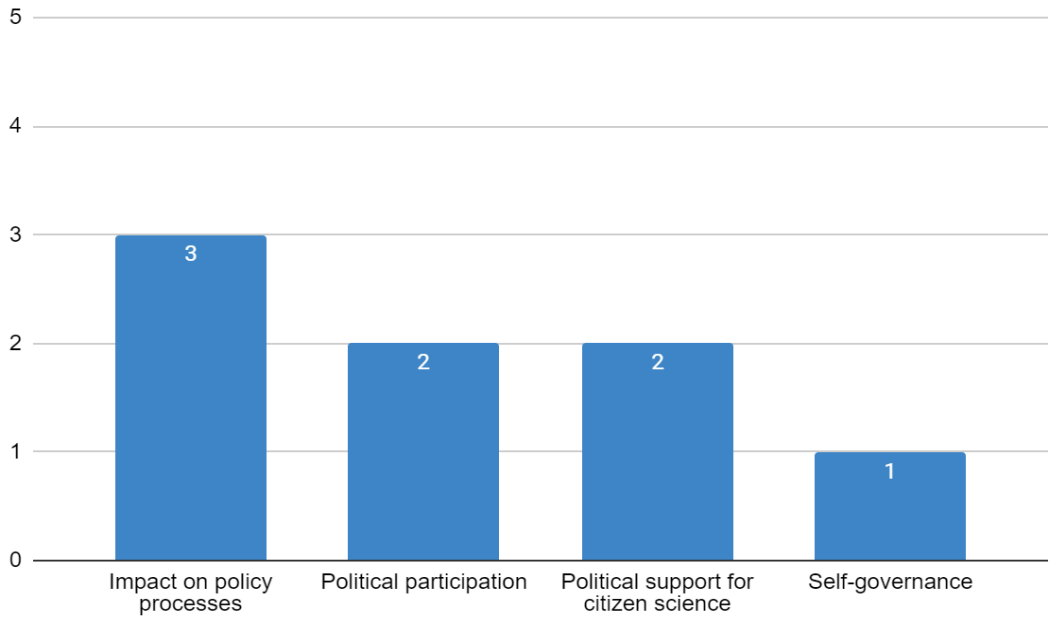


Figure 31: Expected political impact Dragonflies and pesticides as described in the Canvas

At this stage of the project, there is not much political impact, because data collection is still underway. The project does have future potential political impact. Once the project has the results and can assess whether dragonflies are affected by pesticides and know how much pesticides are found in the water, the project aims to get in touch with policy makers, and if necessary, contribute to changing policy to decrease the number of pesticides in the water. In that case, the political impact will be more in line with the expected impact (Figure 31).

4.2.5 Transformative impact

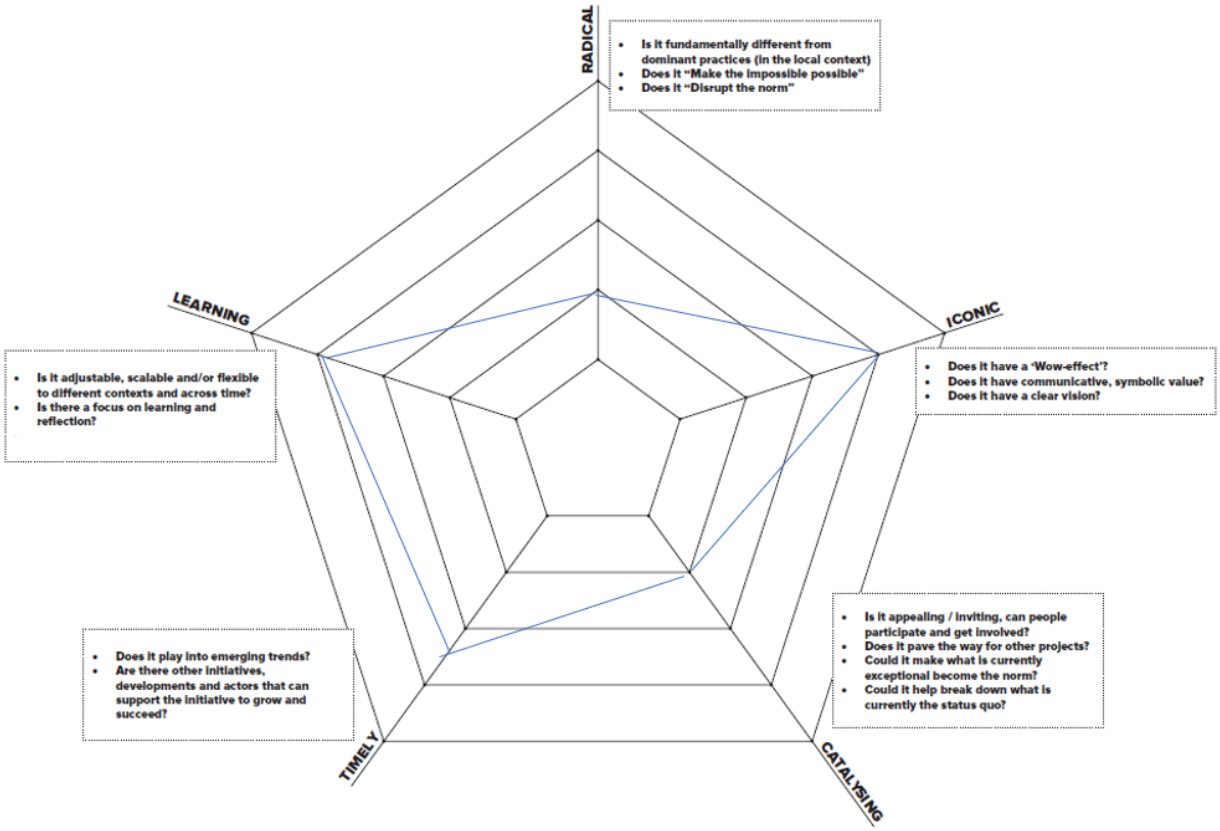


Figure 32: Transformative impact of Dragonflies and Pesticides Project according to citizen science project manager

Overall, the project Dragonflies and Pesticides has a medium transformative impact (averaging 3.1 out of 5). The project scores 2 on **Radical**, because the monitoring of dragonflies follows an existing protocol and is the state of the art, but not novel. The measuring of pesticides is a field in development but not radical. Combining the two and measuring in the field and trying to link these datasets is new, however.

The project scores 4 on **Iconic**, because many people are not aware that these pesticides end up in many locations in their surroundings. The fact that you can't see them means that they are not on the radar. However, this does not mean they are not there.

The project scores 2 on **Catalysing**, because participation is limited to people that are able to identify dragonfly species and thereby it is not easy for more people to get involved. It might be possible, however, that other groups also start to wonder about pesticides in their surroundings and start similar projects.

The project scores 3,5 on **Timely**. On the one hand, pesticides have been around for a long time and there have been concerns about them for decades. On the other hand there has been a surge

in recent attention for insect declines, as chemical analyses are becoming more sensitive and affordable and more citizen science projects are now doing environmental sampling.

The project scores 4 on **Learning**. One part of the project is optimizing the analyses of the water samples. If that is developed, linking pesticide levels from environmental sampling is possible in many locations where biodiversity is monitored.

4.3 Tatort Street Light

Territorial coverage: Germany	**Type of pollution considered:** Light pollution
Relevant SDGs 4 - Quality education, 11- Sustainable cities and communities, 12 - Responsible consumption and production	

Street lighting can severely impair nocturnal flying insects, as many insects are attracted to the light of the luminaires and withdrawn from their actual habitats. The pilot investigates which insects are affected by street lighting and how environmentally sound lighting solutions can help preserve the insects' habitat. It does so by offering a network for citizen scientists and people interested in engaging in the research on how to protect the insect fauna from light pollution.

The project invites amateur entomologists to participate in the research as well as discuss and analyze insect behavior around streetlights and develop ideas for sustainable solutions for nighttime illumination. The research will provide long term data of the current status of insect occurrence in the four German regions engaged and possibly provide insights on the ongoing biomass decline, i.e., which insect orders and species are most affected and how they can be better protected. For school classes, the project provides opportunities to work with insect specimens and learn about their ecosystems and functions as well as check out technological equipment to measure the impact of streetlights on nighttime brightness.

The investigations into the behavior of insects on the lights require the help of citizen scientists and the cooperation of science and amateur experts in the fields of ecology, entomology and measurements of night sky brightness. Furthermore, it includes the collection of insects from traps placed at the streetlights. These serve to educate students in schools and interested local residents about (a) the taxonomy of insects (b) their importance in ecosystems and (c) sustainable use of artificial light at night.

At the time of writing the pilot is at an **early stage** due to the need to postpone and adapt the citizen engagement activities to Covid-related restrictions. Therefore, the analysis mainly focuses on the activities carried out with students and should be considered partial.

4.3.1 Impact areas relevance self-assessment

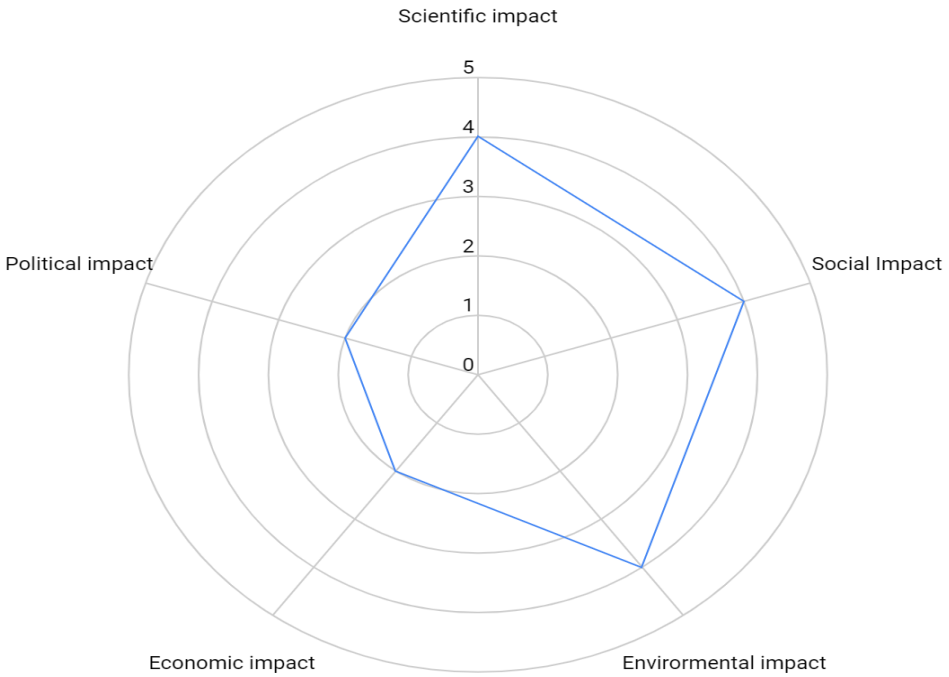


Figure 33: Impact areas relevance self-assessment as described in the pilot's canvas

As we can see in the graph in Figure 33, the most relevant impact areas for this pilot are the scientific impact, the social impact and the environmental impact. As mentioned in introducing this pilot, the activities are at an early stage so that scientific impact is not measurable yet as well as the environmental one. The analysis will therefore focus on the social impact; the other areas are not included in the following analysis.

4.3.2 Social impact

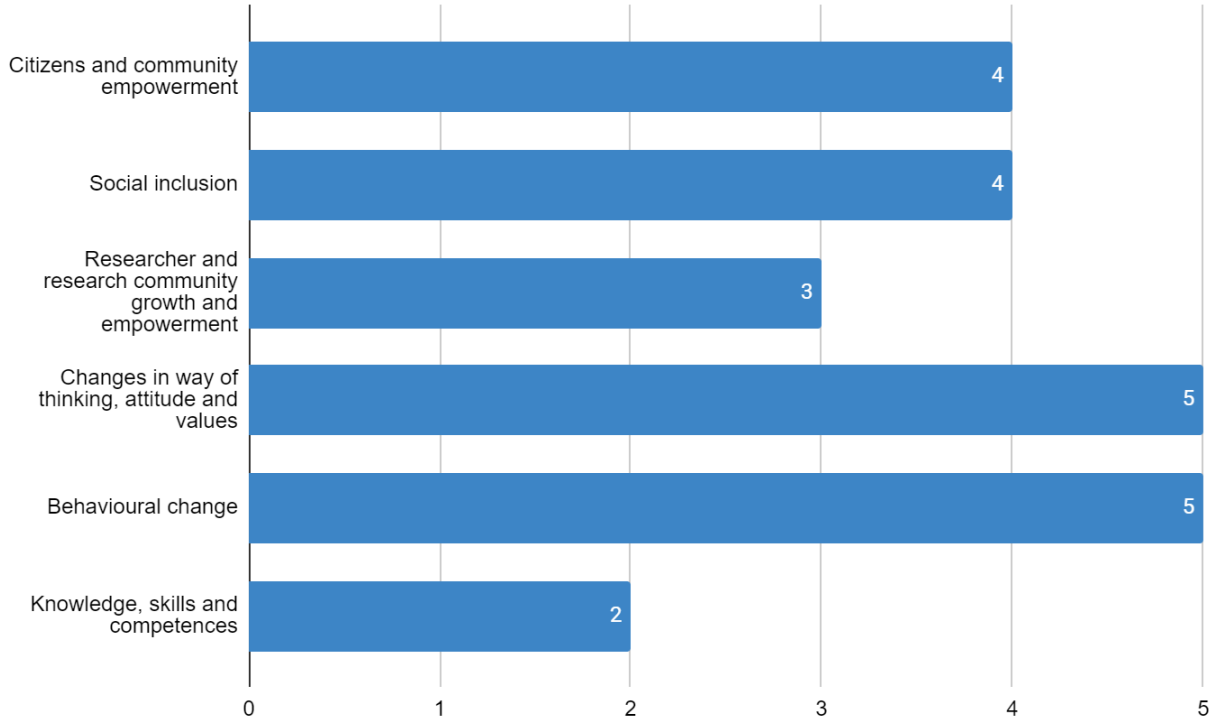


Figure 34: Expected social impact of Tatort as described in the Canvas

Considering the figure above, it is important to notice that - given the early stage of the pilot - is not possible to analyse all the dimensions and, at the present stage, the dimension that we could consider is the last one: Knowledge, skills and competences.

Knowledge skills and competences

Five classes of high school students aged between 11 and 19 years old participated, last September 2020, in a site-based workshop. With the terms site-based we refer to the fact that students visited the location, in the countryside, where the light traps were positioned by the pilot team and got the opportunity to do the whole process of collecting the insects from the traps, identify them with microscopes and classify them with the help of books and teachers. Students were provided an introduction on light pollution too. The activity was aiming at providing students with a better understanding of entomology and related research processes. Indeed, at school they do have biology lessons on insects, but normally do not have the chance to go in depth on classification tasks and on how entomology research processes are structured. The activity resulted to be quite complex for the students because, before identifying the insects, they needed to learn more about taxonomy. From a learning perspective the students showed some difficulties in carrying out the work, but they got a preliminary understanding of the research process, of the subject and of working with microscopes. For some of them the contact with dead insects was not a pleasant one at first, but they overcame this initial difficulty and got the possibility to consider them in a different perspective by the end of the workshop.

The main achievement for this group has been, however, the acquisition of a *new experience in the countryside and of the beauty of nature*. Indeed, for many of them, living in Berlin, it was the first occasion to get in touch with the countryside and being in touch with nature in this way.

Another observable impact is related to the interest of the subject, biology, that seams increased after the workshops and a higher trust and feeling of closeness for the teacher was also observed, which could be positively correlated to the increase in interest for the subject.

Another activity carried out was with 5 younger students, aged 11-13 years old. The activity took place at school, during a biology class. The setting of this activity, within a more usual setting and in a smaller and more homogeneous group compared to the one on the site visit, resulted in more focused activities and better results in terms of classification. Indeed, students were able, by working in a group and with the help of their teacher, to classify 12 samples which is a very good result.

Finally, another activity was performed with a different school, called “school of nature” in which students are working outside, in nature, on a daily basis. 17 students aged 10-18 years old were engaged and really appreciated the activity and learned more about entomology and classification.

Summarizing, beside age and pre-existing knowledge on the specific subject, variables that resulted as relevant in explaining the success of the activities in terms of learning and skills acquisition are: workshop setting, dimension of students’ groups and pre-existing expertise and confidence in working in a natural setting.

Considering now the *learning for the leading teacher*, this resulted as effective. The lead teacher learned more on how to run a CS workshop, how to adapt the activities to different groups of students, how to motivate the students and how to better teach them insect classification. Also, other teachers involved in the activities as supporters of the main teacher reported a positive impact on learning and skills and are now more interested in citizen science as an effective tool for teaching. In the next months teaching materials and guidelines will be prepared for them in order to better enable them to run this type of workshop in an autonomous way.

Social inclusion

Considering the diversity dimension of students participating in the activities, it can be said that they were quite diverse in terms of age (as already mentioned) but also in terms of gender and cultural background. The data refer only to students participating in the first workshop in the countryside as no data are available for the others. In that group, on average, male represented 40% of the engaged students against 60% of females. The group was characterised by a high percentage of students from a migrant background (30%) and, considering the income of the families, most of them could be considered middle- and low-income families with only few wealthy families. There were no students with disabilities.

4.3.3 Political impact

Already at this early stage of the pilot, the team is very active in engaging local administrations and decision makers in the activities. Indeed, the head of the regional district was present at the pilot kickoff event and echoed the social media messages of the pilot on his own. The pilot is also supporting an open consultation created by the pilot team as a result of a previous project: the

recommendations for sustainable lighting is under discussion at the time of writing and could lead to a new legislation.

4.3.4 Transformative impact

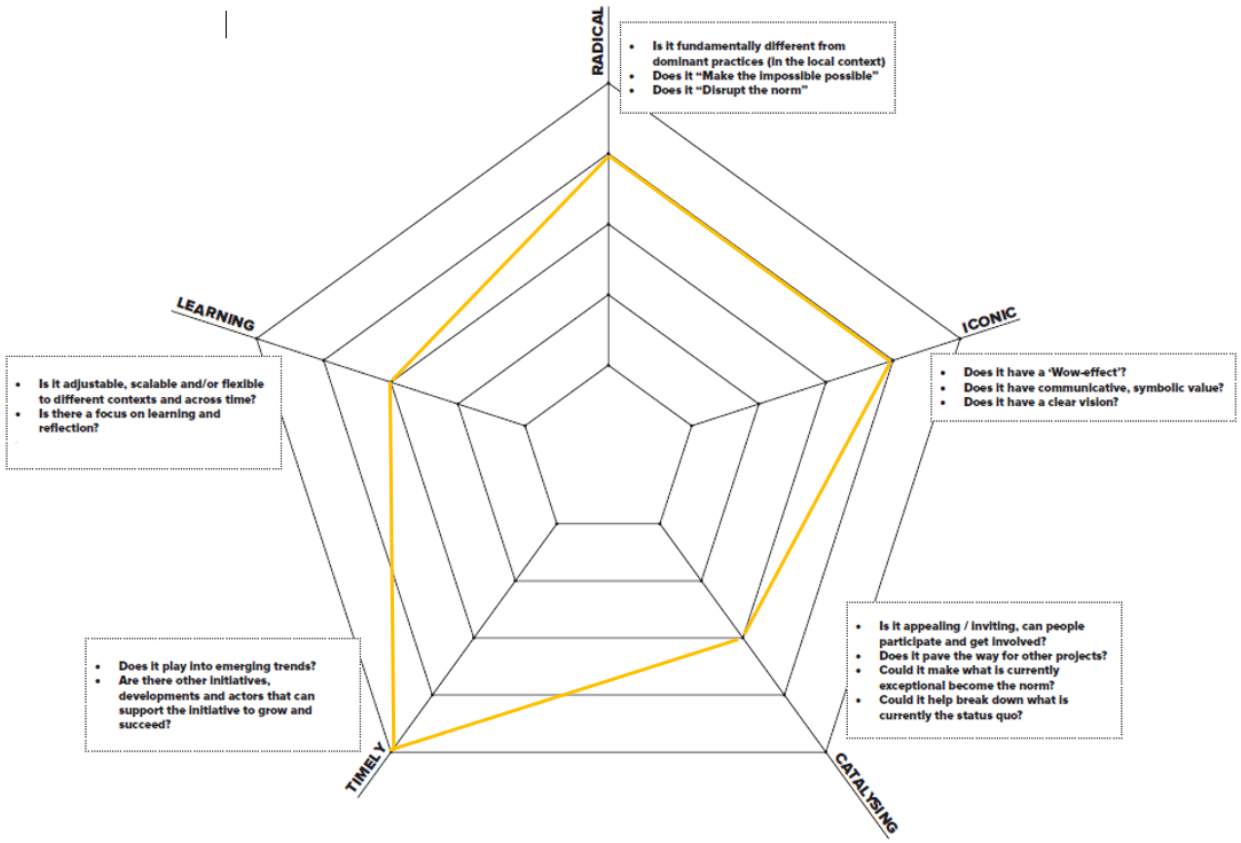


Figure 35: Transformative impact of Tatort according to citizen science project manager

With an average of 3.8, Tatort scores well on transformative impact. The project is **Radical** (4/5) in the sense that it makes the impossible possible: in changing the standard lighting the project shows that it is possible to protect biodiversity.

The project is **Iconic** (4/5) because lighting is a matter that concerns everybody. The project wants to save the darkness, which is unique for the areas in terms of tourist potential (all areas have or have applied for star park status).

The project is **Catalysing** (3/5) because it has a high potential of changing people's beliefs and habits. The project can increase awareness for the protection of insects and most importantly the use of private lighting. The project does not have the maximum score, because not all people will change habits that have been in place for decades, for example light use and using pesticides in the garden.

The project is **Timely** (5/5) in the sense that we are in a highly dynamic time for communities converting street lighting to LED technology. Secondly, the federal environmental law has launched

a draft to strengthen the regulations against light pollution which will become effective in 2022. The geometry of street lighting is one aspect of the new draft for regulations.

The project allows for **Learning** (3/5) because it can offer new knowledge in the field of insect taxonomy, lighting planning and measurements of artificial light at night. These are all subjects that need higher impact in educational education and the project hopes to make a case for the protection of insects and thus biodiversity.

4.4 Loss of the Night

Territorial coverage: Worldwide	**Type of pollution considered:** Light pollution
Revant SDGs 3 - Good health and wellbeing, 10 - Reduced inequalities, 13 - Climate action	

This is an online citizen science pilot, pre-existing ACTION[6], and based on a dedicated App. It invites citizen scientists worldwide to take part in a research project that measures light pollution by using the human visual system as a light meter. The goal of the project is to track changes in artificial sky brightness in urban areas over the long term (ideally many decades). Specifically, participants are asked to look for specific stars, and report if they can see them from their location. In addition to outshining the stars, light pollution is a signal of energy waste, and it disturbs sensitive nocturnal species. Scientists are concerned that light pollution might have a big impact on nocturnal ecosystems, but they have very little information on how skyglow is changing especially considering the recent transition to LED lighting. This cannot be achieved with current satellites, and in general is difficult to do via remote sensing because satellites look at the ground, not towards the sky. This is why the support of citizens is so important.

The observations are sent anonymously to the Globe at Night project (www.globeatnight.org) where they are archived. Participants can also view the data at http://www.myskyatnight.com.

The research is timely as illumination of the night sky continues to increase annually and the evolution of the observation over time is the most relevant part of the research. The Loss of the Night App is downloadable for free for Android (http://tinurl.com/vdn-app) and iOS (http://tinyurl.com/vdn-ios) in 15 different languages among which: Arabic, Catalan, Chinese, English, French, German, Italian, Japanese, Polish, Romanian, and Spanish.

[6]The App was first released in 2012 as part of the Verlust der Nacht network funded by the Federal Ministry of Education and Research (BMBF). Since then it has been updated and translated into 15 different languages. Currently the App is updated to remove bugs related to GPS location services

4.4.1 Impact areas relevance self-assessment

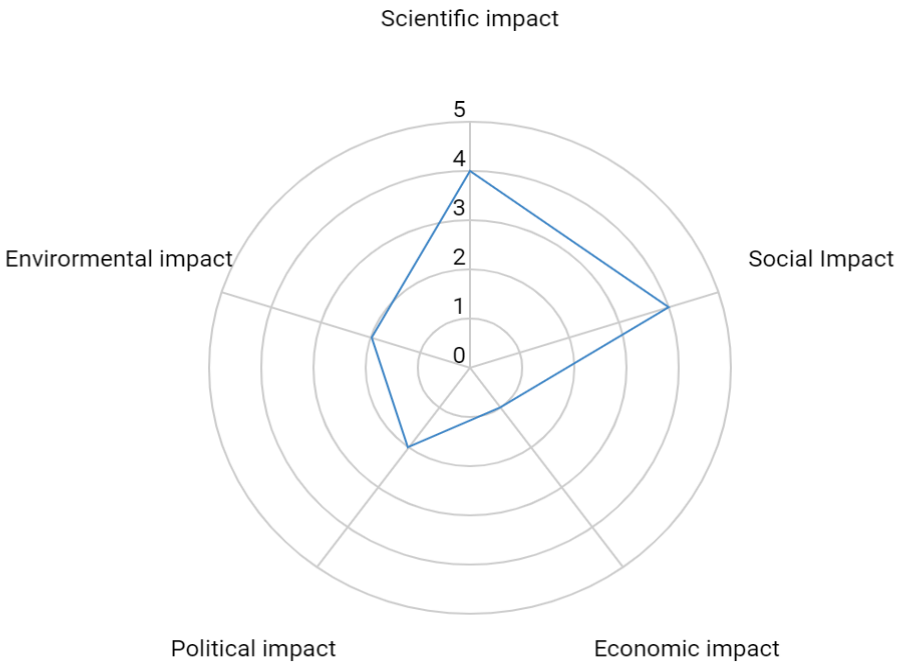


Figure 36: Impact areas relevance self-assessment as described in the pilot's canvas

As we can see in the graph in Figure 36, the most relevant impact areas for this pilot are the scientific impact and the social impact. In the next subsections we report the information collected so far, however it is important to highlight that - during the assessment period - this pilot has been primarily involved in adapting and updating its App (it should be released early spring next year) and in supporting a better management of gathered data. It is also important to acknowledge that, beside the above-mentioned activities, the everyday work of scientists on the pilot is on a voluntary basis and this has limited the amount of time available for further interactions and analysis.

4.4.2 Scientific impact

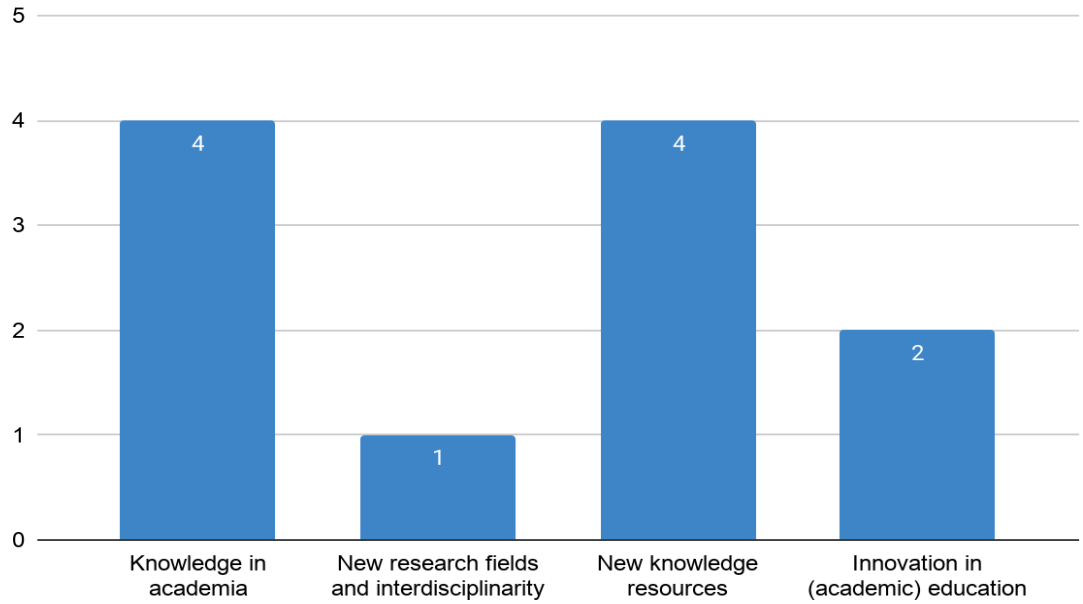


Figure 37: Expected scientific impact Loss of the Night as described in the Canvas

Loss of the Night has a total of 6747 measurements, which means that the App has a substantial impact on **Knowledge in academia**. In 2020, the App noticed a substantial increase of high-quality data observations compared to earlier years (168 high quality observations in 2020 compared to 62 in 2019, 65 in 2018 and 61 in 2017). The visualisations for the data are published on the website: http://www.myskyatnight.com/#map. The data collected is sent to a larger international citizen science project called 'GLOBE at Night' which has been collecting and mapping this data since 2006. The value of the data gathered relies, as said, not only on the quantity and quality of data, but on the capability to have historical data and time series of many locations worldwide. As for other CS pilots, collecting these kinds of data with professional researchers would have been very costly if not impossible.

Besides scientific data, the pilot is constantly updating its blog (on a voluntary basis) and releases regular newsletters. Furthermore, it is a well-known App for teaching about the property of light and light pollution and is reported as a useful tool for engaging both primary and secondary school pupils as well as adults on this topic. Indeed, the pilot is present on relevant CS websites and repositories such as SciStarter (https://scistarter.org/loss-of-the-night). To this extent the pilot blog is also recognized for having useful graphs and images to create discussions and develop more understanding about light pollution in teaching activities. Adding to this, the pilot released - thanks to a collaboration with students from the Worcester Polytechnic Institute - two tutorials on how to use the APP, presented the APP at Mitforschen! Festival in Berlin and, during the last ARS Electronica festival presented a 24h measurement campaign. All of this shows a genuine interest from the pilot in keeping the community alive (see the following sub-section) and in promoting accessible science communication.

In terms of data quality and management, Loss of the night developed a new data management plan thanks to the interaction with ACTION which, however, resulted to be difficult to translate in

actionable information for other pilot activities. Data is not analysed on a regular basis (as they were at the beginning of the project in 2010[7]), but still the quality of data is considered high and the data are stored safely. The value of data relies on his long-term gathering and the possibility to generate long time series (ideally 10 years or more) so the voluntary work that researchers are still dedicating to the community and the App is considered worth in this sense. At the time of writing the pilot is exchanging with ACTION Open Data experts in order to have an anonymized data set available on the ACTION Open Knowledge Portal (linked with Zenodo).

4.4.3 Social impact

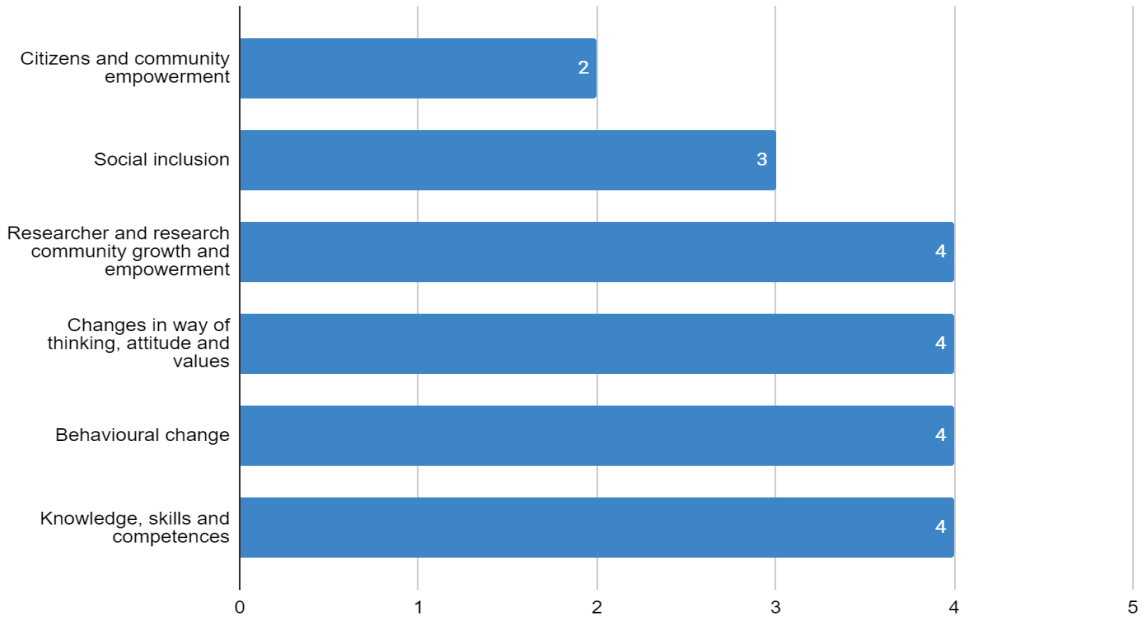


Figure 38: Expected social impact Loss of the Night as described in the canvas

Los of the night can count on a large and international community. Indeed, the App has been downloaded by more than 50,000+ considering only the Android users. The monthly newsletter reaches more than 400 subscribers and the CS manager Twitter profile - used for promoting the pilot - has more than 2400 followers. The Pilot Facebook page has 940 persons.

All of the above, and as mentioned in the previous sub-section, show the interest and effort of the researchers to keep alive a community created in 2012. The data gathered, together with the blog posts are the main assets for supporting the scientific community working on light pollution. The pilot is also very well connected with other researchers in the field and the CS managers are constantly launching other CS pilots on the same topic.

In terms of impact on skills, it would be needed to interview the users for having a better understanding on this aspect, and this has not been possible for the time being, but according to the pilot manager the App is a valid tool for becoming experts on stars and astronomy if used regularly. However, the majority of persons that download the App tend to deliver a small number of

[7]The research project Loss of the Night was funded from 2010-2014 by The Federal Ministry of Education and Research and Berlin Senator for Economics, Technology and Research

observations so that impact on learning could be considered effective only to a limited number of users.

No data are available at this stage on users so that we cannot comment on impact on social inclusion or impact on way of thinking, values and behaviours. The fact that the App is available in many languages represents a positive asset for including people from several nationalities and cultural backgrounds.

4.5 Street Spectra

Territorial coverage: Worldwide	**Type of pollution considered:** Light pollution
Relevant SDGs: 4 - Quality Education 11 - Sustainable cities and communities 12 - Responsible consumption and production	

Street Spectra is an online citizen science project and focuses on light pollution; it aims to map and characterize public lighting sources. Volunteers use a low-cost diffraction grating on top of their smartphones' camera to take pictures of the streetlamps and their emission spectra.

The creation of the project has been motivated by the global switch out of the older street lighting to new LEDs which have a negative impact on ecosystems and human health. The database is considered the primary output of the project. It is public and will allow scientists to study the effects of this change on technology onto light pollution. The pilot is currently using epicollect5 as a tool for gathering the information although an ad hoc mobile application is being developed to improve citizens experience.

- This pilot was designed to raise light pollution awareness to citizens. In general, people do not have any information about the unwanted and negative effects of artificial light at night, and what is more important, they do not know that there is a light pollution problem.
- The pilot gives information to citizens so they can classify lamps of the street illumination and being doing so acquire the knowledge of the existence of different lighting technologies and how some of the white LEDs (with a fraction of the light emitted in the blue part of the spectrum) have negative impacts
- Although designed for participants of all ages, there is a focus in young people at schools. The designed hands-on practical material that the project developed will help to reach this audience (with the help of their teachers) that would be the citizens who will make decisions and write the laws in the future.

4.5.1 Impact areas relevance self-assessment

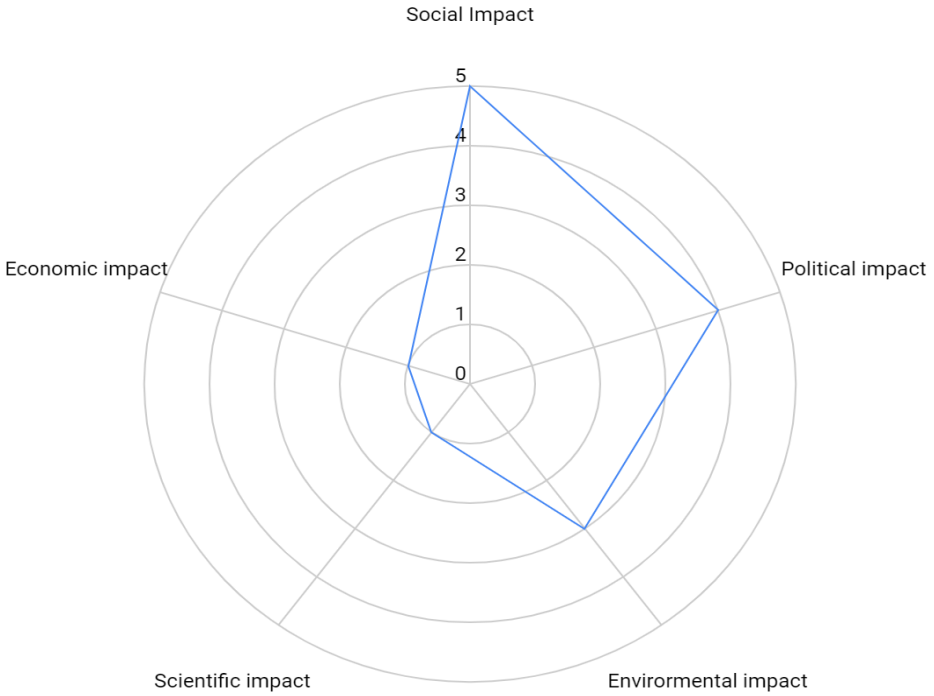


Figure 39: Impact areas relevance self-assessment as descirbed in the pilot's canvas

As we can see in Figure 39, the most relevant impact areas for this pilot are the social impact and the political impact. From discussion with CS managers, it emerged that measuring scientific impact was also relevant and indeed it can be considered the most relevant areas of impact at the time of writing. We'll discuss more in detail each impact area in the following subsections.

4.5.2 Scientific Impact

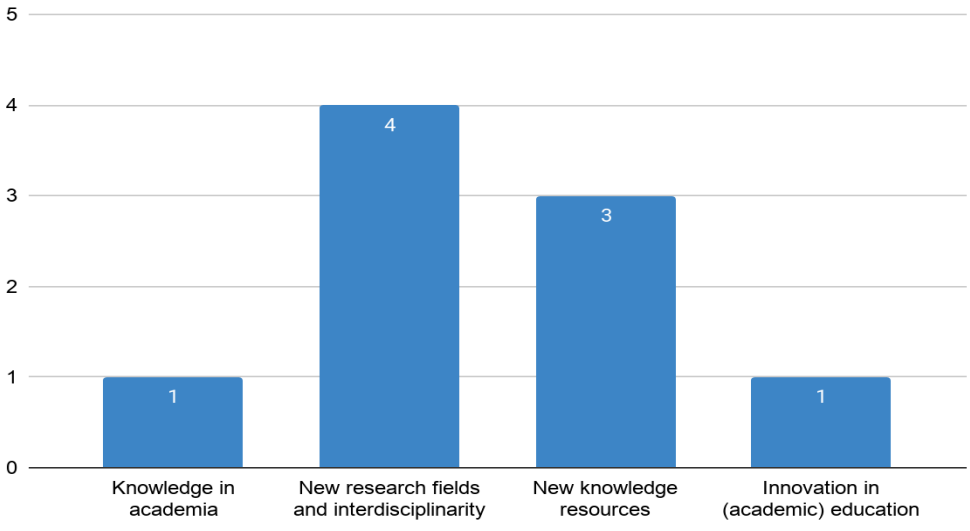


Figure 40: Expected scientific impact Street Spectra as described in the Canvas

Citizens mapping the location and kind of lamps are providing a database that will be used by researchers to check the models of light pollution transmission by the atmosphere. The models predict the sky brightness at zenith of a place, which is important information for astronomers. The measurements of this sky brightness at night during a time lapse (monitoring) inform researchers of changes in the light pollution. At the time of writing, CS managers stated that It is soon to obtain scientific results since this is a long-term project to be continued during the years to come, nevertheless the project is already achieving scientific impacts on knowledge in academia, new research fields and interdisciplinarity, and new knowledge resources. For the first sub dimension, knowledge in academia, this is much higher than expected (see Figure 40).

Knowledge in academia

Street Spectra has generated 791 data points, as well as many publications (see Table 3 for an overview).

Peer-reviewed articles	**5**
Non peer-reviewed articles	**5**
Non-scientific publications	**13 (blog posts)**

Table 3: Number of publications by Street Spectra

Some of the publications have also been highly visible online, with the teaching materials having been viewed 279 times, and downloaded 65 times, and the Ars Electronica presentation with 98 views and 11 likes on Youtube, and 86 likes, 41 retweets, and 12357 views on Twitter.

The quality of the data is very high (5 out of 5). There is a process for adapting the data collection procedures, and the task procedures are systematic and easy for volunteers. The equipment used for measurements is standardised and calibrated across volunteers, and the project records relevant metadata. Furthermore, the data quality will be more fully assessed after a revision of the contributions, by both experts and trained collaborators.

Openness of the data is also very high, with all indicators positively assessed. The data are available as machine-readable structure, in non-proprietary format, they link to other datasets to provide context, will be available on Zenodo, and follow best practices for open data from W3C.

In terms of FAIRness, the project scores quite high, see Figure 41. The data is Findable (4/5), because the project will use Zenodo's DOI's for the datasets. The data is accessible (4/5), but not highly Interoperable (2/5), because the project doesn't use ontologies, or domain-specific vocabularies. The data is Reusable (4/5) with a Creative Commons licence: free to share and to adapt.

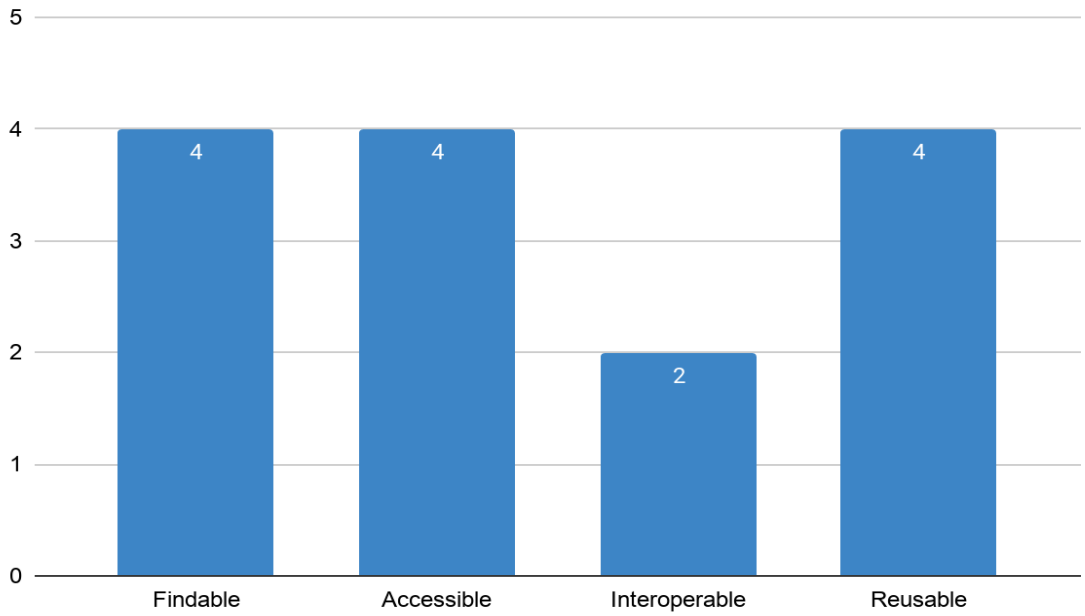


Figure 41: FAIRness of the Street Spectra data

New research fields and interdisciplinarity

The project can be considered quite interdisciplinary, because light pollution is interdisciplinary. For this pilot, lamps characterization is made by analyzing the spectra (Physics, optics), the results are key to determine dispersion of light (Atmosphere science), the light pollution has impact in human health (Medicine), including sleep disorders (Chronobiology) and ecosystems (Biology, fauna and flora).

New knowledge resources

The project eases access to the citizens' knowledge about their local environment and practices, by providing methods and reference material (street spectra database of lamps) with a new visualization scheme. The project has also facilitated knowledge creation between societal actors, in the sense that some associations are creating groups for studying and mapping street spectra.

Furthermore, the project has developed new data gathering tools: a simple method to obtain spectra of light sources using a transmission grating and the camera of any smartphone. Because there is no need for other tools or devices, this makes it easy to start contributing.

The knowledge created would have been very difficult to obtain without a citizen science approach, because of the limited capacity of research teams.

4.5.3 Social impact

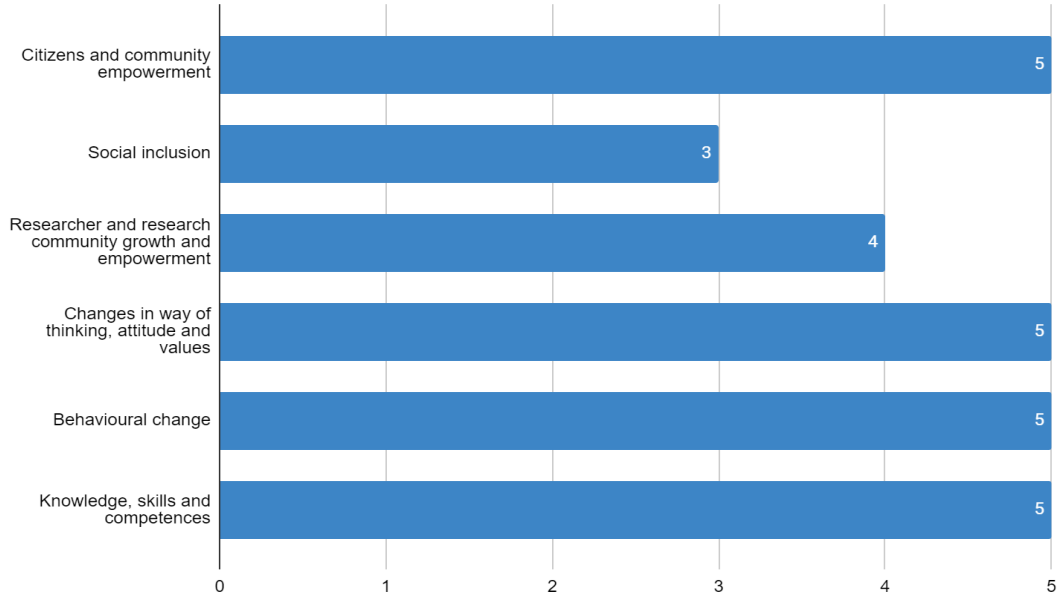


Figure 42: Relevance of social impact dimensions for Street Spectra as described in the canvas

The project was established for raising awareness among citizens on light pollution and its impacts on humans and nature, therefore the relevance of the social impact dimension is considered high in all the sub-dimensions considered (all subdimensions scored 3 or higher). As stated by the pilot team *"In general, people do not have any information about the unwanted and negative effects of artificial light at night, and what is more important, they do not know that there is a light pollution problem".*

Citizen and community empowerment

At the time of writing the pilot engaged approximately 200 citizens and this figure is expected to rise in the next months, when the new version of the Street Spectra smartphone App will be realised. Out of this 200, approximately 60 have been engaged in data (street lamps spectra) data collection. Citizens engaged in these activities often belong to pre-existing local associations and they interact among each other during and after the CS activities. Considering the impact of such interactions on participants's social capital, it is possible to say that this has been moderated (see Figure 43); this is probably due to the fact that they know each other already before the CS activities and that the chance of improving their relationship was modest (being already a positive one).

The CS pilot managers were asked to attribute a value from 1 to 5 to a set of 5 items considering different aspects of social capital. Considering their answers - which will be compared with the point of view of citizens scientists in the next months - the activities carried out supported participants in increasing the number of their social relationships but did not have an impact in improving the quality of pre-existing relationships and the related level of trust among participants and didn't impact on the capability to establish links with people of different age, social group and similar. The latter refer to the capability of a project to increase bridging social capital, i.e. connect diverse communities,

while the first items are related to linking social capital (within the same community). The CS managers didn't have sufficient knowledge for attributing a value to the last item.

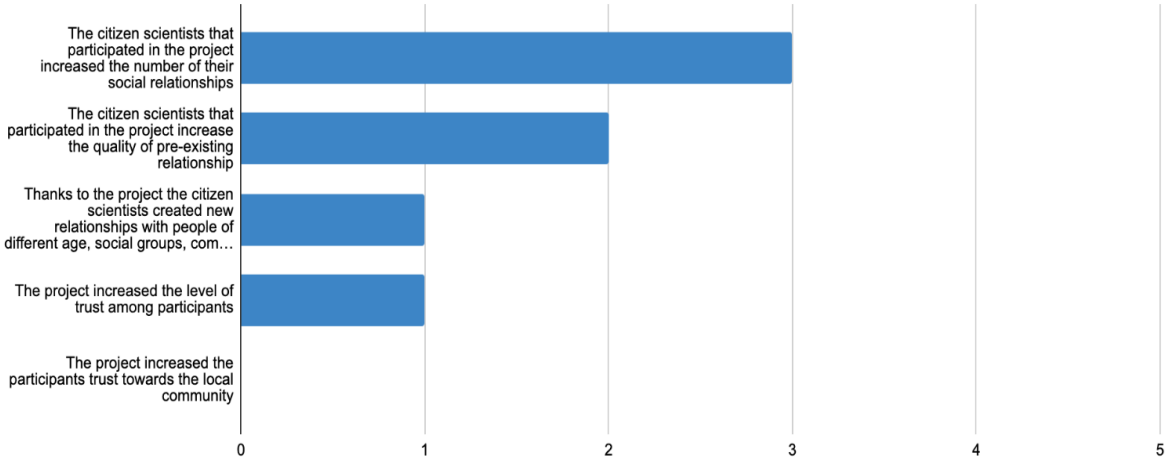


Figure 43: Street Spectra impact on social capital

Beside the persons engaged in CS activities, 400 persons have been engaged in dissemination and awareness raising activities and more than 12000 through social media. The project also participated in the Ars Electronica festival with a dedicated online workshop.

Social inclusion

Although designed for participants of all ages, the pilot has a focus on young people (school age). The designed hands-on practical material the team is developing will help to reach this audience (with the help of their teachers). Besides, the ongoing activities showed the capability to engage the youngest as well as elderly. In terms of gender, however, it is possible to say that the ratio between man and women is: 70%/30%. This information related mainly to the face-to-face activities carried out; indeed, the App, is not collecting demographic information of users so that this aspect - the capability of the pilot to promote social inclusion by engaging people of different age, gender, level of education and cultural background, will be better investigate in the upcoming survey to participants.

Other social impacts

The pilot is promoting changes in way of *thinking, attitudes and behaviours* as participants learn about light pollution and the CS manager reports they tend to share the knowledge with close people (family, friends, coworkers etc.). Considering *knowledge, skills and competencies acquisition,* citizens get access to previously not-available information. They learn how to classify streetlamps and get acknowledgement of the existence of different technologies and how some of the white LEDs (with a fraction of the light emitted in the blue part of the spectrum) have a negative impact on ecosystems and human health.

In terms of *behavioural change*, most participants are now aware of Light Pollution problems and are looking to detect bad lighting practices. Indeed, the change in behaviours in this pilot is not mainly

addressing the direct actions of participants, but more they activation as citizens in promoting better regulations and better practices in the selection of street light lamps by decision makers (see the political impact sub-section here after).

4.5.4 Political impact

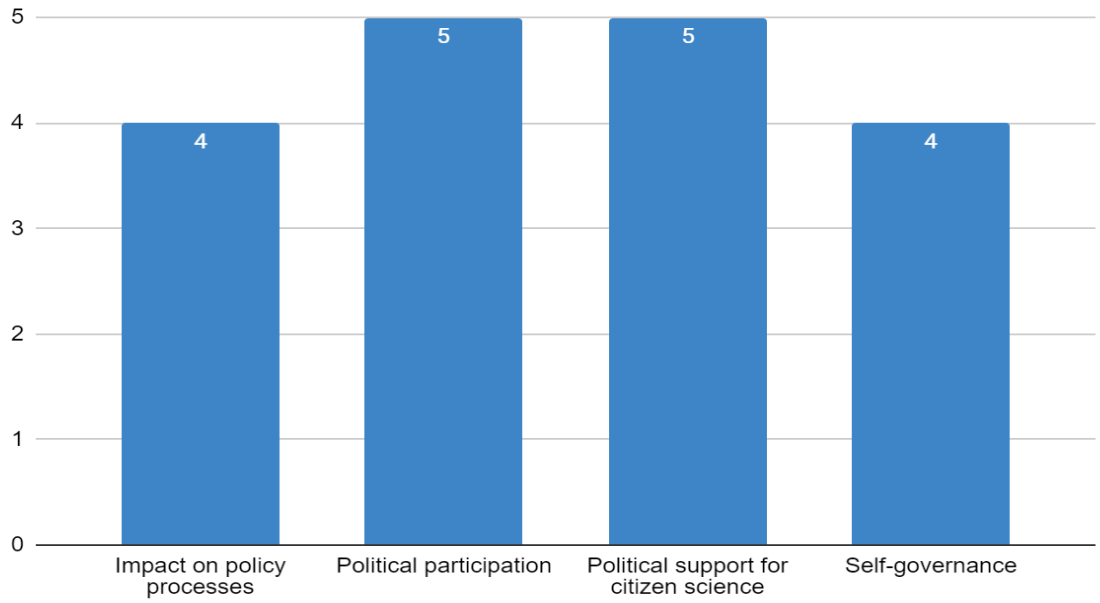


Figure 44: Expected political impact Street Spectra as described in the canvas

Street Spectra has political impact on three out of four subdimensions: impact on policy processes, political participation, and self-governance. This is mostly in line with the expected impact (Figure 44), except for political support for citizen science. As the project is still ongoing, the impact on this sub dimension might still increase.

There has been some impact on **policy processes**, because the project arranged for a meeting with representatives of the Spanish administration in charge with Street Light regolamentation (Ministerio de Industria Comercio y Turismo and Ministerio para la Transición Ecológica).

Street Spectra expects to have increased **political participation** of its citizens significantly (average of 4/5), see Figure 45 for more details.

Last, the project motivated participants to organise events or initiatives to raise awareness about and involve more actors in community projects, which increases the **self-governance** of citizens.

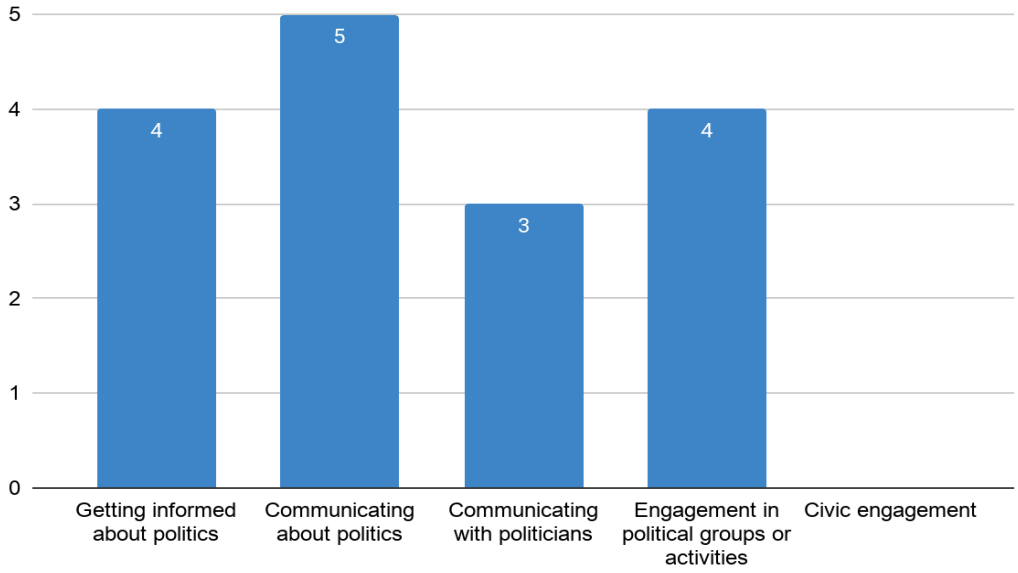


Figure 45: Increased political participation for citizens of Street Spectra

4.5.5 Transformative impact

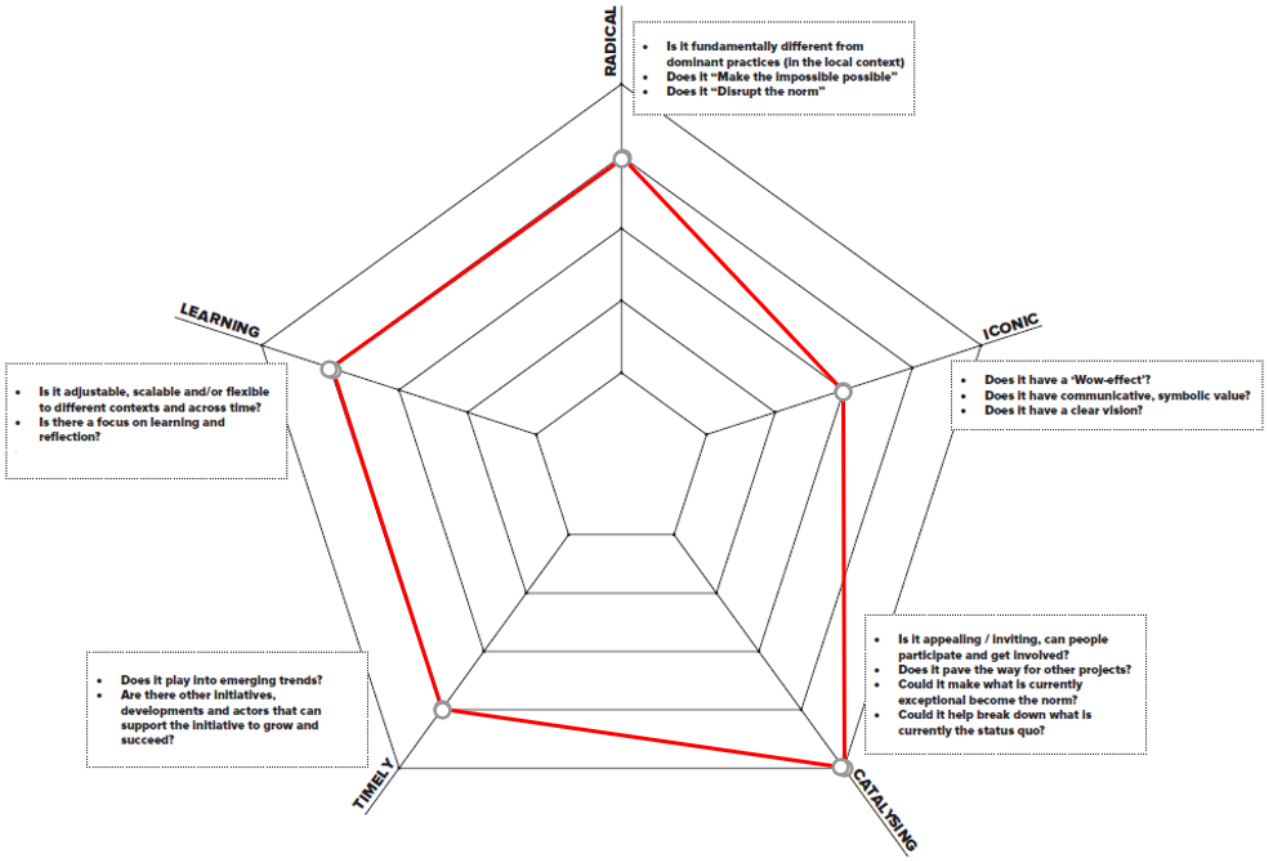


Figure 46: Transformative impact of Street Spectra self assessment by pilot managers

Street Spectra has a high transformative impact, with an average score of 4 out of 5. The project tries to break the status quo in disproving that LED illumination is always better. The project is **Radical** (4/5) because to our knowledge there are no other CS projects doing spectra of urban lamp posts. The project is less **Iconic** (3/5) than some other projects, but the spectra pictures are quite remarkable and thus have a wow effect. The project is **Catalysing** (5/5) because it is quite easy to participate, which makes it attractive. The project is **Timely** (4/5) because it can be easily linked to other projects dealing with light pollution. The project allows for **Learning** (4/5) in the sense that the project has a high educative value and has developed teaching materials.

4.6 Sonic Kayaks

Territorial coverage: South-West England	**Type of pollution considered:** Water pollution
Relevant SDGs: 3 - Good health and wellbeing, 6 - Clean water and sanitation	

The Sonic Kayaks system is a low-cost open hardware for gathering and mapping fine-scale marine environmental data while kayaking. Data, which has not been previously possible to obtain, is sonified through an onboard speaker allowing paddlers to seek out areas of interest and gain real time feedback of the data. The system currently includes underwater temperature sensors and a hydrophone for measuring underwater sound, each recording data every second with GPS, time and date. Working with ACTION, two new environmental sensors were designed and integrated into the existing system (turbidity and air quality), and publishable proof-of-principle data were gathered.

Furthermore, the project developed an online citizen science style survey, where people could try out 4 different data sonification approaches and see which was the most straightforward for understanding the underlying environmental data, and also give their preferences on which sounds they liked the best.

Last a project video was made and put online as part of a feedback survey, which was sent to stakeholders (including local conservation groups, local activist groups, the local council, and academic researchers), people who had taken part in project events previously and general audiences via social media.

When the pilot was first planned as part of the ACTION accelerator it was expected to conduct activities using kayaks and gathering/sonifying data while paddling in selecting sites. Members of a local association working with visually impaired people were expected to engage in this activity. However, due to Covid-19 restrictions it was not possible to organise such group events and visually impaired people (two persons) participated in the above-mentioned survey on sonification approaches.

4.6.1 Impact areas relevance self-assessment

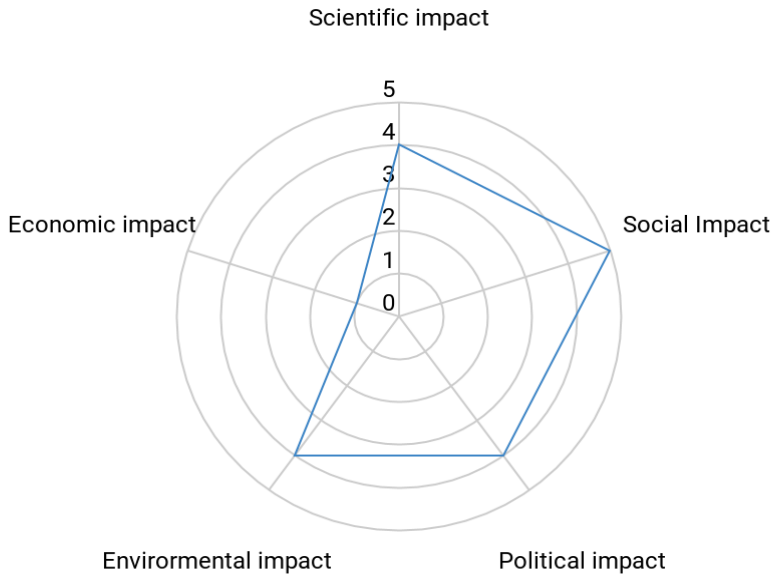


Figure 47: Impact areas relevance self-assessment Sonic Kayaks as descirbed in the canvas

As we can see in Figure 47, the most relevant impact areas for this pilot are the scientific impact, the social impact, the political impact and the environmental impact. Economic impact, even if not considered relevant at the time when the canvas was filled in, resulted in some relevance too. We'll discuss more in detail each impact area in the following subsections, except for environmental impact (see section 3.6).

4.6.2 Scientific impact

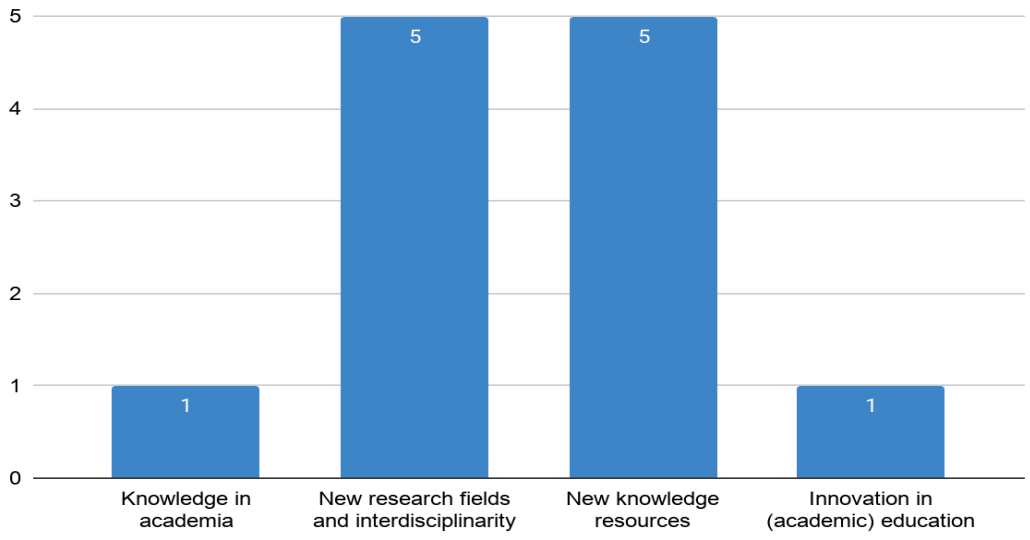


Figure 48: Relevance of scientific impact dimsnions for Sonic Kayaks as described in the canvas

Sonic Kayakss has a substantial scientific impact on knowledge in academia, new research fields and interdisciplinarity, and new knowledge resources. The impact on knowledge in academia is much better than expected (see Figure 48).

Knowledge in academia

Sonic Kayaks generated 35.052 datapoints, as well as several (non-scientific) publications (see Table 4).

Non-scientific publications	**5 (1 article, 2 blogposts, a video, and 1 instruction manual)**

Table 4: Number of publications by Sonic Kayakss

The **quality of the data** is very good - with at least 4 out of 5 indicators positive. The project adapted their process of data collection, by developing four versions of the sensors used to gather data sound and they have collected people's feedback in terms of waterproof quality and temperature. Furthermore, they have processed a lot of data before they started to gather the data, and had redundancy built in (3 systems).

The tasks for the volunteers were quite challenging, but at the same time easy to get it right. The volunteers were on their own doing simple tasks, like stopping every 200m with the GPS. Task procedures and data entry were systematic. The equipment used for measurements was mostly standardized and calibrated across volunteers. They have provided thermometers to volunteers which give standard degrees outputs. They parallelly tested two quality sensors before doing tests. The hydrophone is a low hand one, but they have already used it to gather data that have been published, and they have replicated the same conditions in different situations and the experiments always have worked. So, the quality is good enough. The project also records relevant metadata (GPS).

Project scores well on **openness of data**, with at least 3 out of 5 indicators positive. Data are available on Zenodo with an open license, as machine-readable structure in a non-proprietary format. The data does not link to other data because they are not easily comparable to other datasets.

New research fields and interdisciplinarity

Sonic Kayakss is strongly interdisciplinary: it combines music and environmental sensors to monitor water quality. The project has also created a new research group as part of their long-term strategy.

New knowledge resources

The Sonic Kayaks system is a new and innovative data gathering tool that has already gained quite some interest and traction from other parties. Indeed, during the ACTION acceleration period, the sonic Kayaks team developed and integrated two new sensors: a water turbidity sensor and air particulate matter sensor, in addition to the pre-existing temperature sensor and hydrophone. The team also wrote the software for this system.

4.6.3 Social impact

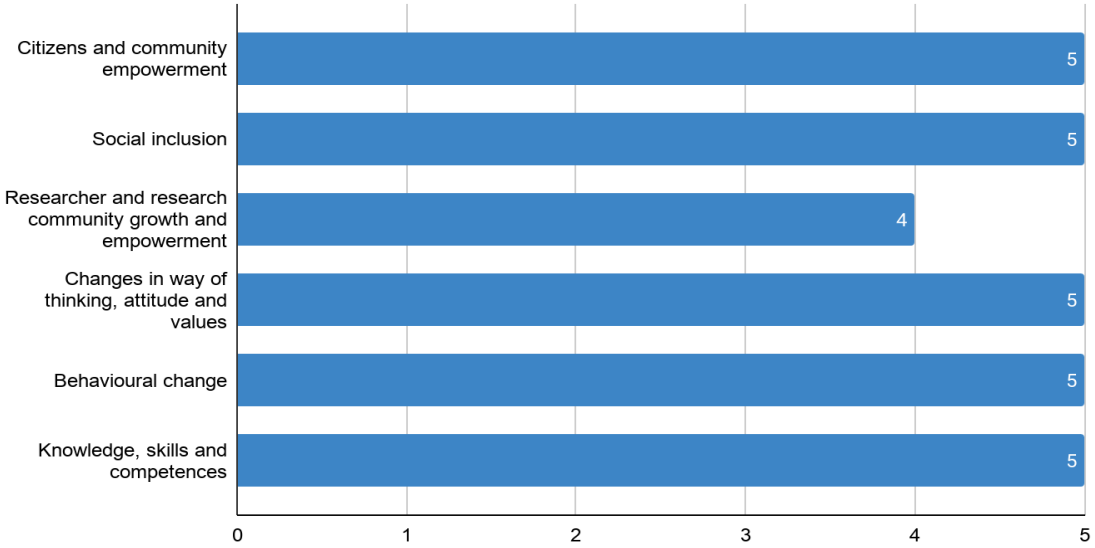


Figure 49: Relevance of social impact dimensions for Sonic Kayaks as described in the canvas

As mentioned in the introduction of this subsection, the pilot engaged volunteers at different stages of the process: 49 people responded to the sonification survey while 27 people to the video-related one. Besides the people directly engaged in CS activities, the pilot reached a wider audience through their social media channels (more than 6 followers on twitter accounts and more than 400 Instagram followers) and blog posts. The team does not usually map the numbers of views to their blog as they prefer focusing on the quality of interaction that is timely and accurate. Indeed, this pilot is based on previous, related CS activities and can count on an interested community of persons caring about the environment or interested in the artistic aspects of their work. Recently, as a result of the pilot, they have been invited for an article in The Raspberry Pi magazine article (https://magpi.raspberrypi.org/issues/98/pdf) an well know journal for makers, especially young ones with more than 300,000 monthly readers, and 800,000 monthly page views.

With reference to participants to the sonification survey, the project team mapped the respondents' profiles considering different profiles and the results are the following (Griffiths, A. 2020):

1. Those who selected '*I work or have worked in scientific research*' but not 'I work or have worked in a sound-related job' or 'I am a musician (either professional or hobby)' (n = 14)
2. Those who selected either '*I work or have worked in a sound-related job*' or '*I am a musician* (either professional or hobby)' but not 'I work or have worked in scientific research' (n = 9)
3. Those who selected both 'I *work or have worked in scientific research' and either* '*I work or have worked in a sound-related job*' or '*I am a musician* (either professional or hobby)' (n = 9).
4. Those who selected 'I have a visual impairment' (n = 2).

The results show how the respondents are close to the interests embedded in the pilot and, in some cases, have a professional profile linked to them. At the same time, the project succeeded in

empowering people to collect data and in having more people engaged in doing data collection. This will support them and the local community in having evidence on pollution and act for improving the situation.

Social inclusion

As already mentioned, this pilot was planned to have a strong emphasis on social inclusion, especially engaging people with visual impairments. This has proven to be almost impossible due to the Covid-19 restrictions, nevertheless a genuine effort was put in making this happen despite the difficult situation and two people with visual impairment participated in the sonification survey. Some of them also participated in the following activities and ad hoc conference call for discussing the project results. The online surveys were checked over by a blind audio and accessibility expert (Power Audio Productions) to make sure it would work for people with visual impairments who use screen readers.

Knowledge, skills and competencies

The CS managers' report that the project had a positive impact on participants in terms of knowledge, skills and competencies acquisition. Most of them learned more on sonification procedures and how data is developed in this context and they increased their understanding of air and water pollution. This is also testified by a video made by participants on how the sensors work and how to measure air and water pollution.

Besides, artists involved in the pilot increase their motivation in participating in alike activities learning new things related to pollution and the scientific process. As one the team member described: the pilot "*taught artists about measurement and scientists to listen and learn music. There is an interdisciplinary learning exchange*".

Changes in way of thinking, attitude and values and behavioral change

Most people were already motivated and interested in air and water pollution so that changes in way of thinking, attitudes, values and related behavioral was not that relevant in this context.

4.6.4 Economic impact

The project was effective for the pilot team in increasing their recognition in the field and generated spill-over effects. Indeed, as a result of the pilot, the team of another ACTION pilot, involved the Sonic Kajaks team in a proposal for local council grant as trainers on how to build sonic kayaks. Then, a marine noise researcher has commissioned the team to train her to build a sonic kayak too and is now writing a 5-years fellowship project which would be based around the Sonic Kayakss, using them at the Great Barrier Reef. Finally, some of the Sonic Kayakss technology will be used in a artistic installation called Sonic Bike installations8 to measure air pollution. All these new initiatives definitely demonstrate the high appreciation of their work in the community and are occasions for further future income generation opportunities.

[8]https://twitter.com/federicovisi/status/1293174742829146113

4.6.5 Political impact

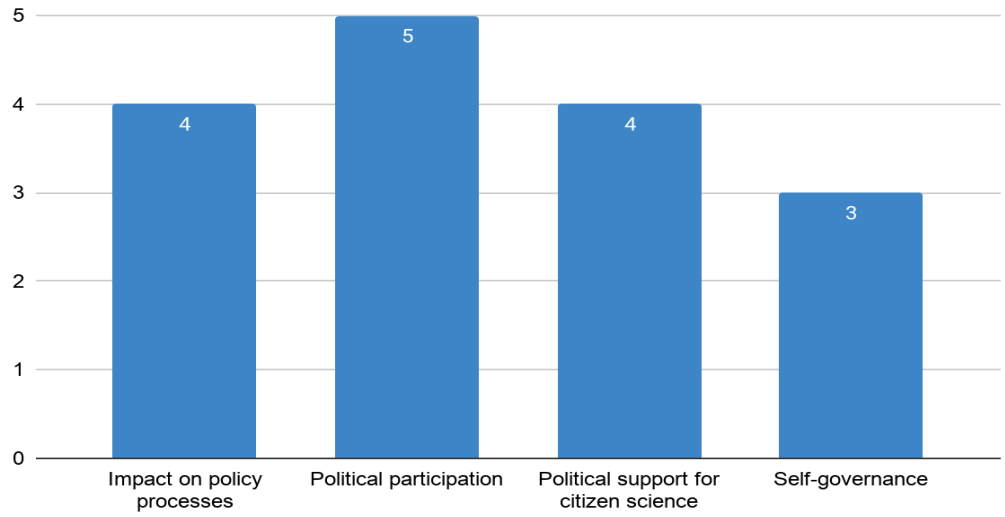


Figure 50: Relevance of political impact dimensions for Sonic Kayaks as described in the canvas

Sonic Kayaks has a potential impact on policy processes. Overall, the political impact is lower compared to the expected political impact (see

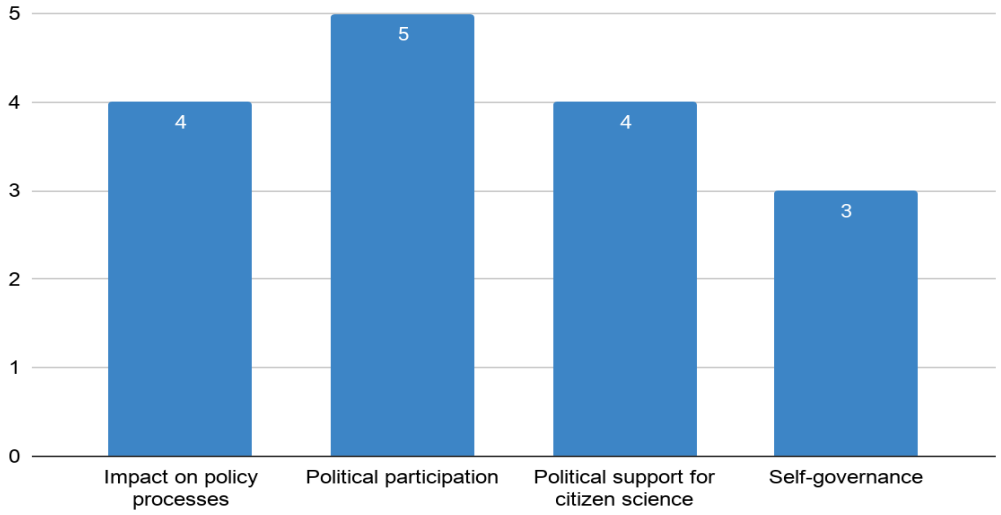


Figure 50). This can be partly explained by the adaptations the project had to undergo due to the pandemic.

Impact on policy processes

The project has a potential lead for impact on policy processes. A connection with the local Cornwall Council has been made through the Helford Marine Conservation Group. This group is interested in using both the data that the project collected and potentially in using the technology on the boats they currently use for surveying. The group's main interest is the interface between recreational

users and the features (wildlife and habitats) of the Special Area of Conservation, and they are specifically working on policy change with local government.

Another way in which the project has an impact on policy processes is in supporting other organisations that are pushing for change. For example, the local activists' group of Extinction Rebellion uses technology and volunteers from the Sonic Kayaks project team for their data collection on air pollution.

4.6.6 Transformative impact

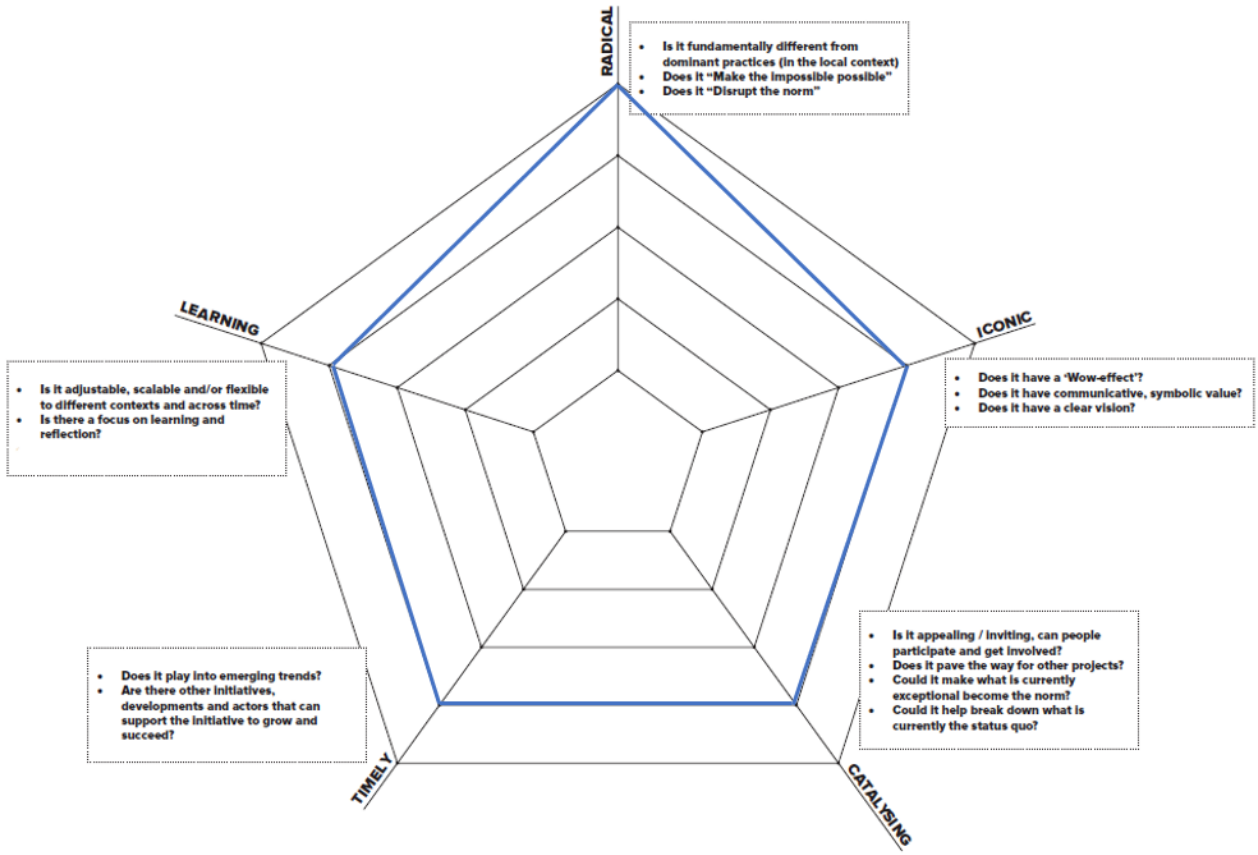


Figure 51:Sonic Kayaks transformative impact accouraging to the CS project manager

Sonic Kayaks has a high transformative potential, with an average score of 4.2 out of 5. The project is **Radical** (5), because it is a very different way of approaching environmental issues. It is **Iconic** (4), in that it has a clear vision and a high wow-effect. It is **Catalysing** (4) because the technology can be used in different settings, even though it is quite complicated technology. The project is **Timely** (4) because it plays into the emerging trend of becoming aware of air pollution and being concerned about it. The project allows for **Learning** (4) in the sense that the technology can be adjusted to be used in different settings (such as the Sonic Bike).

4.7 NoiseMaps

Territorial coverage: Barcelona (Spain)	**Type of pollution considered:** Noise pollution
Relevant SDGs: 3 - Good health and wellbeing, 4 - Quality education, 11 - Sustainable cities and communities	

The Noise Maps project focused on deploying a citizen science process in the neighborhoods of Sagrada Familia and the Raval to address the challenge of noise pollution, a serious problem related to health problems (lack of sleep, psychological ailments, cardiovascular disease, risk of higher stroke) and negative social effects (weakness of social cohesion and coexistence, reduced quality of life, loss of cultural diversity). Noise pollution was an urgent problem in the pilot areas, with active community groups on the lookout for a solution to help improve their living conditions. Indeed, the community can be seen as the project initiator asking support to researchers after a link created by the public administration CS office.

The Noise Maps pilot was deployed for 6 months in the neighborhoods of Sagrada Família and El Raval and developed over three phases. In the Planning phase, representatives of local communities validated the pilot plan. During the Implementation phase, members of the volunteer community became citizen-scientists and learnt to deploy, calibrate and operate their sensors from their home windows and balconies according to scientific standards, as well as to make street-level recordings at local points of interest with portable high-definition sound recorders. And in the Evaluation phase, citizens actively took part in workshops to collectively analyze and make sense of the collected data, generating valid scientific results and public policy recommendations.

Audio recordings were made by citizens who participated in 5 citizen science field workshops. These field workshops, in the shape of ‘sound hunting safaris’, involved street-level collection of sounds at a set of the most representative streets, avenues and squares of the neighborhood, locations which had been selected and agreed upon by the community council of citizen scientists. It is worth mentioning that the first set of workshops were conducted in May 2020, in social conditions of strict confinement, and thus were able to document both areas’ unusual sound signatures at a historic moment. Second, a network of acoustic sensors (Audiomoths) was delivered to citizen science volunteers, who learnt to operate them and installed the sensor that had been given out to their care on the balconies of their suitable private homes to take sound samples from public space.

Right after the end of the final round of pilot sound data sampling in mid-September, a workshop was carried out to analyse the pilot data and co-create the pilot results with Raval volunteers, including the next steps to generate bigger impact and upscale results. Also, the pilot results were shared with public officers and city council services with the aim of feed citizen-generated recommendations into public policy and urban regulations.

4.7.1 Impact areas relevance self-assessment

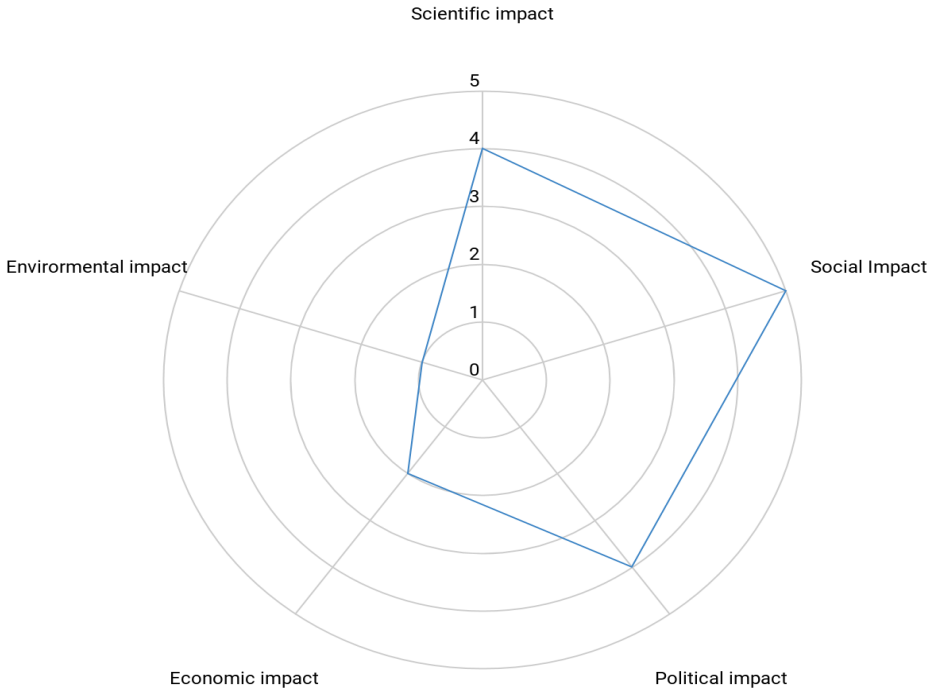


Figure 52: Impact areas relevance self-assessment NoiseMaps as described in the pilot's canvas

As we can see in the graph in Figure 52, the most relevant impact areas for this pilot are the scientific impact, the social impact and the political impact. We'll discuss more in detail the most relevant areas of impact and subdimensions in the next paragraphs.

4.7.2 Scientific impact

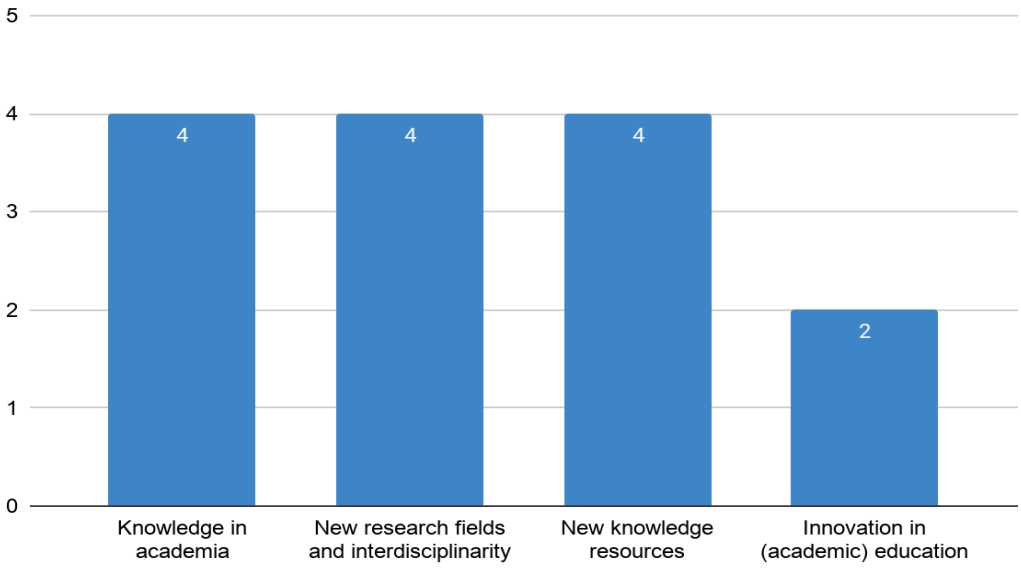


Figure 53: Relvance of scientific impact dimensions for NoiseMaps as described in the canvas

NoiseMaps has had a high scientific impact on knowledge in academia, new research fields and interdisciplinarity, and new knowledge resources. This impact is in line with the expected scientific impact (see Figure 53).

Knowledge in Academia

The project generated a large amount of data, with 1883 rows (and 25 columns). It also published a number of documents with their results, as well as an extensive toolkit with more information on how to carry out a sound documentation and citizen science project - see table X. Furthermore, the project is preparing a scientific article for publication.

Non-scientific publications	**5 (3 maps, 1 toolkit, 1 video)**

Table 5: Number of publications by NoiseMaps

The data quality generated by NoiseMaps is very high, with 5 out of 5 indicators. The procedure for adapting the process of data collection was based on piloting. The tasks for volunteers were initially very challenging. This led the project to adopt two strategies: one group of volunteers followed extensive training, and for another, task processes were automated. Data procedures are systematic: the project put a lot of effort in prototyping the data pipeline, from the point of generation at the audiomot sensor, to the point of the data visualization maps. The equipment used for measurements is standardized and calibrated across volunteers, and the project records relevant metadata.

The **openness of data** scores well: 3,5 out of 5. The dataset is published on Zenodo, and some of the audio files are published. The project did not publish most raw audio files, because there were some problems with privacy. The data visualization is available on the ACTION dataportal. The data of the audio recorded from the balcony are available only through the mathematical representation (open data, not open content). The data is available as machine-readable structure in non-proprietary format, and links to other datasets to provide context.

New research fields and interdisciplinarity

NoiseMaps is strongly interdisciplinary: it combines sound documentation (technical, scientific point of view) with citizen participatory innovation. Furthermore, there is a cultural dimension in documenting the soundscape of the city, the artistic side (soundscape), and city scaping. All in all, the project contains an intersection between urban anthropology, science, citizen participatory innovation, art, urbanism and (co-design) cityscaping.

Furthermore, NoiseMaps even created a new research group: the technology group Music Technology Group at Pompeu Fabra University https://www.upf.edu/web/mtg.

New knowledge resources

The project eases access to traditional and local knowledge resources, by publishing the sound maps about the neighbourhoods - allowing residents to understand their neighborhood in different ways. Furthermore, it facilitated knowledge creation among societal actors and groups by running the co-creation workshops.

NoiseMaps also created new data-gathering tools by making new firmware of the AudioMoth sensor, which allows anybody to generate sound data automatically. This new version of AudioMoth is calibrated in a different way, which improves data quality to such an extent that it is suitable for policy impact - the city council cannot disregard these data.

Innovation in academic or school curricula

No impact is recorded within the accelerator period, but the project will run a number of workshops between January and June 2021 in high school groups.

4.7.3 Social impact

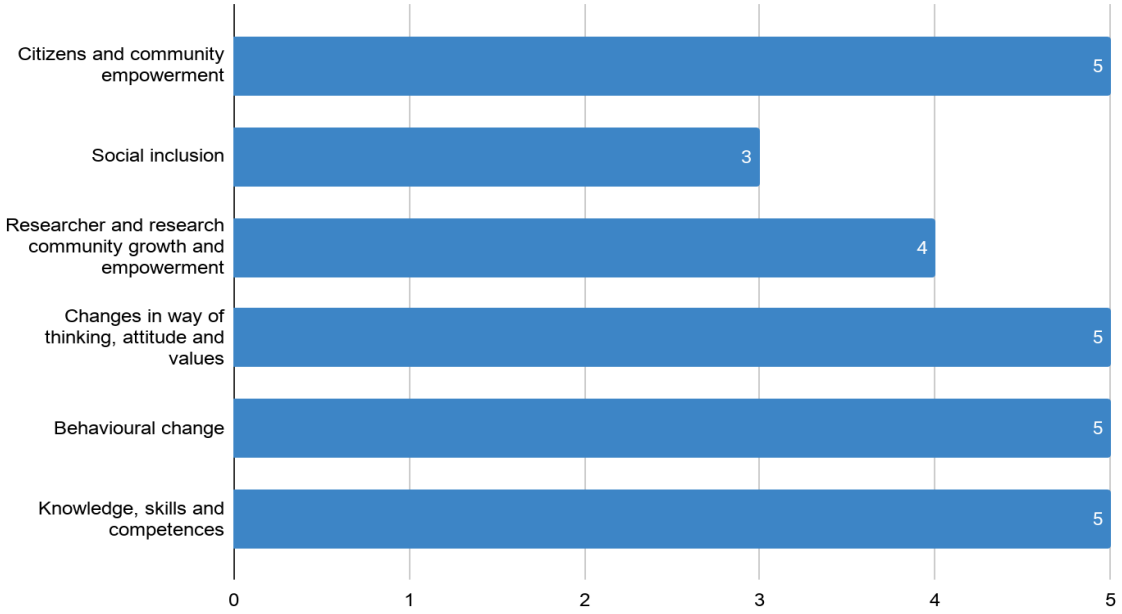


Figure 54: Relevance of social impact dimensions for NoiseMaps as described in the pilot' canvas

Citizen community and empowerment

The project engaged 14 persons in Raval and 6 in Sagrada Familia (two neighborhoods of Barcelona). All of them have been engaged in CS activities, more specifically they were involved in the following activities:

- Develop data gathering instruments;
- Collect Data;
- Pre-process and Curate data;

- Analyse data; Interpret data;
- Share and Communicate results;
- Policy Agenda Setting;
- Community Sustainability.

While 20 people participated in the activities and exchanges with the researchers' team, more people have been involved since Audio Moth has installed households balconies so that, very probably other elements of the families have been interacting with the sensors and contributed to the activities. Beside this, the project reached more people through Twitter (more than 450 followers) and dissemination activities such as the participation to Ars Electronica in which two online workshops were organised by the team.

Initially, the citizen scientists were expected to interact with one another, but, because of Covid-19 restrictions, this was not possible in the way originally planned. They had interactions in the online workshops, and in small groups during a face-to-face workshop held in September 2020. The project's manager reported that the project increased the level of trust among participants even if they were already part of a local association and the project might have attracted more members to it.

Furthermore, the project improved the citizen scientists perceived *self-efficacy*, i.e., the perception of a person to be able to make a difference in a given context. Indeed, at the beginning of the pilot, participants were struggling on how to interact with the local governments in order to improve the situation of their neighborhoods in terms of noise pollution which constituted a real problem for them. They felt frustrated by the situation, but this changed during the pilot. First of all, now they have data, and this puts them in a better position for talking with the decision makers with solid evidence of the situation. At the same time, they appreciated the process and are willing to record more sounds, not only the noise related one but those linked with the immaterial cultural heritage of their neighborhoods that they now appreciate more. As the project manager declared: "*Participating in the whole pilot makes them realize their power to produce knowledge*".

Social inclusion

In terms of participation, two persons with a physical disability were engaged in the project activities. Participants' age is between the late 20s and 60s/70s, with a mixed-gender composition. Most of the people involved are highly educated, and most of the participants were born in Catalunya and are long-term residents of Raval neighborhood, although there were participants that come from Italy and Pakistan. In terms of value orientation, participants mostly have a post-materialistic view, with interest for the environment and sustainability, but there were also people, especially elderly, which were more traditional in terms of value orientation and participated in the project activity for improving their personal and community situation (for example for having back the possibility to sleep at night and to preserve the old Raval from gentrification). The project's manager didn't use a dedicated strategy for social inclusion, but the use of a snowball approach to citizens engagement resulted in quite a mixed group. The pilot planned ad hoc activities and workshops with children, especially from economically disadvantaged and/or migrant families by collaborating with a local association supporting them in after school activities. Unfortunately, the Covid-19 restrictions made these activities impossible.

Knowledge, skills and competences

Participants of the project improved their understanding of scientific processes; indeed, they have been engaged in several steps of such a process and not only in data gathering. They developed skills on the use and understanding of technology and on sound. Moreover, they learned how to interact with public authorities to be heard (see Political impact subsection here after).

Changing in way of thinking, attitudes and values

As mentioned earlier, the majority of participants was already very interested in the topic before the beginning of the activities (indeed the project was initiated by the local community who "engaged the research team"). Nevertheless, the project had an impact on external-to-the-pilot people as participants talked about the activity with families and friends and supported the awareness raising of the community with regards to noise pollution.

Behavioural changes

The project got an impact on participants' behaviours both at an individual and collective level. Individually, they become aware of day-to-day behaviour that can generate sound pollution. Collectively, the project prototypes a new way of engaging people politically. Citizens now have the pipeline to generate quality data, to create and bring evidence to the city council in order to change rules or reflect on the problem. As stated by the project manager: "*Through the gathering of the sound of actual public space we can direct public space social usage*".

4.7.5 Political impact

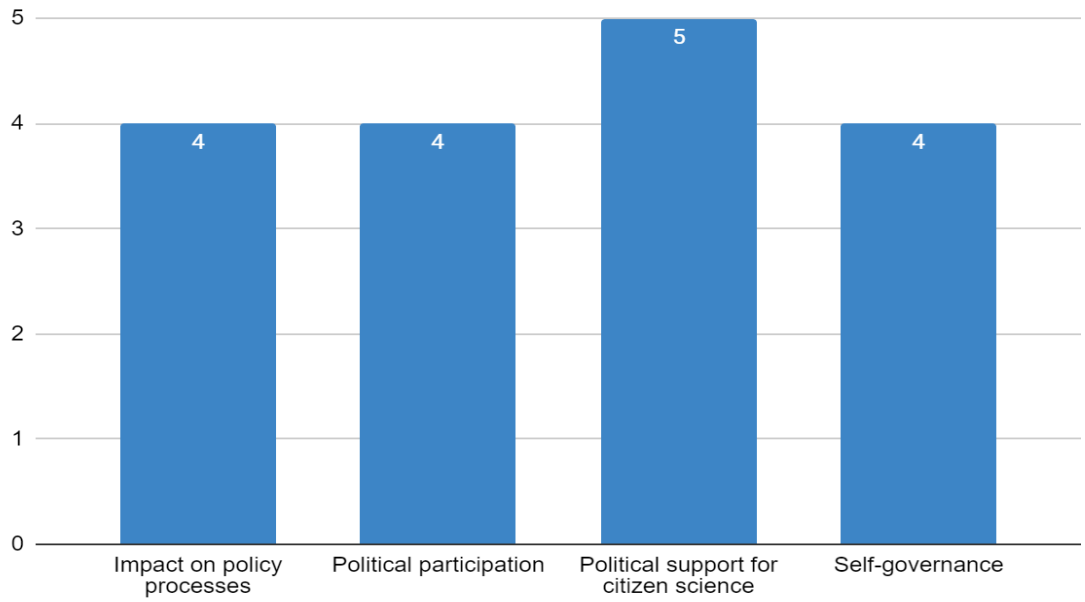


Figure 55: Relevance of political impact dimensions for NoiseMaps as described in the canvas

NoiseMaps has had political impact on all four subdimensions, which is in line with the expectations as described in the canvas (see Figure 55), although the impact on policy processes is still at an early stage.

Impact on policy processes

It is too early to tell whether this project has had an impact on policy processes, although the team already had some meetings with the city council. The team tries to engage with politicians and public officers, but it is difficult to get attention from them during the pandemic.

Citizen empowerment.

There was a community in Raval who had problems with sound pollution. NoiseMaps empowered these citizens with skills: open technology and know-how, in order to be able to collaborate with the city. This empowerment entails changes in their way of thinking, how they approach this problem and also transforms their outlook. It was a contentious relationship, and the community started out very angry. The project was able to build bridges between citizens and the city council and change the attitude of both parties to one of collaboration. The citizens even loved the processes so much that there was willingness to continue the research – they wanted to record noise but also other sounds that they now considered very interesting.

Self governance

NoiseMaps allows citizens to have an evidence based-voice. Although the participating citizens were already quite engaged in politics (they already vote, etc.), the project increased the participant' civic engagement, because they are able to show the evidence of noise pollution.

Political support for CS

The project has received positive feedback from the city council – they are keeping track and are interested. NoiseMaps even became one of the official citizen science projects in the Citizen Science office of Barcelona. The project is a success story that spreads via public administration.

4.7.6 Transformative impact

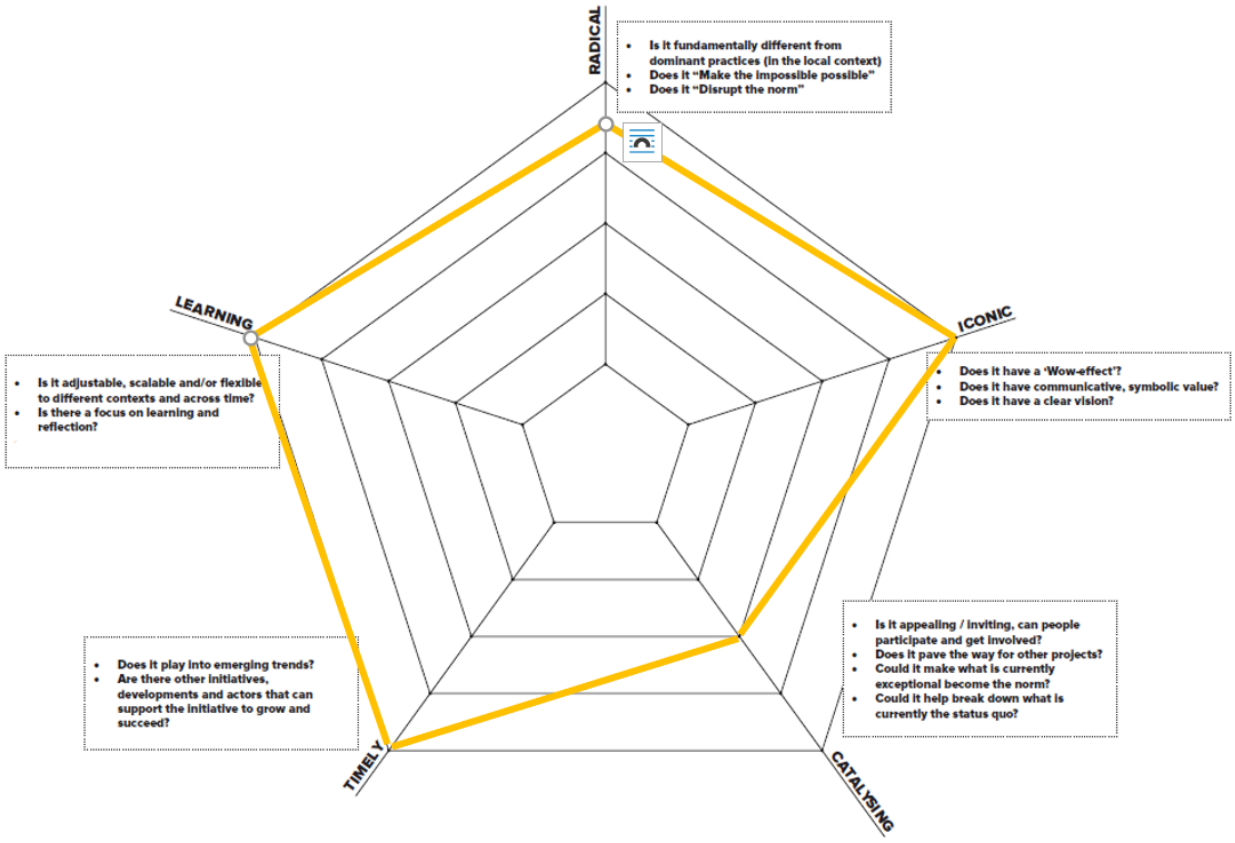


Figure 56:Transformative potential of Noice Map accordingly to project manger

The project has a very high transformative impact, with an average score of 4,5 out of 5. The project is **Radical** (4,5) in the sense that it democratises complex tech, and in that it has the potential to change the way citizens interact with the government. The project is very **Iconic** (5): it is powerful in terms of visualization, as shown by the maps. The project is **Catalysing** (3), but there are also some barriers. It should be democratic for everyone, but currently it is not, because there are barriers for participating. The project is very **Timely** (5), because it aligns with two big trends. First, with the realisation that technology needs to deliver for all, because if it does not, it can lead to bigger gaps between people. Second, there is pushback against gentrification and tourists - the city is not just a playground for global capital. Last, the project scores very high on **Learning** (5). The project is built in a modular way, which means there are a lot of different options on how you want to set up the project. The project can fit in different contexts.

4.8 CitiComPlastic

Territorial coverage: Oslo (Norway)	**Type of pollution considered:** Plastic/bioplastic (Soil)
Relevant SDGs 3 - Good health and wellbeing, 11 - Sustainable cities and communities, 12 - Responsible consumption and production	

CitiComPlastic focused on bioplastic PLA (polylactic acid) waste management engaging volunteers in experimenting with home-scale composters in order to understand how and to what extent it can be properly disposed and how it can be effectively biodegraded. The project was implemented by Nabolagshager, an Oslo-based think tank established in 2013. They work on green and social entrepreneurship projects following a LivingLab approach to promote a shift to sustainable futures and involve as many people as possible in the opportunities around this. The pilot was originally designed to take place in a specific neighborhood of Oslo, a disadvantaged one, characteristic also by a high rate of youths from a migrant background. Unfortunately, due to the Covid-19 related restrictions the project could not carry out the face-to-face activities originally planned and needed for interacting with this community so that citizens scientists have been recruited through a social media campaign.

Citizen scientists were given all the materials they needed for the experiments: PLA tableware and PLA glasses, sugarcane plates and horse manure. In terms of equipment, the citizen scientists received a composter, a compost mixer, a compost thermometer and gloves. After the distribution of materials and equipment, the citizen scientists received instructions for making compost and managing it. Throughout the experiments the citizen scientists collected temperature, visual and smell data. Thanks to the instructions guide, some of the citizens uploaded the data on epicollect 5. Others either published on the project's Facebook page or emailed the pilot manager the data they collected along with pictures. Constant communication and support was offered to citizen scientists by the project team.

4.8.1 Impact areas relevance self-assessment

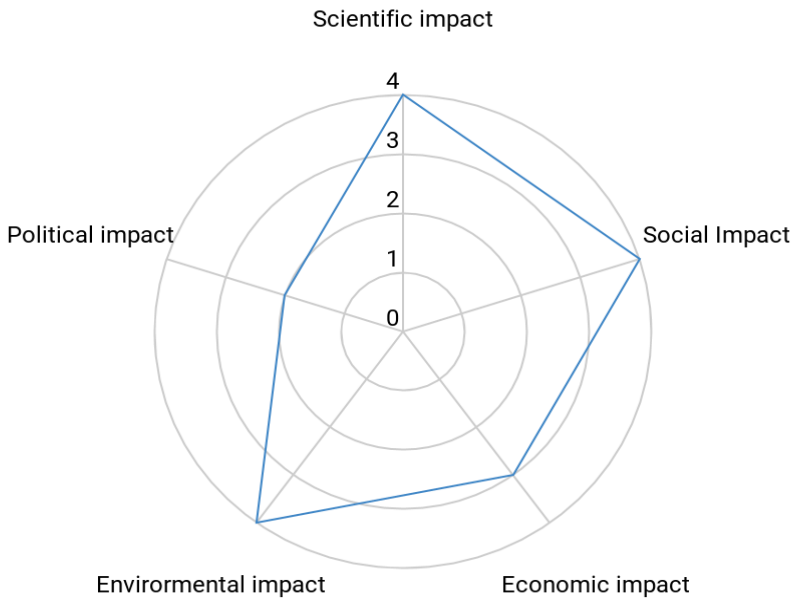


Figure 57: Impact areas relevance self-assessment CitiComPlastic as described in the pilot's canvas

As we can see in the graph in Figure 57, the most relevant impact areas for this pilot are the scientific impact, the social impact and the economic impact. The political impact showed to be relevant as well when engaging with the project managers in the interview. We'll discuss more in detail each impact area in the following subsections.

4.8.2 Scientific impact

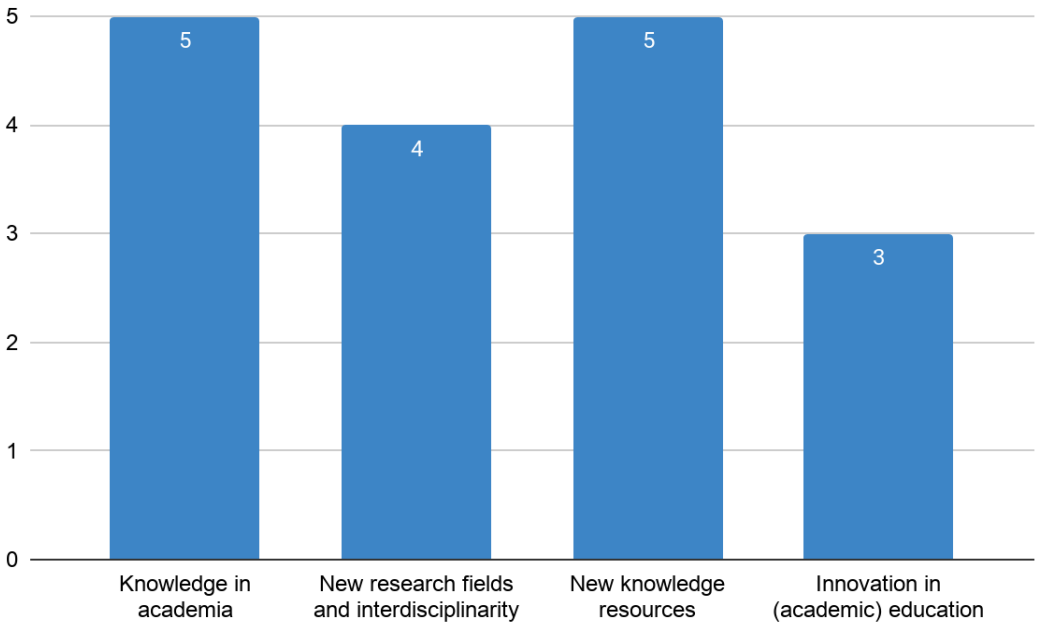


Figure 58: Relevance of scientific impact dimensions for CitiComPlastic as described in the canvas.

CitiComPlastic has scientific impact on the subdimensions: new research fields and interdisciplinarity, and new knowledge resources. Especially for knowledge in academia, this is lower than expected. This can partly be explained by the changes the project had to undergo due to the pandemic.

Knowledge in academia

In this project, 33 datapoints were collected, consisting of temperature measurements and visual observations of how the material was changing in the composters. Some of the data was published on Epicollect and the project also published a video.

The project scores 2 out of 5 on data quality. The tasks for volunteers were easy and they were given clear instructions. Furthermore, the thermometers are of reasonable quality. There was no procedure for adapting the data recording procedure, data entry was not systematic, and no metadata was recorded.

The openness of data scores 2 out of 5. The data are available on Zenodo, with a machine readable structure.

Non-scientific publications	**1 video**

Table 6: Number of publications by CitiComPlastic

New research fields and interdisciplinarity

This project is strongly interdisciplinary: it combines political activism with chemistry and environmental science. Furthermore, it draws on interdisciplinary research methods, targeting the gap between knowing and doing. It is an action-based project by citizens, with an action learning methodology.

A research institution called Nibr (the Norwegian institute of bioeconomy research) is interested in the results, and also in the way the experiment has been set up. This institute is collaborating with the waste management world and they are interested in solving societal problems.

New knowledge resources

Through the project, citizens are more aware of where their waste comes from and where it is going. They now know where and how bioplastic is created and sold and know of the problems in composting it.

3.8.3 Social impact

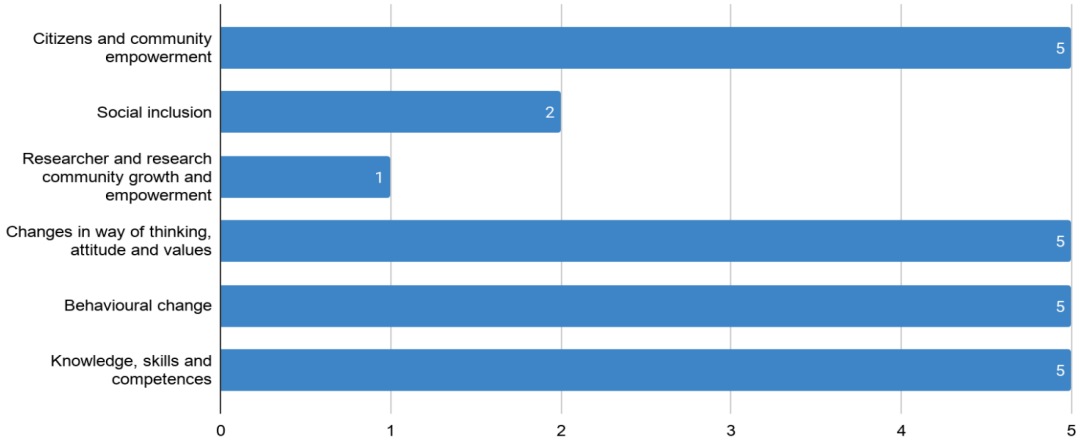


Figure 59: Relevance of social impactdimensions for CitiComPlastic as described in the canvas

The pilot engaged four citizen scientists in the data gathering process with composters, while more people have been reached through awareness raising and dissemination activities. Indeed, the recruitment process was based on a social media campaign on the organisation accounts, especially Facebook which showed 7701 followers and Instagram with 429 followers. 32 people participated in the kickoff event while the final one took place in a local festival with thousands of participants. The pilot also participated in Ars Electronica festival as part of their incubation within ACTION.

Citizens and community empowerment

The need to rethink the pilot due to the Covid-19 situation limited the possibility to work with a local community, but participants built a small community as a result of the project. Indeed, participants increased the number of their social relationships, became friends on Facebook, and they met each other on Zoom. The pilot was also an occasion for the participants to get introduce, by other volunteer, to new persons in the local community. Beside the 4 citizen scientists which were directly connected with the pilot management team, other people participated in the activities as other family members, including children. It is probably that the work around composting becomes a social activity for the engaged families to spend quality time together, especially during the Covid-19 situation. One of the participants was a teacher and shared the activities and related results also with her students.

No direct data were gathered from the volunteers about the empowering aspects of the pilot, but from the pilot manager point of view, they got exposed to opportunities to exercise their agency and do something together on the addressed topic. Some were interested and engaged in this potential aspect of the pilot, while others showed a lower interest in it.

Social inclusion

As mentioned, the original project was planned in an area of Oslo with low socio-economic status compared to the average in Oslo and a high rate of migrants. At the kickoff with this community the majority were women, all migrants, speaking many different languages. They normally do not interact with local social services and the pilot was seen also as a way to better link the community with the

public services. Unfortunately, it was not possible to carry on the pilot within this community due to Covid-19 restrictions to social interactions, but the communication flow with them on this topic remained and at the end of the pilot, results were presented to a diverse, mixed group of citizens from this community. The project team is willing to carry on the activities with this community in the future would opportunities emerge.

The citizen scientists actually engaged in the pilot, recruited online all female, aged 30-40 years old, well-educated and with a medium-high income rate. They are mixed in terms of nationality (two Norwegian, two from other countries); they show a pro-environmental concern and attitude and are already interested in CS and composting. It is interesting to observe that, through online engagement, the difficulties in assuring socio-cultural differences among participants and supporting social inclusion seems to be increased.

Knowledge skills and competencies

Participants showed an increased interest and understanding for composting "science" and practices while their interest and knowledge on the scientific process was already high due to their level of education. On this, one of the volunteers already had some experience. For two of the volunteers that live in a farm, also soil quality was an important topic as they were looking to use the results of the composting for their farming activities. Unfortunately, this was not possible, but all learned a bit more on soil quality. Considering soft skills, volunteers have been involved in interviewees local administrators and waste management experts and this gave them the opportunity to improve their skills in terms of qualitative data collection.

They learned about materials and also got a better understanding of the waste management processes in Norway, discovering that the country is not recycling as much as expected and that waste management could be and need to be improved.

Change in way of thinking, attitudes and values

This is one of the most interesting impacts of the pilot, indeed volunteers changed their opinion on bioplastic and waste management systems. They - as well as the CS project manager - were all thinking waste management was at a high level of quality and professionalisation in Oslo, but this resulted to be less so. As the CS manager reported "*we were shocked about what we learned, we were disoriented and this led to changes*". The main achievement was to support critical thinking on materials among participants and among the persons reached through dissemination activities. They changed the way of reasoning about materials: not considering only the materials that are used for creating them (biomaterials, as in the bio-plastic case), but also on how they can be re-used or recycled after usage.

Behavioral change

What volunteers learned and the difficulties in properly managing bio-plastic lead them to changes in their behaviours, especially in their willingness to inform others about compostability of materials and provide right information on bioplastic. In terms of purchasing behaviours participants changed their habits by bringing recycled plastic instead of bio-plastic, reducing single use plastic and bringing cups and plates from home as much as possible when consuming food and beverage outside.

4.8.4 Economic impact

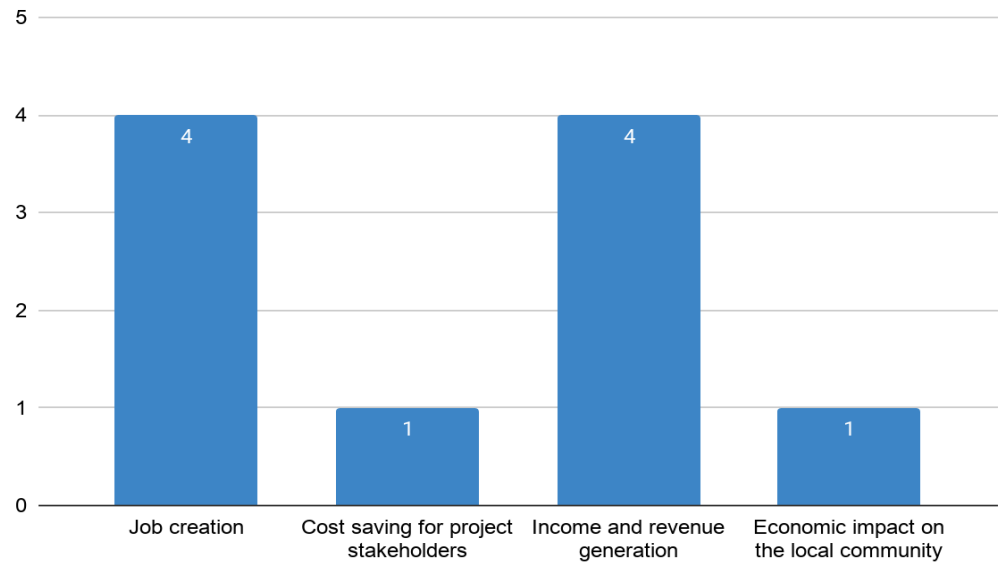


Figure 60: Relevance of economic impact dimensions of CitiComPlastic as described in the canvas

The pilot leading organisation was very interested in developing entrepreneurial and job opportunities around bioplastic management and composting (see Figure 60). For this an initial business model canvas has been developed highlighting costs and benefits and funding opportunities. This option of building a start-up engaging migrant youth as social entrepreneurs is still of interest for the pilot leading organisation that will keep working on this in the future. Now they have a much more close understanding of the related costs and challenges and ways to overcome them and are looking for additional, ad hoc, funding.

Beside this, the pilots connected local organisations that can work together now like a waste management facility and research institute. This link was established thanks to the municipality. This can lead to income generation for them, which - even if not directly linked to the pilot - can represent a positive impact on the local economy.

Finally, the pilot leading organisation acquired new competencies on CS that will be applied to other fields, such as agriculture, for example in the example in the Oslo urban incubator agriculture space in which they are engaged.

4.8.5 Political impact

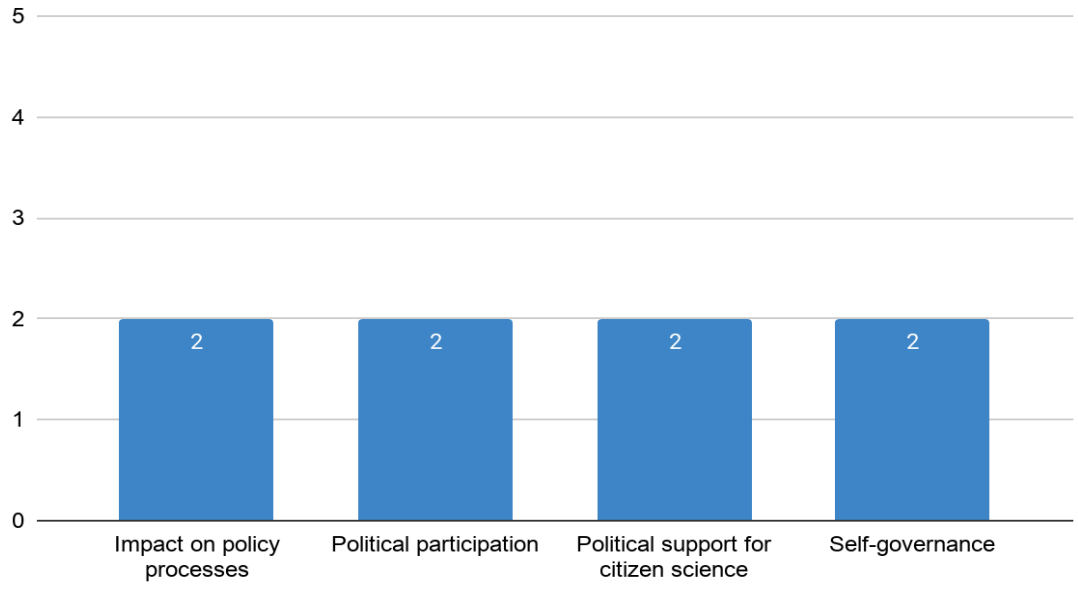


Figure 61: Relevance of political impact dimensions for CitiComPlastic as described in the canvas

While the expected political impact of CitiComPlastic was low (see Figure 61), there is in fact some impact on policy processes.

Impact on policy processes

The core team of CitiComPlastic started up a conversation with the municipality through a couple of meetings with them. They talked to the waste manage department and the city environment department. Through this they became aware that the municipality does not have any plans to deal with bioplastic waste, and it is not a priority to them. The project might have initiated a process at the municipality, because just after these meetings the municipality started issuing articles on the topic of bioplastic.

4.8.6 Transformative impact

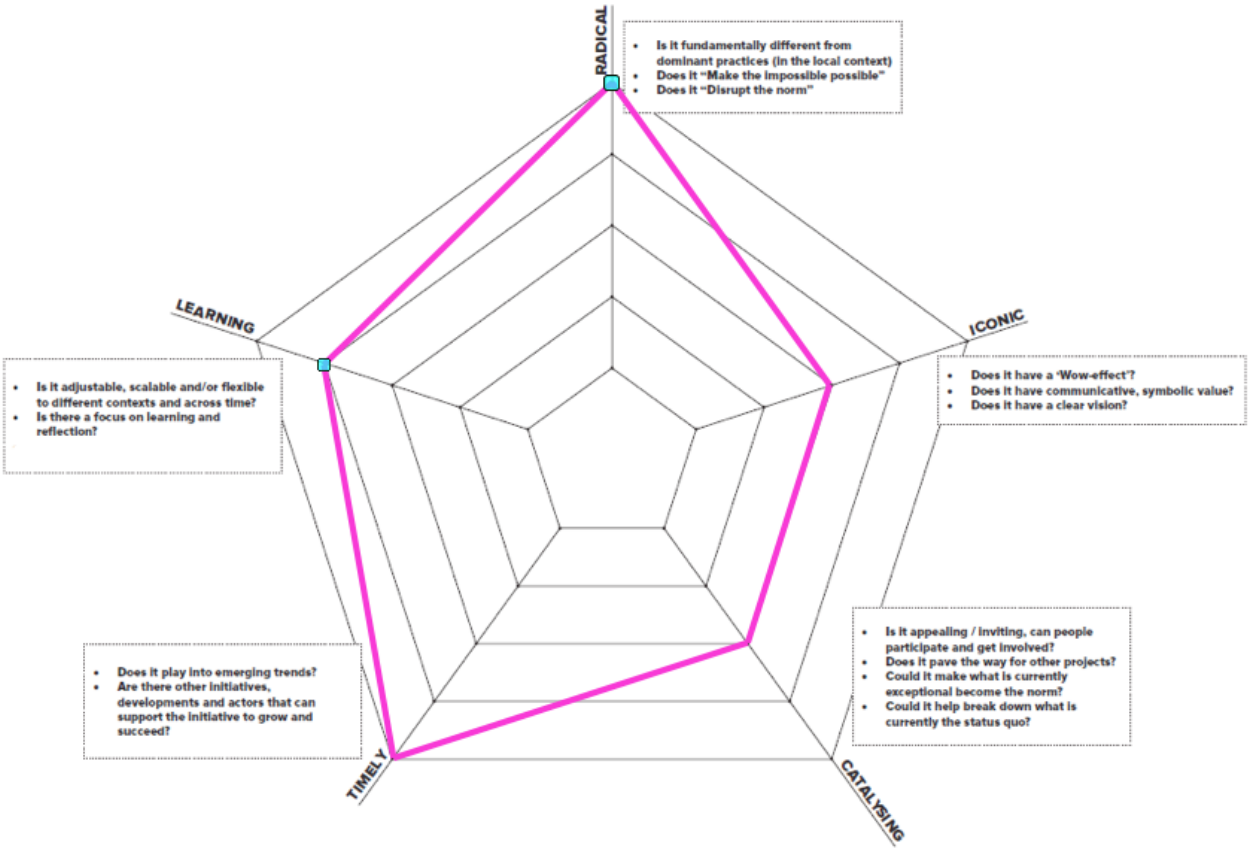


Figure 62: Transformative potential of CitiComPlastic accordingly to project manger

CitiComPlastic has a high transformative impact, with an average score of 4 out of 5. The project is **Radical** (5/5) because it is completely new, unheard of, and intended to disrupt the current practices. It is quite **Iconic** (3/5), though the vision had to be adapted to be realistic. It is quite **Catalysing** (3/5), because the project has the capacity to enable collective engagement and diverse participation since composting can be a collective activity. However due to Covid it is not realistic to have a collective scheme. The project is very **Timely** (5/5) in that it aims to raise awareness and come up with solution strategies for an emerging waste product which is very new in our lives. The project allows for **Learning** (4/5) because the project can be scaled up and carried into different contexts. There are researchers all around the world who are already looking at the same problem in their own contexts, the most potential collaborators, but very little citizen action oriented towards coming up with solutions.

4.9 In my Backyard

Territorial coverage: Esposende region (Portugal)	**Type of pollution considered:** Noise pollution
Relevant SDGs: 2 - Zero hunger, 3 - Good health and wellbeing, 12 - Responsible consumption and production	

The project is implemented by the NGO Rio Neiva in collaboration with the Esposende Environmental Education Centre. The aim was to to understand and map the use of pesticides and fertilizers in the context of home farming and gardening. Simultaneously, it aimed to disseminate information on the topic with the final aim of reducing the use of pesticides and fertilizers.

The pilot area is the Neiva river mouth area, in the municipality of Esposende, Portugal, just within the Northern Littoral Natural Park, working with a community of home farmers and gardeners.

The activities carried out include on-site visits to domestic backyard based on an ethnographic approach coupled with questionnaires, and an online survey. With reference to the on-site visits, project managers were able to see 25 backyards, talk with the owners and discuss with them their gardening practices in detail. The online survey, based on a convenient sample, reached 110 persons and investigated motivation about gardening and the used techniques such as their way of watering, the frequency, the use of pesticides, the use of sustainable practices for detailing with insects and other gardening-related issues and use of composting.

Beside this, 11 dissemination and capacitation meetings with local community members. The meetings provided participants with detailed information on sustainable home gardening practices, including how to create fertilizers in a do-it-by- yourself way.

4.9.1 Impact areas relevance self-assessment

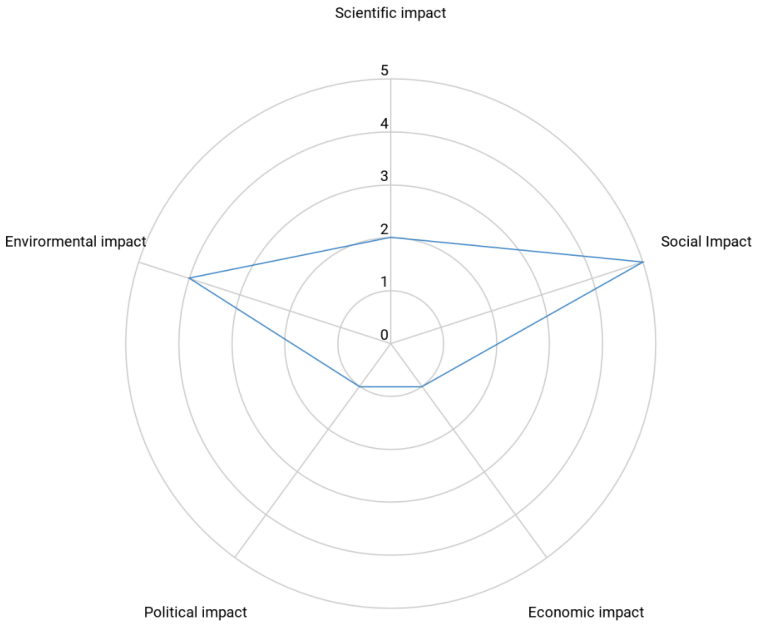


Figure 63: Impact areas relevance self-assessment In My Backyard as described in the pilot's canvas

As we can see in the graph in

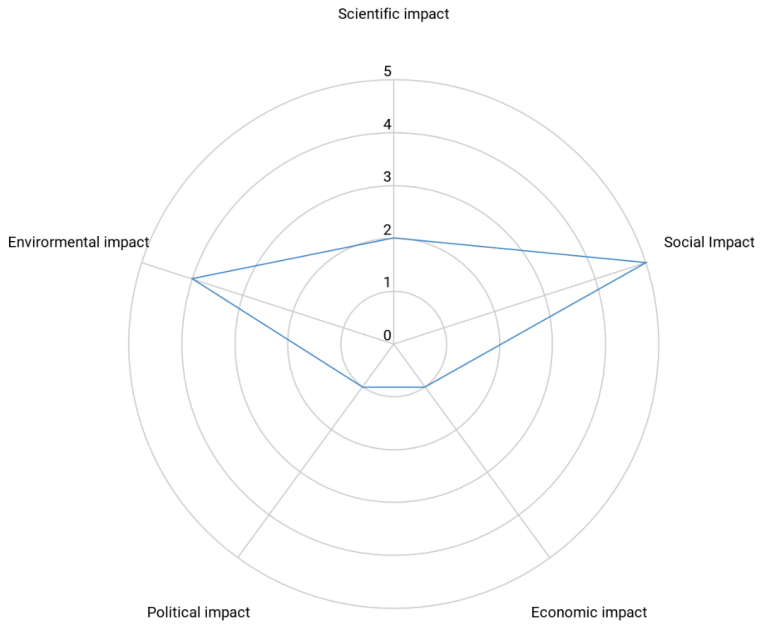


Figure 63, the most relevant impact areas for this pilot are the social impact and the environmental impact, but also the scientific one emerged as important while talking to the project managers during the interview. We'll discuss more in detail each impact area in the following subsections.

4.9.2 Scientific impact

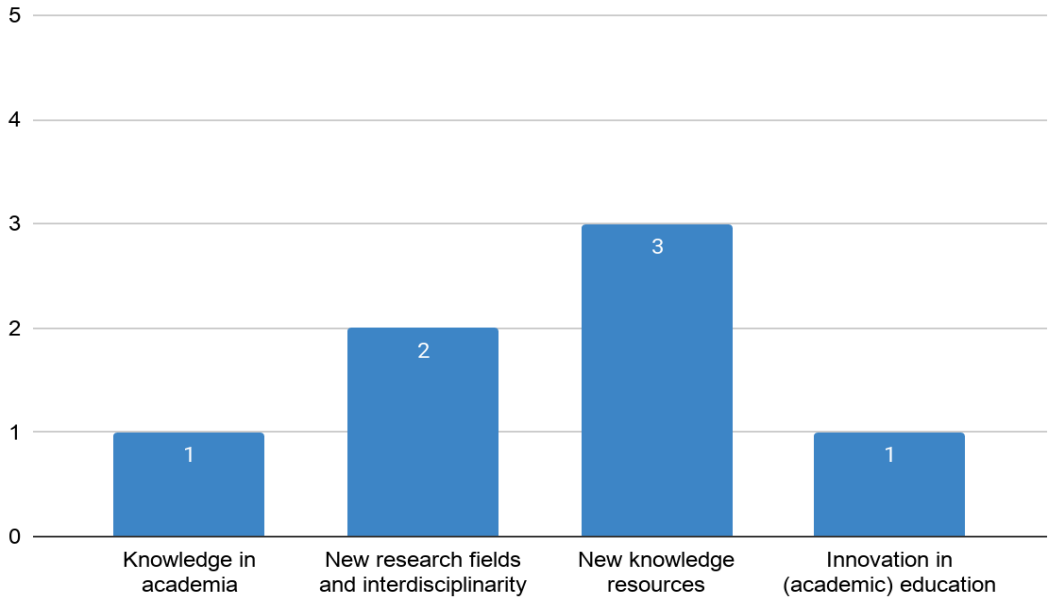


Figure 64:Relevance of scientific impact dimensions for In My Backyard as described in the canvas

In My Backyard has a reasonable scientific impact, with some impact on knowledge in academia and a substantial impact on new knowledge resources. With this, the impact on knowledge in academia was higher than expected, see Figure 64.

Knowledge in Academia

In My Backyard has a reasonable scientific impact, with roughly 6500 datapoints through online surveys (110) and on-site visits (25), and a good number of publications: a scientific report on data analysis, a documentary about their project, and some other non-scientific documents on data analysis and ethnographic analyses from onsite visits. The results are published on Zenodo and the project's website.

Non-scientific publications	**7 (1 documentary, 1 booklet, 1 report, 4 articles on magazines and online portals)**

Table 7:Number of publications by In my Backyard

New knowledge resources

In my backyard eased access to traditional and local knowledge resources in the sense that they enhanced citizen's knowledge about their own backyard practices. The onsite visits are

(unexpectedly) creating awareness on the topic. Also, the team is organising a special workshop on the argument on how to improve backyard practices.

Furthermore, the project facilitated knowledge creation among societal actors and groups. This started from the beginning during a workshop and a dinner, when people started to discuss among themselves what the best practices are for growing food in their backyard.

4.9.3 Social impact

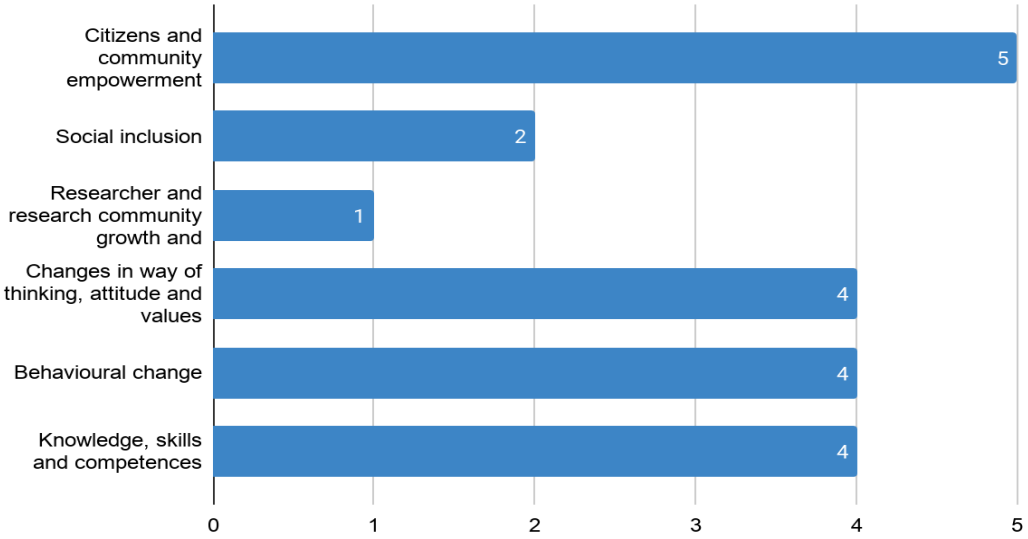


Figure 65:Relevance of social impact dimensions for In My Backyard as in the canvas

Citizens and communities' empowerment

The project engaged 25 families through home visits which implied persons to show their backyards practices, answering a questionnaire and talking with CS project managers. 110 persons have been engaged through an online survey.

More people have been reached through capacitation and dissemination online and face to face events. Indeed, 689 persons participated in the 11 events organised during the pilot period; this includes also the persons engaged in the home visits and the same persons could possibly participate in more than one event. The project attracted the attention of specialized and mainstream media which adds to the persons reached through social media and other dissemination events (European Week of Cities and regions, Citizen Science sustainable development goal conference) for a total of approximately 10.000 people reached.

Some of the participants knew each other already before the beginning of the pilot activities as some belong to local associations. The project didn't have a visible impact on the participants' social capital in terms of increasing the number or the quality of the interactions among participants but the atmosphere of the events has been reported as light and cheerful and the level of trust among participants was probably increased by the interactions and it also increased the trust of participants for the pilot leading organisation.

The pilot supported participants in increasing their self-perceived efficacy by providing them with new information and actionable solutions for sustainable home gardening that they were not aware of before.

Social inclusion

Social inclusion was not considered a relevant impact dimension at the time when the project managers filled in the ACTION impact assessment canvas, nevertheless some data are still worth to be considered. From a cultural point of view the participants are homogeneous, with only very few participants to the events with nationalities different from Portugues. Considering the gender dimension, in the home visits 19/20 out of 25 of persons were female, but they could be representing families with sons and husbands. Also, participants in the online survey show a slightly higher percentage of females (58,2%) on males (41.8%) (see Figure 66)

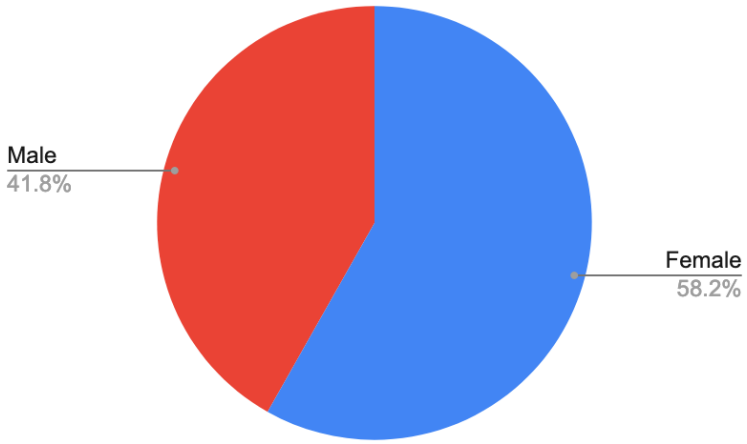


Figure 66: In My Backyard, online survey survey respondents' gender distribution[9]

Considering the participants' education level, as shown in Figure 67, with reference to the respondent to the online survey, the majority have a high level of education (university degree or similar).

[9] The data here reported with reference to In My Backyard online survey are by Rui Monteiro, Rui Pedro Almeida, Rui Coelho, & Clara Roberti. (2020). In My Backyard: Online Survey Responses Raw Dataset [Data set]. Zenodo. http://doi.org/10.5281/zenodo.4081774

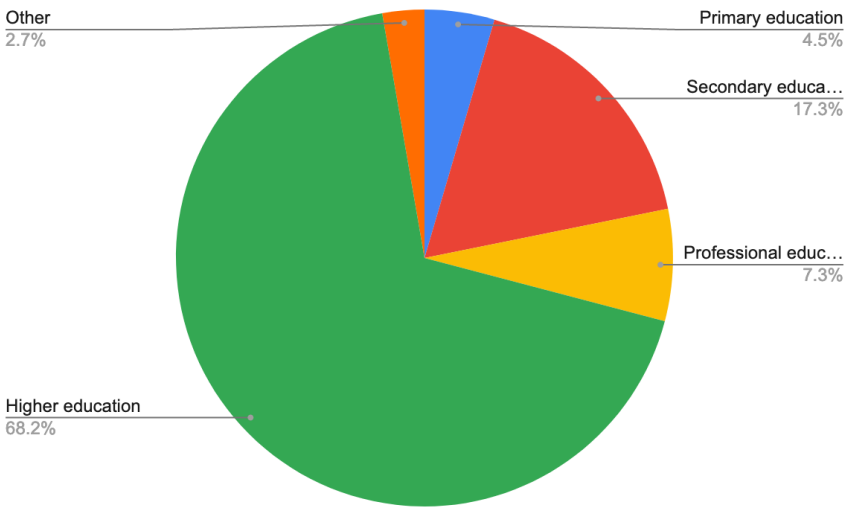


Figure 67: In My Backyard, online survey respondents' level of education

Considering the participants to the home visit, half of the respondents to the related questionnaire report to have a primary education degree, while the other half includes respondents with a secondary education and a higher education degree. However, only half of the persons engaged in the home visit provided information on this topic so these data should be considered as partial.

Knowledge skills and competencies

The workshops organised by the project team were the main occasion for learning and skill acquisition; indeed home visit follows an ethnographic approach aiming at observing the gardening proactive with a free-of-judgement profile. This supported the team in gathering the needed information; adding a "teaching" moment to the home visit would have risk to lose volunteers' trust considering that some of them were already concerned by the possible criticism an environmental NGO could have on their gardening practices.

The pilot team reports two levels of impact: an increment in awareness and understanding for sustainable gardening practices and an increased technical capacity in sustainable pesticide self-production. On the first level it is interesting to report that some of the home visits made evident that people were using harmful chemicals without being aware of the related danger for health and for the environment. In addition, some of them were creating domestic recipes that actually pollute the soil without knowing it.

The pilot increased participants' interest and attention for the environment but did not have an impact on interest for science; scientific thinking indeed was not explicit in the workshop programs, but it was in the background.

Change in way of thinking, attitudes and values

From a point of view of values and orientation, most online respondents were already environmentally conscious, and this is probably due to the fact of using online surveying which engages people already into the topic of environmental impact. For the home site visit, a snowball

sampling approach was used, but direct data gathering on this aspect was not carried out so that it is difficult to describe them from this point of view. The fact that some were worried about showing their practices to the pilot team could indicate that they weren't into environmental protection issues before the pilot, but more in depth analysis would be needed in this regard.

It is reported that most of the participants to the workshop left with new ideas on urban farming and gardening and a different attitude towards pesticides.

Behavioral change

We didn't carry out an ex-ante-ex-post analysis of the gardening practices of engaged families, but the CS managers, considering the interactions had with volunteers, are confident that they were going to adopt more sustainable practices as a result of the pilot.

4.9.4 Political impact

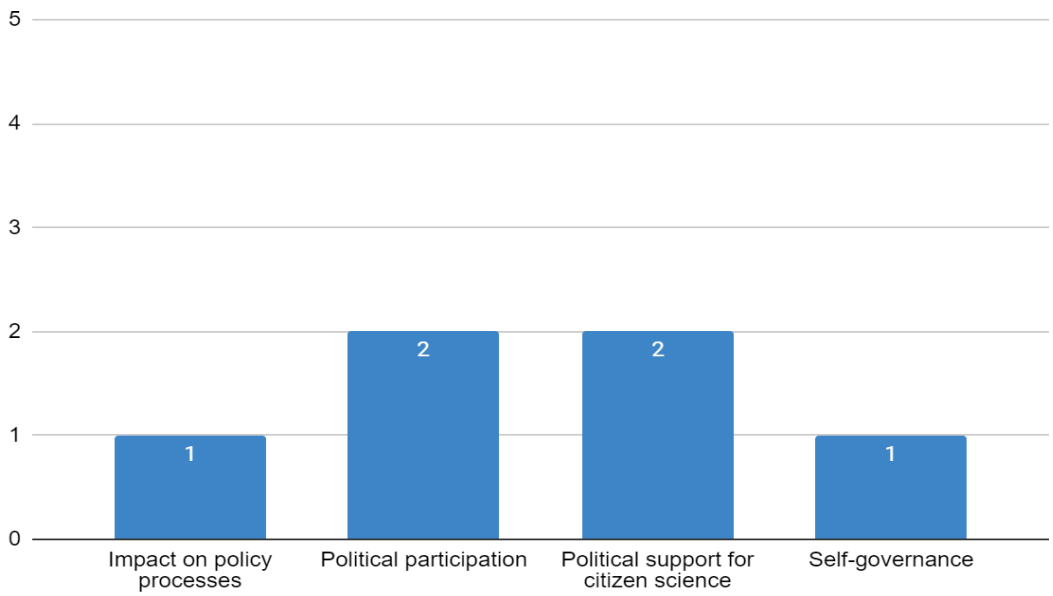


Figure 68: Relevance of political impact dimensions for In My Backyard as described in the canvas

In my Backyard had a positive political impact in terms of impact on policy processes, and political support for citizen science. This is higher than expected (see Figure 68).

Impact on policy processes

The In my backyard team has involved the municipal authority on environmental education as a partner in their project. Before, they never had projects together. The municipal authorities helped to develop the survey, because some data about people's behaviour are critical to them too. As a result, they have begun to change environmental policy in the municipality.

Political support for citizen science

Because of this collaboration, the municipality is now much more aware of citizen science. The team even had a meeting with the major, who now knows what citizen science is.

4.9.5 Transformative impact

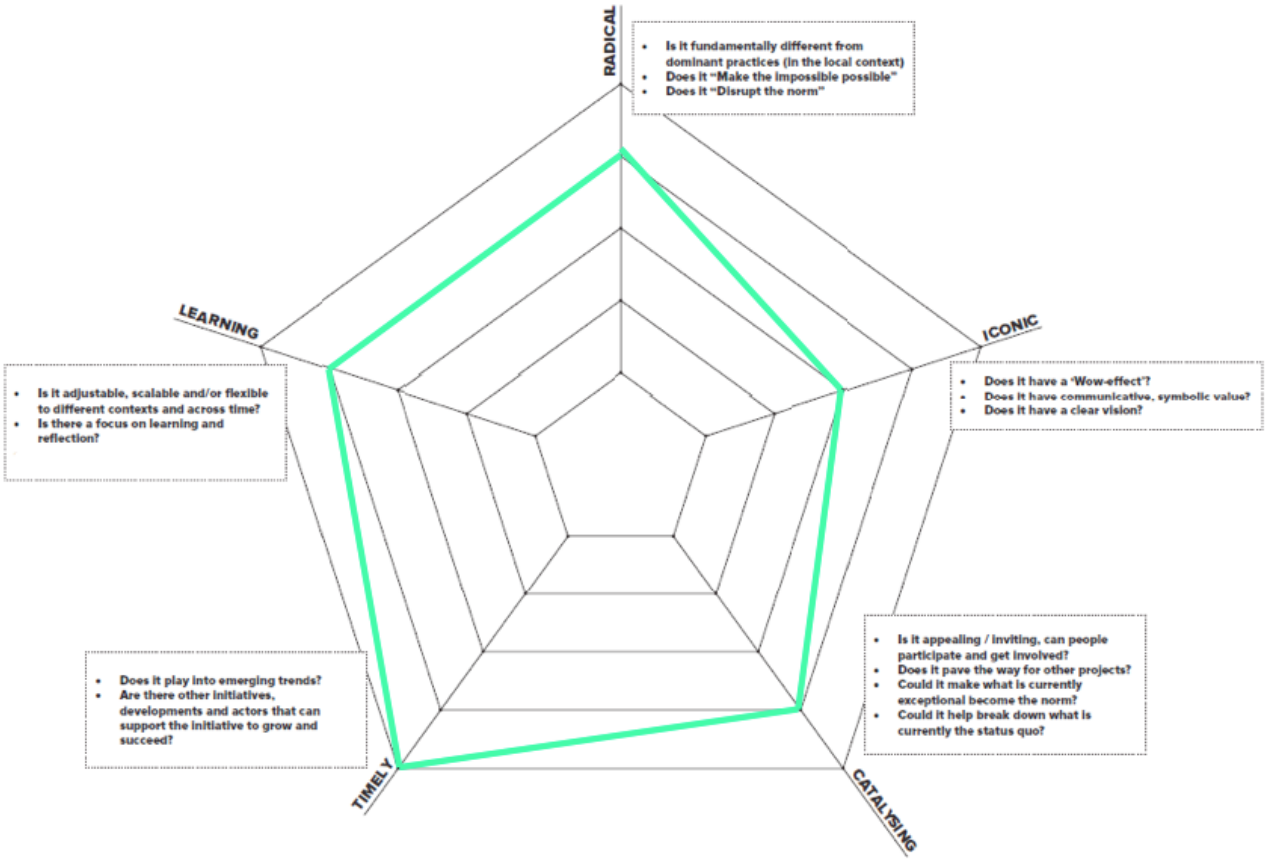


Figure 69: In May Backyard transformative potential from the point of view of project manager

In my backyard has a good transformative potential, with an average score of 4 out of 5. It scores 4 on **Radical**, because it has the potential to change behaviours, which are very different from current practices. The project scores 3 on **Iconic:** although it is difficult to score, everyone involved believes the project is interesting, important, and enjoyable. The project is **Catalysing** (4/5) in the long term. The next steps are to ensure replication in other places in an open way. The project is very **Timely** (5/5), because there is a lot of focus on the environment and on soil at the moment (for example in the European Green Deal). The project allows for **Learning** (4/5), in a way that the core and the principles and the openness can be used in other places.

5 CONCLUSIONS

This deliverable represents the impact assessment of the ACTION projects' activities until M22. The impact assessment is based on the flexible and modular methodology that ACTION developed (see section 2) and used the data gathering tools developed in D6.2 (Passani, Janssen, Hölscher. (2020)). This first impact assessment report contributes to WP6's aims, and more broadly, to ACTION's objectives in the following ways:

- To refine and adjust the impact assessment methodology and data gathering methods in co-creation with project partners, as well as external stakeholders.
- To inform the work to be done in the third year of the project and adapt project activities in order to strengthen the impact achieved thus far.

In this section, we will reflect on both these aspects and make suggestions for further improvements in the upcoming year of the project.

Impact assessment methodology and data gathering methods

From the impact assessment results presented, as well as the feedback received from the projects during the assessment, the methodology works well and responds to the needs of citizen science pilots. The modular and flexible structure makes sure that a diverse range of projects can show their impact, while allowing for some comparisons across projects, while being mindful of time-constraints on the part of the project managers and volunteers. We will therefore continue with our impact assessment work by gathering data from the incoming ACTION accelerator pilots and the ongoing ACTION projects, analyse those data, and aggregate them in the final impact assessment report.

On the data gathering process, we noticed that self-administered questionnaires provided more information, especially quantitative ones. It can be said that it worked better than doing an online interview based on the same questionnaire. The self-reported questionnaire allows project managers to reflect before answering and is less time-consuming for both project managers as well as the impact assessment team. For future activities, we therefore plan to do the following. We first send the canvas for the project managers to fill out, after which we have a short call to make sure that everything was clear, to ask for feedback and for planning the timing of the next data gathering activities. We then send the projects the targeted questionnaire for the project managers (and volunteers, where relevant) to fill out themselves, after which we again have a short call with them for any additional input or feedback.

With regard to the methodology that is based on the five areas of impact, as well as the transformative potential, we believe the scientific, social, and political impact and the transformative potential work very well and are in line with the expectations from citizen science projects, and external stakeholders. For the economic and environmental impact, we need to make some adjustments. For the former, we plan to focus on cost-saving for doing scientific work with volunteers rather than professionals. This should be calculated for those projects for which this is relevant. For the environmental impact, we will test different metrics for one or two of the incoming ACTION accelerator pilots. These metrics should allow us to complement and further specify indirect environmental impact based on behavioural changes and/or policy changes.

ACTION projects' impact

In general, we can say that the impact of the diverse ACTION's projects is well represented in this impact assessment. Furthermore, in most cases the results are aligned with the expected impact. We see that many projects have a strong scientific and/or social impact, a high transformative potential, and promising political impact.

In order to increase scientific impact, we suggest further increasing our training of incoming accelerator pilots on the aspect of data quality. We have seen that this aspect is vital for scientific impact, but also for political impact. While some projects are already very experienced in data quality management, others are less so and we think that this can be increased by continuing the training work as per WP5.

For social impact, we want to increase diversity and social inclusion. Mainly due to the adjustments of the projects during the pandemic, this has been difficult thus far. To increase the impact in this subdimension, we suggest making sure that the project plans of incoming accelerator pilots carefully reflect on how to engage a well diversifies group of citizen scientist also in time on lockdown and carrying on mainly online activities. Furthermore, the training and reciprocal learning in diversity and inclusion issues will be continued in WP2.

We expect to increase political impact by involving the incoming accelerator pilots, as well as the interested first cohort of pilots and the ongoing ACTION projects in policy masterclasses in their country. These masterclasses will be organized in the upcoming year and will increase the visibility of the projects for the relevant policy makers and will make the general policy landscape more receptive to the political impact that the projects want to achieve.

Last, we want to increase transformative potential by letting the incoming accelerator pilots use the transformative impact tool at the beginning of their project (as well as at the end). This will allow them to make changes to their project that increase the transformative potential.

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https://www.threebility.com/sustainability-impact-canvas

Appendix A: ACTION impact assessment canvas

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 • **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?*		**To what category does your CS project belong?** ❑ Action project ❑ Conservation project ❑ Investigation project ❑ Virtual project ❑ Education project

This project is co-financed by the European Union
Grant Agreement No.: 824603

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.*

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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	
Innovation in education	

Social impact	**Value**
Community building and empowerment	
Social inclusion	
Researchers and research community's 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	

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

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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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Appendix B: ACTION's scientific outputs

Peer-reviewed articles
Bara, S., Bonmati-Carrion, M. A., Madrid, J. A., Rol, M. A., & Zamorano, J. (2019). Multispectral estimation of retinal photoreceptoral inputs. *Photonics Letters of Poland*, *11*(3), 60-62. [SS]
Burggraaff, O., Schmidt, N., Zamorano, J., Pauly, K., Pascual, S., Tapia, C., & Snik, F. (2019). Standardized spectral and radiometric calibration of consumer cameras. *Optics express*, *27*(14), 19075-19101. [SS]
Bará, S., Lima, R. C., & Zamorano, J. (2019). Monitoring long-term trends in the anthropogenic night sky brightness. *Sustainability*, *11*(11), 3070. [SS]
Barmentlo, S. H., Vriend, L. M., van Grunsven, R. H., & Vijver, M. G. (2019). Environmental levels of neonicotinoids reduce prey consumption, mobility and emergence of the damselfly Ischnura elegans. *Journal of Applied Ecology*, *56*(8), 2034-2044. [DBC]
Sánchez de Miguel, A., Bará, S., Aubé, M., Cardiel, N., Tapia, C. E., Zamorano, J., & Gaston, K. J. (2019). Evaluating human photoreceptoral inputs from night-time lights using RGB imaging photometry. *Journal of Imaging*, *5*(4), 49. [SS]
Bará, S., Aubé, M., Barentine, J., & Zamorano, J. (2020). Magnitude to luminance conversions and visual brightness of the night sky. *Monthly Notices of the Royal Astronomical Society*, *493*(2), 2429-2437. [SS]
Reeves, N. T., & Simperl, E. (2019). Efficient, but Effective? Volunteer Engagement in Short-term Virtual Citizen Science Projects. *Proceedings of the ACM on Human-Computer Interaction*, *3*(CSCW), 1-35. [KCL]
Celino, I., & Calegari, G. R. (2020). Submitting surveys via a conversational interface: An evaluation of user acceptance and approach effectiveness. *International Journal of Human-Computer Studies*, *139*, 102410. [Cefriel]
Celino, I. (2020). Who is this Explanation for? Human Intelligence and Knowledge Graphs for eXplainable AI. *arXiv preprint arXiv:2005.13275*. [Cefriel]
Non peer-reviewed articles
"Street Spectra" Lucía García, Jaime Zamorano, Rafael González, Oscar Corcho, José Gómez, Cristobal García, et al eALAN 2020, online 16 Jun (2020) [SS]
"Street Spectra: Ciencia Ciudadana para caracterizar farolas" (poster) Jaime Zamorano, Rafael González, Carlos tapia, Cristobal García et al II Congreso ProAm de la Sociedad Española de Astronomía. Huesca Dic 6-8 (2019) [SS]
Lucía García, Jaime Zamorano & Rafael González "Street Spectra teaching materials" [SS]
Jaime Zamorano, Rafael González, Carlos Tapia

"Street Spectra tutorial: to identify spectra of common lamps" [SS]
Webpage: Color visualization of street lamps spectra (on line) [SS]
Non-scientific publications
Action Lab - Schools and the science of air pollution - Workshop during Ars Electronica [AQ]
Blog post.Pilot initiative at ActiON [SS]
Blog post. Tutorial at AAM [SS]
Blog post. II Encontro da noite [SS]
Blog post. Workshop at ASAAF [SS]
Blog post. Poster presented at SEA [SS]
Blog post. Updates on Street Spectra for ActiON [SS]
Blog post. Sevilla at night [SS]
Blog post. Teaching light pollution through citizen science [SS]
Blog post. Street Spectra project launched in Spain [SS]
Blog post. Street Spectra presented at Sociedad Española de Astronomía [SS]
Blog post. We are proud to announce the launch of Street Spectra new website [SS]
Blog post. 7 projects on light pollution [SS]
Video. Ars Electronica, the Festival for Art, Technology and Society [SS]
Action Lab - Tired Moths and Quiet Stars - workshop during Ars Electronica [TS]
Action Lab - Loss of the Night - workshop during Ars Electronica [LN]
Sonic Kayaks - Raspberry Pie magazine [SK]
Instructions for building the system - GitHub [SK]
Video. Sonic Kayakss - citizen science in the marine environment for the ACTION project [SK]
Blog Post. Sonic Kayaks update - new sensors, sonifications, and visualisations [SK]
Blog Post. Sonic Kayaks environmental data sonification [SK]
“No Meu Quintal” – o projeto que quer conhecer o quintal dos portugueses - Greensavers [ImB]
No Teu no Meu no nosso quintal! - Aspea [ImB]
“NO MEU QUINTAL” QUER TORNAR TODOS OS QUINTAIS MAIS VERDES E ECOLÓGICOS - Ambiente magazine [ImB]
“No Meu Quintal”, o novo projeto de ciência cidadã - Lisbon European Green capital [ImB]