NEWSERA
#CITSCI IS THE NEW #SCICOMM

NEWSERA - Citizen Science as the new paradigm for Science Communication

Deliverable 2.2

Report on indicators for impact assessment of science communication in Citizen Science Projects

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SUMMARY

Assessing impact is a growingly urgent need for scientific research. Within the newly established Horizon Europe program, citizen active participation, engagement and co-creation will become pivotal and thus proper impact assessment needs to be addressed. In this setting, Citizen Science (CS) arises as a fundamental tool for widening participation and contributing to reach social, economical, scientific and political impacts. However, different challenges have been described for CS impact assessment tools that impede a proper evaluation of communication actions. NEWSERA project tries to address current limitations from a different angle, by interpreting CS as part of the communication process.

NEWSERA will thus analyse and evaluate the complex and multidirectional science communication strategies, including digital and non-digital ones, addressed to quadruple helix stakeholders in citizen science projects across Europe as the new paradigm for science communication (#CitSciComm).

Our hypothesis relies on improving the science communication of citizen science projects, by co-designing *ad hoc* #CitSciComm tools and strategies with engaged stakeholders, during our "Citizen Science Communication Labs" (#CitSciComm Labs), while validating the concepts of **Citizen Science Communication** and **Citizen Science Journalism**. Reaching broader target audiences will allow at the same time to increase the expected outcomes and impacts of the CS projects themselves, while providing a greater compliance of the Responsible Research and Innovation (RRI) pillars, i.e. science education, ethics, open access, gender, public participation and governance.

This deliverable thus aims at setting up a **multi-level impact assessment framework**, as the NEWSERA method, considering the impact assessment under three packages: Science Communication Actions ("NEWSERA Impact Assessment Package"), the assessment of CS on different dimensions ("ACTION Impact Assessment Package"), and the Responsible Research and Innovation (RRI) pillars ("RRI Impact Assessment Package"), for the analysis and evaluation of communication tools and co-designed strategies by CS projects, in an iterative process.

Indicators development, implementation and testing is part of the NEWSERA consortium work. In close collaboration with Work Package 5 (WP5) "Evaluation and impact assessment: the legacy of NEWSERA", we will quantify indicators throughout an iterative analytical process for the assessment on the basis of current recognition, informed by the literature review and on the theoretical and methodological consideration developed hereby.

This report is presented in the following order: first, a literature review on impact assessment in science communication and challenges when assessing citizen science projects; second, a succinct explanation of the proposed NEWSERA methodology considering multi-level dimensions; and third, the description of indicators selection and implementation.

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1. Introduction

The Work Package 2 "Analysis of Citizen Science as a Science Communication Tool" (from now onwards WP2) has been conceived within the NEWSERA Project to contribute to several tasks. First, it serves to take stock of existing science communication strategies in citizen science initiatives to provide a solid empirical as well as conceptual basis on the **current state-of-the-art of Citizen Science (CS)** projects, including the identification of their current practices in science communication and the exploration of key areas to be included in the impact assessment of Citizen Science communication. Accordingly, WP2 is composed of three main steps:

- defining the state of the art of science communication in citizen science projects;
- selecting some indicators useful for the evaluation of the quality and the effectiveness of science communication in citizen science projects and its influence on the perception of science;
- grasping the barriers that prevent the quality and effectiveness of science communication with quadruple helix stakeholders.

Within the newly established Horizon Europe program, citizen active participation, engagement and co-creation will become pivotal and thus proper impact assessment needs to be addressed (EC 2021). In this setting, Citizen Science (CS) arises as a fundamental tool for widening participation and contributing to reach social, economical, scientific and political impacts.

However, different challenges have been described for CS impact assessment tools that impede a proper evaluation of communication actions. **NEWSERA project tries to address the current limitations from a different angle, by interpreting CS as part of the communication process.**

NEWSERA will analyse the new communication channels and digitalization effects in science communication through citizen science projects in order to set priorities and indicators using a **holistic approach**, taking care not just of the **effectiveness** and quantity of the sender information but the **perception** of the information on the receivers, in terms of their feelings, trust, and interest.

Analysis of effectiveness aspects (including quantity) will be defined and classified by relevant importance, to determine the best effectiveness indicators to evaluate science communication strategies, tools and channels. **Analysis of perception aspects,** including variables such as social environment, territorial context, socio-economic status, socio-cultural profiles, gender mainstreaming, or age, will be defined to determine the best perception indicators to evaluate science communication in a highly inclusive manner.

The combination of the different aspects will pave the way to the definition of Science Communication Indicators for reliability and effectiveness. The **indicators** will be used to evaluate the state of the art of science communication and the benefits, in terms of increased impact, wider audiences reach, and trust, of the proposed innovative strategies to **improve the effectiveness** of science communication addressed and from **quadruple helix stakeholders** in CS projects. Contribution by the receivers (citizens) in the communication will allow to empower citizens and enhance accountability allowing debate and promoting participation.

In this report, a **multi-level impact assessment framework** is defined, as the **NEWSERA method**, considering the impact assessment under three packages: Science Communication Actions ("NEWSERA Impact Assessment Package"), the assessment of CS on different dimensions ("ACTION Impact Assessment Package"), and the Responsible Research and Innovation (RRI) pillars ("RRI Impact Assessment Package"), for the analysis and evaluation of communication tools and co-designed strategies within CS projects, in an **iterative process**. The final objective of the multi-level framework is to demonstrate how increasing the efficiency of science communication in CS projects increases, at the same time, the overall expected outcomes and impacts of the projects, while allowing to better comply with the RRI dimensions.

Moreover, we will address the issues connected to impact assessment and the construction of indicators, starting with a review of the different areas that entails the main issues related, thereafter proposing our own strategy in order to overcome them.

1.1 Impact assessment: a matter of discontent

Assessing impact is a growingly urgent issue for scientific research. In EU research funding schemes the issue emerged already in the past years but, currently, with the Horizon Europe framework program, impact is something that becomes even more relevant (EC 2018; 2021). While already within FP7 and H2020 programs, applicants needed to provide some detailed description of the impact projects envisage to achieve, also defining some tools for effective assessment of the impact, strategy to obtain and, moreover, measuring impact saw its relevance grow. Indeed, in the forthcoming EU Horizon Europe framework, impact assessment becomes pivotal in the form of "impact pathways" in the short, medium and longer term.

A further element that emerges according to the presentation of the new framework for EU research is a **lesson learned from H2020**: citizens need to be engaged actively and this further becomes a specific issue to be assessed. In such a landscape, CS projects are definitely part of such a challenge. As many agree, CS configures a way to perform scientific research that goes beyond top down enrollment into scientific research - at least potentially (Haklay 2015; Strasser *et al.*, 2020). Indeed, as an approach towards engagement and inclusiveness, CS promises to keep these within the scientific knowledge production process, thus promoting an effective Open Science.

Assessing projects and the impacts they may have in this regard is of paramount importance. The same applies to the potential of CS projects to inform public policies (EC 2018; Manzoni-Brusati *et al.*, 2019; EC SWD 149 final, 2020) and to boost social innovation in a broad sense. However, while giving account of project impact is a more and more requested task to be performed, it is not easy to assess its outcomes. To give some sketchy examples, recruitment campaigns by Citizen Science projects do not always assure a proper enlargement of participation, nor a public engagement able to fulfill the purposes of Open Science. Indeed, inclusiveness does not always come out, despite the nominal efforts by projects and connected activities (Felt and Fochler, 2010).

Similarly, it is **not yet confirmed** that CS projects **can universally contribute** to **increase scientific literacy**; first, because not all the projects consider it as an aim (Bonney *et al.*, 2016); for instance, many projects asks volunteers to contribute with data collection (Hecker, Garbe and Bonn, 2018) and if people are not taking part to activities beyond mere data collection they might not gain significant experience (Phillips *et al.*, 2019); second, because it is not easy to proof long-term effectiveness of a CS activity, especially if there is not a specific planning of engagement for local communities aimed at keeping participation (Id.); third, as already mentioned, participants that are more likely to volunteer in CS projects may already have higher education and training in science compared to others (Martin, 2017).

Most of **these issues can be retrieved even in science communication:** when addressing the effects of science communication as a proper bidirectional relationship between science and society often we see the same problems arise. Effective engagement is not an easy task to be solved and some impact assessment tools are not tailored to give account of who is effectively engaged. The same applies to the issues of science literacy improvement, to the contribution to innovation trajectories or to informing policy making.

The NEWSERA project combines the aforementioned issues introducing a different angle in the debate; indeed the consortium is committed to interpreting CS as part of a communication process, and thus proposed **CS as the new paradigm of science communication (#CitSciComm)**.

With the aim of opening up science and innovation broadly to society, **innovative strategies will be co-designed** for specific stakeholders groups in our **"Citizen Science Communication Labs"** to improve their science communication strategies proposing innovative ways to open up science and innovation **to key stakeholders** as defined by the quadruplex helix innovation model (that includes society at large, academic scientists, industry and SMEs, and policy makers), and increase trust in science communication and, thus, in science at large.

The strategies will be analyzed in terms of effectiveness within the interactions between the **quadruple helix stakeholder engagement model**, going beyond interactions between scientists and other R&I stakeholders, the media and the public. The Labs will allow co-designing, experimenting and evaluating the **concepts of Citizen Science Communication** and **Citizen Science Journalism**, by challenging the interlinks between science communication, citizen science and data journalism.

Coherently, all the activities planned by NEWSERA define the **development of a framework for understanding CS in communicative terms**. This is just the beginning of a journey aimed at promoting CS as a communication action, #CitSciComm, and to define coherent assessment tools to estimate the impact of strategies deployed by CS projects. NEWSERA will further contribute to its replicability by providing **#CitSciComm blueprints** addressed to each specific category of stakeholders, as defined by the quadruple helix innovation model plus **data journalists**, a community with which a mutual win relationship is being established to build stories of the interest of society from **citizen generated data**.

1.2 What is the deliverable about

The current report aims at setting up the **framework for the analysis and evaluation of communication tools and strategies as deployed by CS projects**. More precisely in the following pages we will review **key areas** to be taken into account for the **development of a brand new multi-level impact assessment framework, the NEWSERA method.** Therefore, the focus here is on communicative actions as deployed by CS projects being part of a broader communication strategy. Although the NEWSERA project can already count on the experience of the different partners in analyzing communication strategies and their outputs, the challenge of what we call #CitSciComm (Citizen Science Communication) requires a dedicated path. If from the side of CS there is a push to the deployment of science communication tools, conversely, as science communication scholars highlighted, models of engagement for the public have been proven to be often unsatisfactory.

The NEWSERA's idea addresses exactly these limits: carrying out CS initiatives in the framework of fostering an improved and effective participation in science communication. In this way, NEWSERA aims at bringing #CitSciComm into the debate of CS, specifically providing blueprints from which to extract lessons and guidelines to be further applied in future projects and ensure replicability. These are the outcomes of a co-creation process (see D3.1 Description of #CitSciComm Labs) that gathers 38 CS projects as pilots, engaged quadruple helix stakeholders (society at large, academic scientists, industry and SMEs, and policy makers, according to Carayannis and Campbell, 2009), communication experts, data journalists and the NEWSERA team members. The aim is to **co-create innovative *ad hoc* communication strategies** and to **co-develop appropriate tools for assessing** them. NEWSERA envisages an **iterative process** for the assessment: this deliverable presents the starting point of such a process contributing to setting up the **baselines of impact assessment** for #CitSciComm strategies.

Accordingly, the deliverable develops as follows:

- section 2, summarises the two branches of literature from which the developing framework of #CitSciComm is based on, such as the impact assessment of Science Communication and the assessment of CS on different dimensions and most specifically on engagement and scientific literacy;

- based on this recognition, section 3 illustrates the NEWSERA method, integrating previous experience on CS, in connection with Responsible Research and Innovation (RRI) pillars, introducing the distinction between quantitative and qualitative indicators and the focus on outputs and outcomes of specific activities;
- section 4 defines the NEWSERA approach for selecting and implementing combinable impact assessment packages according to the needs of a project. In line with the experience and outcomes of the ACTION, MoRRI and Super-MoRRI H2020 Projects, NEWSERA follows the approach of tailoring impact assessment packages (to be considered as combinable bundles of indicators) according to the overall objectives, key stakeholders, expected outcomes and impacts of a single CS project.
- Finally, in section 5, the Conclusion will resume the main take-home messages from this review as the baselines for subsequent co-creation and assessment phases of the project to be developed within WP5.

2. Literature review and related works

This section addresses the issues connected to impact assessment and the construction of indicators. We configured this section as a review of the different areas that entail the main issues of impact assessment. The structure of such a review considers the two branches NEWSERA wants to combine, such as Science Communication and Citizen Science. As it can be read in the subsequent pages, the two branches share many issues and often look for the same kind of tools.

In a landscape that sees the rigid separation between professional scientists and the public becoming less certain than in the past, as well as less desirable, the European policy perspective on scientific research confirms its interest for Responsible Research and Innovation (RRI). Indeed, it further develops its **growing interest for citizen involvement, engagement in R&I processes and co-creation** (EC 2021). Public consultation and public participation well fit the idea of Open Science, supporting the right to take part in the scientific research and innovation processes.

In this regard, **CS and Science Communication have several points in common**. They share the intention to pursue larger engagement and an increase in scientific literacy as a way to democratize the scientific knowledge production process as a tool for a more equal society. As such, we are referring to a series of activities that both CS and Science Communication pursue: dissemination of knowledge, promotion and exchange of data and knowledge, the sharing of perspectives on societal challenges and possible solutions to be put in place.

CS and Science Communication share objectives as well as challenges about assessment that require to be known and conversely addressed. The review in the following sections collects themes addressed for the assessment of science communication efforts and CS. Being these transversal and common, they offer a valid starting point for the development of a framework from which NEWSERA developed its original methodological approach for the #CitSciComm impact assessment.

2.1 Impact assessment in Science Communication

Impact assessment in Science Communication may address several dimensions related to the effectiveness of a specific communication campaign or a public initiative promoted by a research center or a public institution, as well as individual research efforts. Literature on the assessment of Science Communication originally concentrated mainly on the literacy and the connected improvements of the audience exposed to some scientific related contents. This view **echoes the so-called deficit model**, according to which, scientists should concentrate in presenting their results in order to inform and educate the public (Bodmer, 1987).

Such approach suffers from some criticisms since it **reduces the role of citizens** mainly as an audience to be reached for a **one-way science communication**; furthermore, the effects of science communication typically are conceived in terms of audience knowledge about a given topic. Indeed, as put by Jones (2011) “It may be that increased public understanding of science will lead to a more prosperous country with a healthier relationship to science and technology, but this is a long-term project. In the meantime, it has been crisis management that has caused some of the most urgent thinking about science communication” (p.2).

In that sense, knowledge and skills are to be measured in order to assess the level of literacy. This perspective did not disappear in the contemporary context of Science Communication, nonetheless its relevance decreased. Indeed, as dialogical perspective entered the debate of Science Communication further encouraged by public engagement, **assessing the level of literacy is no longer at the core** of impact assessment of science communication.

Engagement and inclusion of citizens saw their importance grow, contributing to a framework more adherent to the actual complexity of science and society relationship (EC, 2018), even from a communicative perspective: not only communicating towards colleagues or an undifferentiated audience, but also trying to promote a mutually fruitful dialogue. While aiming for a **wider involvement and inclusion**, we have noticed that the **background, perception and knowledge** of the volunteers **are not considered a fundamental asset** capable of enriching the research experience.

Recognizing that citizens have the skills and knowledge with which to identify relevant environmental and ecological issues is the first step to enter in a relationship of **mutual trust**. According to the quadruple helix approach (Carayannis and Campbell, 2009) - identifying citizens and society at large, academic scientists, industries and SMEs, and policy makers - NEWSERA envisaged four labs (henceforth #CitSciComm Labs) in which the **potential to use CS as a communication strategy** has been explored.

#CitSciComm Labs have been conducted through a co-creation method where each partner in charge of a specific stakeholder group, led different workshops with selected CS projects (38), run in parallel in three different countries (Portugal, Spain and Italy). During the Labs, **we identified** that participating Citizen Science projects **had difficulty in fully exploiting** the characteristics, skills and ascribed knowledge of volunteers.

These evidences, which emerged during the comparison between the three Labs that took place in each country, have shown that **widespread and circular participation process is rarely activated**, taking into account three levels:

- Information: to bring the citizen closer to the theme of the project through a dual approach. Soft strategy with which to welcome requests, the result of knowledge and experience; training problems; etc.;
- Involvement: organization of territorial events in which the citizen becomes a promoter;

- Active participation: access the media / political agendas to influence and negotiate in the various decision-making arenas.

Besides the adding issues to be considered for the impact assessment, other actors entered into the quest for the impact assessment: in the general transition that brought towards a more dialogical approach, research institutes started to be asked to implement specific paths of scientific communication together with specific assessment tools.

2.1.1 Effects on scientific literacy

As aforementioned, research on scientific literacy used to be the most prominent, if not the only area of investigation about science communication in the past. Especially from the ‘60s onwards, the issue of understanding competence of the public about general or specific scientific topics kept its relevance at the beginning of the so-called Public Understanding of Science (PUS), in the last decades of the XX century (Bauer, 2008).

In this case, researchers are **not taking into consideration attitudes** about scientific issues or controversial topics such as biotechnologies or nuclear power. These issues emerged at the core of PUS in the late nineties, and were typically explored asking survey respondents to position themselves in terms of agreement/ disagreement with specific statements.

Literacy, on the other hand, consists of something different and it has a longer tradition. Concentrating on literacy means to frame the public uniformly as non-experts regarding specific notions. Coherently, research aims to measure the competence of the public. A competent public is believed to be supportive for policy programs dedicated to scientific innovation and to be a key asset for economic development (Laugksch, 2000).

Although this approach developed around the second half of the XX century, it is still at the core of many assessment programs at the international level, such as the OECD PISA tests and other international survey programs. In this sense, the **importance of scientific literacy** as a theme to be assessed has still **some strategic importance** and is also part of the repertoire of promises of CS’s approach to positive impact on society at large.

Moving to the tools for literacy assessment, anyway it is interpreted, these consist in most of the cases in questions with multiple answers. These questions are normally part of experimental or quasi-experimental research designs oriented to test the effects of a communication campaign or about the exposure of an audience to a specific series of contents. Such an approach is still very common to be adopted across different contexts as for instance assessing tools that provide contents for food risk communication (Crovato *et al.*, 2016) and health risk (Silk *et al.,* 2012).

2.1.2 Impact of bidirectional communication engagement and inclusion

The latest studies conducted (Entradas *et al*., 2020) highlight the difficulty of European research institutions to use **performance indicators** that can offer an adequate representation of the Public engagement. The interest on Public engagement by researchers can be defined as specialists in higher education that listen to, develop their understanding of, and interact with non-specialists. The 'public' includes individuals and groups who do not currently have a formal relationship with a higher education institution through teaching, research or knowledge transfer (HEFCE, 2006:1).

However, there are still many **challenges to the evaluation** of public engagement. Although the European Commission (2018) identifies public engagement as one of the 'keys' for Responsible Research and Innovation, and is considering ways of better evaluating the impact of its research in Horizon Europe, there are still some challenges.

The **evaluation of public engagement** with research can be assumed as a process that collects, analyses and reports data on the effectiveness of public engagement programmes and activities in terms of their design related to their context and purpose. It gives immediate outputs, and the beneficial impacts that arise for participants and wider society, improving the effectiveness of future engagement and/or enables timely, reliable and credible judgements to be made about the effectiveness of engagement (Rowe *et al*., 2008).

Public engagement should produce benefits for the economy or society, and that evaluation should therefore **assess the subjective worth or value of engagement** to different publics and stakeholders (Hart, Northmore and Gerhardt, 2009).

Many public engagement activities are unplanned for several reasons: limited budget, staff or evaluation expertise reduced, difficulty in motivating researchers to evaluate their engagement practice (Rowe and Frewer, 2005; Burchell, 2015).

Frequently, researchers are exposed to resource constraints, lack of structured techniques for identifying relevant publics and other end stakeholders. This inability is often due to the **lack of attention to indicators and the evaluation process that is rarely used**. Evaluation, as a moment of ongoing research but ex post type too, allows to measure the effectiveness of an intervention over time. This is an expensive but significant phase of the research activity. Through the evaluation it is possible not only to measure the effects of a project, but also to communicate the impact it has had on society. It is one of those phases which, if valued, plays a profitable role in the negotiation carried out in the public arena.

Monitoring the effects of public engagement also means that the research institution recognizes its potential. However, there still seems to be few research institutions that allocate funding for this activity, therefore even today it seems that public engagement plays a marginal role. Even when research addresses openly the issue of assessment of public engagement actions, some tools may risk inadequate, or not providing the useful elements. Jensen, in a commentary about this, precisely asked if assessment tools are effectively giving back results that can inform about the outcome of a strategy (Jensen, 2014). It is a matter of technicalities, read as how to define the wording of a question in a survey, but it also reverberates an issue connected to the culture of assessment (Renda, 2006).

It is clear that **citizen science projects**, on the other hand, make **engagement** one of the **main assets** with which to **encourage the participation of volunteers**, employed in the various research activities. If, on the one hand, research institutions seem to have difficulty integrating the practices of public engagement, on the other, society acquired tools of analysis and reasoning with which to question science. Being able to dialogue with a society that is aware and interested in the issues of technology, innovation, health and so on, represents a challenge that research institutions are called upon to take up.

The professionalization of science communication raises new questions about its autonomy. Is it subjected to media logic or is it really independent in the choice of the communication tool, the narrative style and the target audience? Does the ability to attract funding affect the scientist's professionalism and research interests? In short, it seems that there are open questions on which to carry out new research to return a detailed analysis of the ability that public science has to show its results, by engaging society in general.

2.1.3 Efforts by scientific institutions

Public engagement activities have become fairly regular for several research institutions in Europe: there are numerous initiatives of participatory communication, dissemination and involvement of non-experts which are increasingly used (Entradas and Bauer, 2017).

Research organizations have addressed a wider audience to whom they have destined diversified communication activities also because of the specific policy push for adopting strategies aimed at performing actions for engagement of non-scientists. The various interlocutors: students, research funders, journalists, NGOs, companies and industry and other stakeholders are targeted through communication strategies focused on satisfying various objectives.

The introduction of **academic research evaluation procedures** led to the need to fund those that would also have an **impact on society**. Therefore, the awareness towards some issues, the ability to dialogue with non-experts, finding new supporters among policy makers, in addition to the commitment to involve volunteers in the research phases, has ensured that universities and research centers developed an area of science communication capable of reaching a wider audience.

On the one hand, scientists left the ivory tower, expanding the target audience and becoming the bearers of a participatory approach to science communication. On the other hand, competition to obtain public visibility that allows for legitimacy and therefore funding has increased.

In other words: this has **put pressure on institutions to open up** to public communication and compete for public visibility, which is likely to have positive consequences for the social conversation about science. So far, empirical research on this communication activity of research organizations has been fragmented and not on a comparable basis (Entradas *et al.*, 2020).

However, a different level of performance persists among the various institutions, which shows a different capacity for adaptation and adherence to the purposes of science communication. In fact, indicators and public engagement are often still considered as a goodwill exercise (Neresini and Bucchi, 2011).

Some research institutions **welcome the change** promoted by Public Engagement by working on issues related to Evaluation, for example, in a **systematic way**. Argyris and Schon, in particular, distinguish between single loop learning and double loop learning (1996), in other words, whether attention to the lay public has become an integral part of the organizational culture of research institutions, or whether, instead, such concern is still a matter of marginal importance (Neresini, 2011).

Research institutions face the challenge of public engagement through an incremental or systematic approach.

- In the first case, they equip themselves with communication structures, such as press offices or internal magazines, for reasons related to funding. In the presence of a shared vision at different levels, it is easier to find economic funding. Research focused on news values such as large numbers, crisis, catastrophes, conflicts, human interest has a better chance of being communicated than exploratory research. From these findings it seems evident that at the central communications level, communication science serves the goals of public visibility rather than public engagement (Entradas *et al.*, 2020);

- In the second case, however, there is an awareness of the potential assumed by public engagement. It can develop and support public science communication activities capable of intercepting a lay public, on issues of general interest through the use of all available media.

Several studies have highlighted **the bias and resistances** that research institutions show in adopting public engagement practices. Even today, the approach to public communication of science known as the deficit model seems to prevail. Despite the institutions and research centers that have provided themselves with communication infrastructures (press offices, websites), the openness and involvement of non-experts is still marginal.

Mainly, the websites still speak only to experts, they are difficult to reach by lay people and seem to be not very interactive. The accessibility of data still pays for those feelings of refusal to share, also due to the logic of publication, of the evaluation on the performance of the individual scientist. Although the public communication of science has identified the need to adopt open science approaches and research co-design, it seems that it still remains linked to the work of the individual.

On the one hand, **although many researchers recognize open data as important, it is not an easy task to be performed**. Indeed open access may require use of web 2.0 tools representing an evolution of older communication. Shifting in that direction is not a smooth process, nor in dealing with them neither when considering the outcomes (Grand *et al.*, 2016). Indeed, also when scientists provide diffusion of articles across social media, the reach of these papers rarely extended beyond the same users of an already well-connected community of scientists, thus failing to foster openness and engagement (Alperin, Gomez, Haustein, 2019). On the other hand, in a context that growingly asks for open access, as part of a cultural trend towards 'open science', as supported by the European Commission as a policy priority (with citizen science as one of its eight ambitions; EC Open Science factsheet, 2019) and by Horizon Europe, **researchers and research institutes are encouraged to engage with open data: data should be provided on repositories in a form that is accessible and not simply available.** Funders and governments make open access to the results of publicly-funded research mandatory, especially within EU context but still it is hard to know how many non-specialists, non-experts grasp the opportunity to have access to those data.

In other words, public engagement activities, being communicative or the display of resources to be reused, **still seem to be an expression of the individual scientist's** will which is engaged in dissemination through media performances rather than the result of an organizational and cultural awareness of the research centers. Also when present it is not necessarily providing the output one should expect.

2.2 Assessing Citizen Science impact

Openness of science is indubitably a key asset for European research agenda and a desirable goal since it may fulfil purposes to advance towards a better integration between research practices and societal needs. Horizon Europe will promote the **adoption of open science practices, from sharing research outputs as early and widely as possible, to citizen science, and will develop new indicators for evaluation research and rewarding researchers** - and NEWSERA is already contributing.

Horizon Europe will also **engage and involve citizens, civil society organisations and end-users in co-design and co-creation processes and promote responsible research and innovation.** The European Open Science Cloud (EOSC) has entered its next stage of development in 2021, with stakeholders deeply involved. In addition, the Commission has developed an open-access publishing platform to host Horizon 2020 (and later Horizon Europe) beneficiaries' publications free of charge. Within such a framework, **citizens can contribute by participating in the process of**

knowledge production, also called by institutions into training paths that assimilate the contributions of citizens.

The inclusion of a wider array of subjects into such processes are at the core of many funding schemes. Indeed, most publicly funded projects for technoscientific innovation expressly require strategies of engagement. **CS is expected to positively contribute as many supporters of CS initiatives provide new methods and technologies aimed at interesting, attracting and recruiting stakeholders.** Being both a top-down or **bottom-up action, CS may shake up the typical paradigms of institutional knowledge creation**. Moreover, **citizens can be empowered to become science communicators by themselves** and to disseminate the sense, the outcomes and the experiences of their activities in a broader way. They can become **CS ambassadors** that can contribute to policy-decision making.

However, within this context, **the issue of the effectiveness of CS strategies and their impact looks underdeveloped.** CS may fulfill potentially the dialogic perspective to imagine, to seek highly engaging approaches in the co-creation of scientific knowledge. Over the years, **assessment of CS initiatives did not provide a clear answer on their impact but contributed to develop some further tools to be considered.** According to the main areas towards which Citizen Science is supposed to have a positive influence (Strasser *et al*., 2020), below we address three of them in parallel with the review provided above: i) engagement and inclusion; ii) scientific literacy; iii) scientific communities.

2.2.1 Impact on engagement and inclusion

CS projects promoted as research methods insist on opportunities to broaden participation and promote the involvement of non-scientists. The so-called “democratization thesis” aims to broaden the number of people involved in the creation of scientific knowledge, potentially increasing participation in the governance of environmental issues and science policy.

These last two elements combine to **tackle** the issues of **Public Engagement for a wider participation**, as required by the dialogic turn in the Communication of Science, in line with the seminal idea of “scientific citizenship” promoted by Irwin (1995).

The idea of **engaging citizens not only for data collection, but from the very definition of the research question,** is leading to new research questions and new applications precisely driven by people who would normally be excluded from the scientific process. As regards the latter, a wider participation and greater commitment could lead to **producing scientific evidence** on phenomena understood from a different perspective, as also theorized by Haklay (2015), given the fact that citizens own the local knowledge of their own environment and can be key not only to contribute to the generation of new data, but to their analysis.

Interpreted in this way, the promises of CS can be understood as a proposal to respond to the desires of an **effective dialogic approach** for the Communication of Science, further contributing to a real path of Public Engagement. This clearly contributes to the RRI framework (Schade and Tsinaraki, 2016) and allows embedding all the RRI dimensions into the research process, as promoted in SwafS H2020 projects such as D-NOSES (Distributed Network for Odour Sensing, Empowerment and Sustainability, 2018 - 2021, GA 789315). These promises are still far from being empirically confirmed due to the difficulties of measuring their level of achievement.

However, the recruitment by Citizen Science projects does not ensure an adequate expansion of participation, nor a public commitment capable of leading to a democratization of science. For example, Martin (2017) questioned one of the ideas that characterizes CS: the ability to involve people who are not already engaged in science, such as amateurs. Citizen science is often assumed to increase public engagement in science; however, **little is known about who might volunteer and the implications for greater social impact.** The reasons that push the volunteer to participate in a CS project are different: altruistic, when participants primarily want to help the environment or take care of the environment (the so-called “usual suspects”, people already interested in science or in nature observation); selfish when, on the other hand, one is moved by knowledge or career interests in expanding one's CV or one's scientific skills; motivated, when participants find in the research a matter of their own concern (e.g. because they are affected by air pollution or any other socio environmental issue that decreases their quality of life or affects their way of living).

Being able, therefore, to intervene on volunteers who are not already interested in scientific activity, is a **challenge for CS projects** that intend to retain citizens by stimulating participation, especially in that segment of citizens who rarely come close to these activities, and maintaining their engagement throughout the process is also difficult.

Citizen Science projects are often unable to provide insights to those marginalized groups or those who are normally excluded from the knowledge production process, even though there are some successful examples such as D-NOSES (Paleco *et al.*, 2021). In other words: using a Citizen Science approach does not ensure the overcoming of those classical barriers that prevent participation, use and sharing of knowledge (Strasser *et al.*, 2020; Bauer *et al.*, 2016; Stilgoe, 2014; Felt and Fochler, 2010), including the digital divide, since many times Apps or other types of software are used to collect the data. Being able to **diversify the target of volunteers is one of the needs that CS presents**. Reaching potential volunteers through innovative strategies and methods of involvement represents a possibility to mobilize people who otherwise would not participate in CS projects. Using strategies that are attractive to the youngest or that can also **mobilize women or the most fragile social groups,** such as minorities or migrants, can be an opportunity for CS projects that are expanding widely. In addition, including citizen groups with different socio-economic and cultural backgrounds, provides the opportunity of demonstrating and addressing the concept of environmental justice, since air pollution, noise, odours, climate change or the global COVID-19 pandemic, as we have recently seen, do not equally affect all citizens, both including the exposure and the related health effects (European Environmental Agency, 2018).

2.2.2 Impact on scientific literacy

CS activities often envisage engaging non-professional scientists in scientific investigation through training, education and outreach. Some research studies conducted on the **social impact of citizen science actions** suggest that this practice engages participants in science, provides opportunities for participants to gain scientific knowledge, allows exploration of the physical world, allows participants to reflect on science and develop positive attitudes toward science (Bonney *et al*., 2009). In fact, usually the discourse in support of citizen science projects states that participants will increase their understanding about the scientific process.

Moreover, there is a clear vision that **citizen science can contribute to scientific literacy**, as well as to **knowledge and societal advancement** that is needed to support societies at a time where evidence-based policy-making, sound scientific expertise and certain foundational truths about democracy cannot be taken for granted. Engagement in citizen science can provide **in-depth learning opportunities** through learning by doing (Bela *et al*., 2016) and promote the public's ability to understand and deal with variability and uncertainties in complex issues without the need to jump to easy conclusions (Bonn *et al*., 2018).

However, very **few studies have assessed the role citizen science can play in changing their science literacy and a large proportion of citizen science projects still do not evaluate the outcomes for individual participants** (Phillips *et al*., 2019). There are, however, some examples dealing with the subject in some specific contexts. Amongst those studies investigating the projects' impact on individual citizens, the most common outcome documented so far is the one of learning new content knowledge. Gaining knowledge on scientific subjects was, by far, the most reported type of learning in citizen science projects (Stepenuck and Green, 2015). This ranges from research in climate change (Groulx *et al*., 2017) to public data collection projects in the field of biodiversity (Bonney *et al*., 2016).

Also, the study by Bonney and co-workers (2009), reviewed ten citizen science projects and concluded that there were **impacts on participants' scientific knowledge**, ranging from increased understanding of the scientific process to project-specific knowledge about birds. Similarly, empirical studies in school-based settings have reported positive impacts on science learning (e.g., Perelló *et al*., 2017). Moreover, a very interesting overview related to the **effects on learning and scientific literacy** arising from the participation in **online citizen science** and on the methods used to study the impact, is presented by Aristeidou and Herodotou (2020).

However, **further analysis and studies on this area are needed if one wants to understand more broadly the impact of citizen science in scientific literacy**. As stated by Schaefer *et al*. (2021), more standardization is needed and new evaluation approaches and methods would be highly enriching. Additionally, the examples of studies done so far only analyse impacts on the public in general, so the analysis is still underdeveloped for the impact of CS activities. Henceforth, it reveals the **lack of analysis of the impacts of citizen science projects** directed to other stakeholders as is the case of those represented in the **quadruple-helix innovation model** (society at large, academic scientists, industry and SMES, and policy makers and the public sector).

2.2.3 Impact on scientific communities

A final element to be taken into account consists of the **potential impact CS may have on the scientific community**. It is not an easy task to judge how the contribution of non experts into scientific research can promote an advancement into scientific debate nor even it is easy to detect movement in the way through which scientists do their activities.

The recent article "Analysis of the evolution and collaboration networks of citizen science scientific publications" (Pelacho, Ruiz, Sanz *et al.*, 2021) explores the study of citizen science publications in journals indexed by the Web of Science (WoS), in particular how they have evolved over the last 20 years and the collaborative networks that have been created between researchers around the world during this period of time. This contribution provides an attempt to approach the signals of **CS as a cross-cutting concept into the evolution of scientific communities**.

This evolution can be analysed, quantitatively, using the usual tools, such as the number of publications, authors and impact factor of the papers, as well as the aggregate of the different research areas. However, as citizen science is a cross-cutting concept that appears in almost all scientific disciplines, this analysis really addresses a **multifaceted problem that is only partially modelled by the usual bibliometric measures.** It is necessary to consider new tools to parameterise a set of complementary properties.

A convenient one consists of the bibliometric analysis through the exploration of resources available on WoS introducing graph theory in the study of the expansion and evolution of citizen science. The analysis enjoys the contribution of Kampal Research tool, from Kampal Data Solutions, a spin-off from the University of Zaragoza (Spain). **Kampal detects, analyses and plots the relationships between researchers.**

More specifically, for this task, Kampal concentrated on co-authorship and the resulting collaboration networks. Through graph theory the strength of relationship between authors embodied by co-authorship becomes measurable and, at the same time, visualised. The attempt provided tries to **understand the success of CS as a practice for the work of scientific research among the communities of scientists.**

The results obtained lead mainly to:

(a) a better understanding of the current state of citizen science in the international academic system - by countries, areas of knowledge and interdisciplinary communities - as a legitimate methodology in expansion, and

(b) a better knowledge of collaborative networks and their evolution, within and between research communities, which allows a certain margin of predictability, as well as the definition of better cooperation strategies.

The main outcomes can be summarised as follows:

- There has been an **exponential growth** in the number of papers per year, with an exponent close to 0.3. If nothing changes on a global scale, we can expect this growth to continue in the coming years.

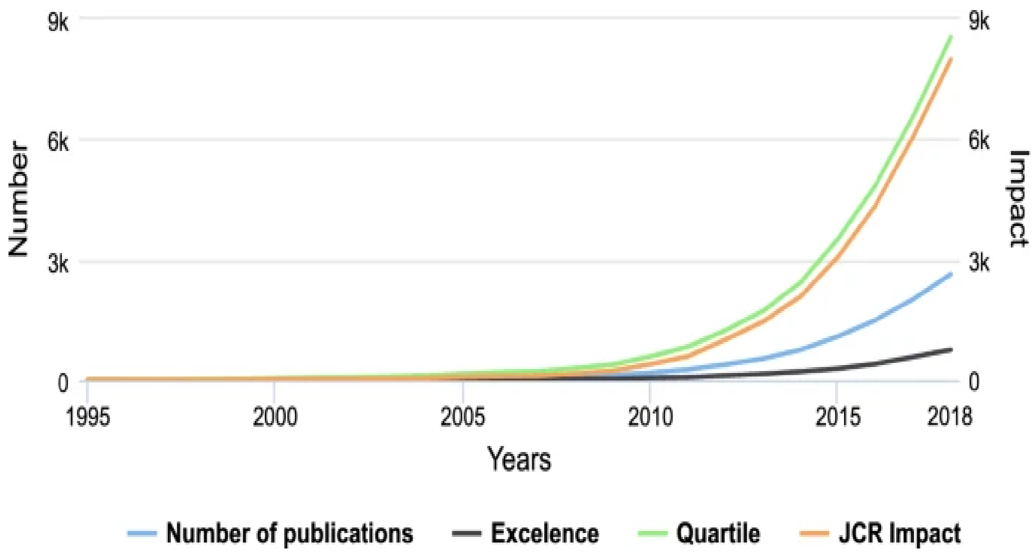

Figure 1. *Number of papers published based on CS activities from Pelacho, Ruiz, Sanz et al., 2021.*

- The average number of papers published is of **high quality**, with an average impact factor close to 3.

- The **number of researchers** publishing papers with CS activities is near 10,000.

- There is a minority of authors who have conducted research in many different areas. Complementarily, most researchers have used citizen science in their respective fields, not on a regular basis but occasionally. The different communities are isolated from each other, with very little contact between them. The structure therefore seems to **show a large number of professional scientists who consider citizen science to be an applicable methodology in their respective research areas**. At the same time, the fact that some authors, although a minority, have carried out citizen science activities in very different areas of study also seems to show the real **possibility of certain methodologies to be transferred from one area to another**.

- Regarding the evolution of different countries in citizen science, we have seen how the situation of isolated authors at the beginning of the century is changing over time. The evolution seems to lead to a **structure with a huge dominant node**, represented by the Anglo-Saxon countries (US, UK and Australia), and **one or two smaller nodes** represented by the European countries, and their respective partners.

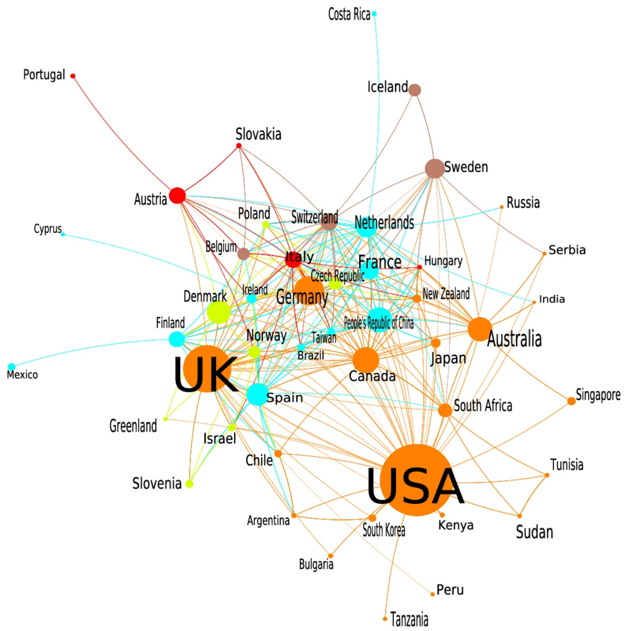

Figure 2. *International networks of collaborations through CS, from Pelacho, Ruiz, Sanz et al., 2021.*

- As far as the search for labels is concerned, the term "citizen science" seems to be the most relevant for finding scientific papers **related to active citizen participation in science**, but the debate on other different useful terms is still open. Some of the search terms are of little relevance, while it seems interesting to consider some others, defining an appropriate methodology to avoid false positives.

3. The NEWSERA method

In the review provided so far we have explored some of the current limitations that qualify both CS and Science Communication as potentially effective tools to provide a democratization of science, engaging people who normally would not be part of the process, impacting on the level of knowledge, trust and confidence into science and effects on the communities of scientists, with the potential of promoting public participation in decision making processes and informing public policies.

We have also provided some points about the efforts put in place by research institutions in order to properly contribute to the implementation of public engagement. To sum up the **outputs of this review**, we could highlight at least three elements:

1. while there is a lot of advancement into theoretical debate about the contributions that both CS and Science Communication can provide to Open Science, still the evidences are limited to good examples that show they may work;

2. assessment of those experiences rely on the goodwill of researchers when there is no specific requirement for audit by the scheme a specific activity is funded by;

3. when present, assessment procedures may not enjoy comparable measures since there is not always agreement on what should be assessed or what should be privileged as a key area.

A further rarely considered element among these themes is the **importance that outcomes of a proper engagement**, both in CS and in Science Communication, may **have for policymaking as well as for the productive sector.** These last elements are often overlooked but still they provide an innovative way to open up science and innovation to the quadruple-helix stakeholders.

On the other hand, **CS and Science Communication pursuing the idea of Open Science can be considered together** since they share several points in common as reported above. This is the conceptual proposal of NEWSERA of #CitSciComm, in other words, to conceive CS as a communication process that should be inclusive, impacting literacy and effective in providing inputs for a fruitful innovation process potentially closer to societal needs.

Below we provide the key elements of the framework we are developing within NEWSERA activities, combining CS and Science Communication within the framework of RRI.

3.1 The framework: Merging Citizen Science impact and communication assessment within the RRI framework

As emerged from the review provided in the previous sections, considering CS and science communication means to deal with many issues envisaged in the RRI framework. René von Schomberg, among the most influential theorists of RRI, considers it as "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)" (von Schomberg, 2013, p. 63).

Put in this way, **inclusiveness is a major element** but it can be further split into **different sub-areas**. Indeed, RRI counts on five different pillars that qualify responsibility for innovation processes and their governance.

Table 1. *Presence of RRI pillars across CS and Science Communication research domains according to our review.*

RRI pillars	Science communication	Citizen Science
Public engagement	✓	✓
Open access	✓	✓
Gender		
Ethics		
Science education	✓	✓
Governance		

As indicated in Table 1, this resumes the issues raised in the review, both Science Communication and CS address most of the thematic areas provided by RRI. **Gender, Ethics and Governance pillars deserve a brief integration**: although gender is not an issue at the core neither for Science Communication nor for CS, to perform inclusiveness properly, means to **integrate a gender dimension**.

Indeed, it should not be overlooked since, on the one hand, even in EU funded projects, through schemes that openly encourage gender equality, **gender gap is still present** (Büher and Wroblewsky, 2019); on the other hand, gender-science stereotypes have a significant impact on reducing the STEM aspirations of female, because still a strong masculine image of math and science is widespread among youngsters, significantly decreasing the likelihood of choosing a STEM major among female students (Makarova, Aeschlimann and Herzog, 2019). Hence, choices for higher education may suffer from gender segregation processes, with STEM disciplines that are chosen mainly by male, are deeply rooted in cultural systems as recently confirmed (Barone and Assirelli, 2020).

Moreover, considering the importance given in Horizon Europe to gender, we want to move one step further and propose the **inclusion of a gender dimension in the content of the research questions to be explored under CS projects** - and, in general, in any research and innovation project. Indeed, even though gender perspective in co-creation and participatory research, and specific case-studies have been included in the Policy Review: GENDERED INNOVATIONS 2: How Inclusive Analysis Contributes to Research and Innovation (EC, 2020, p. 191), the field is still in its infancy.

As noted by Kimura and Marks (2021), Citizen science is already contributing to and could contribute to the monitoring of more than 30% of the Sustainable Development Goals indicators (Fraisl *et al*., 2020), with the **potential to mitigate several gender data gaps** within SDG5 Gender equality.

In this sense, we propose **including gender data collection and gender-sensitive participatory methods** as areas to be explored by CS communication actions, for which the following indicators would be taken into account: sex- and/or gender-disaggregated data collected, and strategies developed considering gender dimension and intersectionality.

This would further contribute not only to **tackle the gender gap in data** but also to the **awareness and advocacy of gender disparities** in the context of many CS initiatives, including the **digital divide** and its strong gender gap (OECD, 2018).

If we focus on **Ethics**, we have to acknowledge these issues are **present to a lesser extent within the CS and Science Communication debates compared to others**. Moreover, **ethics as an issue is conceived differently across the debates** we are referring to: in CS, ethics may be about the **relationship between volunteers** safety, their role in the process, the opportunity for them to be informed about the research project and the data they are contributing to collect, mainly in projects addressing health issues (Smalmann, 2018; Senabre Hidalgo *et al*., 2021), personal data protection to comply with the GDPR and ownership of the data and the research results. In fact, the 10 Principles of Citizen Science by ECSA reflect on some of the ethics aspects that a CS project must comply with, including feedback, copyright, intellectual property, data sharing agreements, confidentiality, attribution, and the environmental impact of any activities (ECSA, 2015). In Science Communication, ethics is interpreted as a way of **transparency, balance and correctness of science communication** when addressing potentially controversial topics (Priest, Goodwill, Dahlstrom, 2018).

Turning to governance, a widespread general idea considers that the more society is informed and involved in scientific issues, the more policymakers can develop evidence-based decisions and define lines of intervention that better adhere to societal needs (Stirling, 2008). Developed as a specific subtheme in both CS and Science communication, it is assumed as a **main potential achievement of participation often interpreted as shared decision making** (Senabre Hidalgo *et al*., 2021); if not as an issue of policies for scientific research, or science policy (Pelacho *et al*., 2021). Nonetheless, still the chief relevance of fine-grained and trustworthy sources of data makes CS a desirable tool for decision making (EC 2020, Göbel *et al*., 2019). While in Science Communication some concerns arise about how to concretely do a participated governance, thus coming back to the issue of public engagement and the limits it may face (Sturgis, 2014).

RRI on the contrary, invokes the principle of ethics in adherence to the cultural, spiritual features of society and therefore to keep into **consideration the ethical implication of research also for what concerns governance** (ENGAGE Consortium, 2020; Reber, 2018). In a nutshell, for CS, ethics is a matter of how a project should be conducted especially in relation to whom volunteers; for Science Communication, it is mainly related to how to provide contents to the public and to frame them properly; for RRI, ethics entails the accountability and responsibility of research from the early stages of a research process.

This state of affairs reminds us that **a proper translation and inclusion of all the RRI pillars is not immediately possible in an unique framework.** Nonetheless, we took inspiration from RRI in order to enrich the areas to be addressed for defining the NEWSERA framework, also to validate the hypothesis that CS can potentially embed and contribute to all RRI dimensions.

With the aim of potentially extend it to innovation blueprints, validated and consequently integrated in the assessment of #CitSciComm, we opted to **integrate the outputs of two main H2020 projects dedicated to RRI,** such as MoRRI (Monitoring the evolution and benefits of responsible Research and Innovation) and Super-MoRRI (Scientific Understanding and Provision of an Enhanced and Robust Monitoring system for RRI)[1], the latter being subsequent evolution of the former with improvements on empirical implementation and further theoretical elaboration.

The two projects offered key contributions in the assessment of the dimensions and pillars of RRI as a source of learning and reflection for potential (Meijer and van de Klippe, 2020; van de Klippe, 2019). They provided assessment tools, advancing in understanding the practices and offering self-monitoring tools for whoever wishes to perform research addressing directly those pillars (Yagmaehi, 2020).

As NEWSERA consortium, we believe that they can be chief for the challenges of #CitSciComm. Indeed, we rely on them in order to **include experiences of theoretical elaboration and practical implementation for assessing RRI**

[1] Deliverables of both projects are available on Super-MoRRI project website. https://super-morri.eu

dimensions. This is an opportunity to keep on track to the general debate of RRI as the dominant framework - at least - for EU funded research and has already become part of the state of the art (EC 2021).

However, it should be noted that **NEWSERA unit of analysis consists of projects**, while MoRRI and Super-MoRRI indicators rely on nationwide sample data, for instance deriving from the Eurobarometer survey (Meijer and van de Klippe, 2020) or to data provided by other large institutions: for instance a series of indicators from MoRRI about science education exploit data from European Citizen Science Association (ECSA) to establish levels of commitment that activities might bring in increasing scientific literacy (Stilgoe, 2018). Thus, the MoRRI and Super-MoRRI indicators may not always be measurable or applicable when applied to CS projects, and new RRI indicators may need to be developed.

On the one hand, we thus **relied on MoRRI and Super-MoRRI** experiences and contributions, especially for the **approach about RRI pillars and to provide research projects with self-assessing tools**; on the other hand, we **adapted their content to the needs to track and assess output and outcomes of communication strategies as implemented by CS projects,** in other words #CitSciComm.

A further source of inspiration that we considered, is the recent H2020 **ACTION project** (https://actionproject.eu/) that is **oriented precisely to assess the impact of CS projects.** In this case, we have the **same unit of analysis and therefore the same indicators can be used as they provide useful elements for contextualising facets and configuration of #CitSciComm** - always considering the specific objectives and expected outcomes and impacts of the individual CS projects to select the more suitable CS impact assessment indicators. The ACTION project (Passani, *et al*., 2020) operationalises - i.e. makes it operative, detectable and measurable - the different areas for CS impact assessment as considered in most recent literature (Schafer *et al*., 2021). Moreover, it provides an inspiring framework for what concerns the **tailored indicators according to aims, research domains and stakeholders** involved in the CS project to be assessed. The ACTION project distinguishes pilots according to those variables and coherently uses them to design indicators for CS impact assessment.

To conclude the review of **NEWSERA starting framework** for #CitiSciComm impact assessment, we considered the **Kampal tool.** As described previously (see section 2.2.3) Kampal offers intriguing insights about CS impact. Indeed, Kampal has a specific package called “Kampal social” that provides data visualization services allowing the users to collect, filter, analyze, quantify and visualize selected information from different internet sources. The opportunity to work smoothly with different web sources represents for NEWSERA a key asset to be explored for the analysis of the outputs of the communication strategies by the enrolled CS projects.

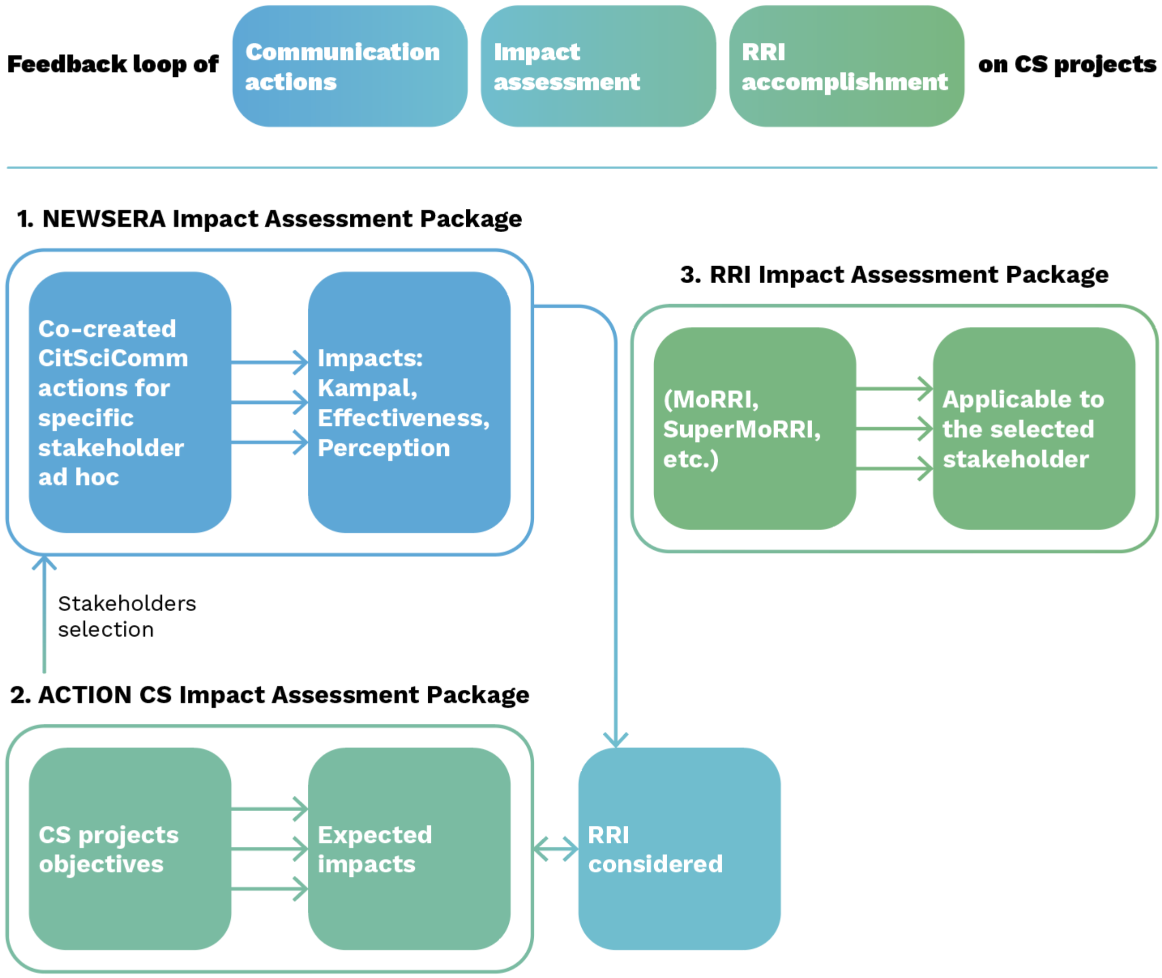

Figure 3. *NEWSERA Framework for impact assessment of #CitSciComm in CS projects.*

As a whole, NEWSERA opted to integrate these three **impact assessment "packages"** of resources into our starting multi-level impact assessment framework (See Figure 3), which will be further developed starting precisely from a three level composition. We will account for it in section 4. Before that, we will further define two key complementary dimensions for the assessment of #CitiSciComm, such as the distinction between quantitative and qualitative indicators and the separation between output and outcomes.

3.2 Quantitative indicators: measurable outputs and outcomes

Indicators are tools that can show (measure) the trend of certain phenomena an observer wants to take into account. It means that through **indicators we can assess cross-sectionally or monitor across time the phenomena we are interested in.** The approach of studying evolution through indicators is well spread in policy analysis and social sciences (Vogel, 1997) and it is also applied in the assessment of science policy and science and technology productivity (Glänzel, *et al.*, 2019).

The analysis of a communication strategy thus represents a field of application that requires the same care as other ones. When considering indicators, it should be clear that a **single indicator does not coincide with the specific phenomenon we want to assess, rather is a proxy.** Phenomena, in general, are complex and multifaceted; therefore, to grasp the current state of a specific phenomenon we possibly need to rely on more than one indicator in order to have a satisfactory picture.

A further issue is the selection of what is considered representative for the analysis. In the NEWSERA case, the adequacy of the activities as part of a communication strategy by CS projects require careful planning. Indeed, selecting dimensions to be considered in a cross-sectional assessment or monitored across time is possibly the most relevant matter of concern. **In assessing the impact of CS we are facing a multifacet object that is continuously evolving** (Schaefer *et al.*, 2021). Indeed, as previously said, many issues are often overlooked (e.g. gender balance, gender perspective) or interpreted in a limited way (ethical dimension) since there are other issues at the core of the assessing focus. Since CS is a methodology providing data from not-professionals, it usually concentrates on the assessment of data quality. In our case we are referring to **CS as a key attempt for fostering participation and engagement**; we know that CS is largely interpreted in that way and for this reason it is thus important to implement, even to establish, if certain effects drive eventually to a successful outcome.

Since we are addressing #CitSciComm as a label that merges together CS and Science Communication efforts for inclusivity, we are supposed to identify key areas. By doing so, we have considered **dimensions from the three packages aforementioned** (Figure 3), **distinguishing between output and outcome indicators**; where the former consists of objects produced as the result of a specific action as part of a communication strategy. An example could be the number of public events organized by a CS project; this would give an idea of the level of commitment of the project to meet the public. As an output indicator then, it directly contributes to understanding the achievements in terms of time and other human or material resources applied by a CS project for a communication campaign.

Outcome indicators operate at a different stage since an outcome consists of the projects' achievement according to the expected effects/changes in the short, intermediate, and long term. In other words, it is exactly what a project gets from its own efforts. From that we can assume the impact (Figure 4).

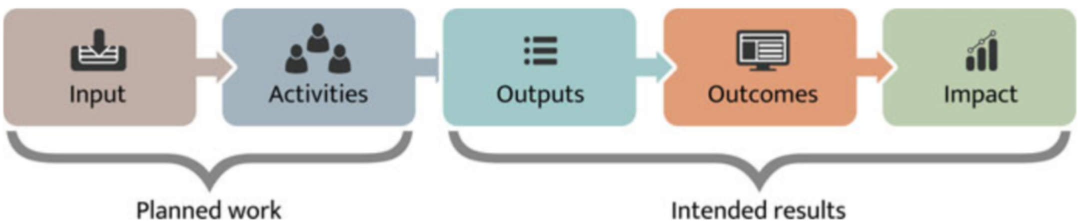

Figure 4. *Visual representation of logic of impact assessment as provided by Schäfer et al., 2021.*

3.3 Qualitative indicators: opinions and self reported attitudes

When talking about indicators in assessment research, quantitative ones immediately come up to mind. Quantitative measures give account of specific features (dimensions) that are relevant to those who define the assessment tools. In our case, **quantitative indicators regard actual numbers recorded during activities that may inform about a specific performance**.

However, we **cannot limit our assessment of CS experience and outcomes of communicative strategies.** Indeed, as reported in section 2.2.1, from our experiences during the #CitSciComm Labs as the key NEWSERA activity (Deliverable 5.5 Policy Brief), many projects' spokespersons described how citizen scientists perceived positively their engagement into a CS activity: the sense of belonging, the feeling of being part of a community, as well as the pleasure of being engaged, are constitutive parts of the entire path of a CS project.

Either training in schools or a bioblitz in a nature reserve, these activities may bring positive feelings that entails issues connected to the involvement of citizens. Any change in the communication strategy can provide, as many CS and public engagement scholars hope, positive changes in attitudes regarding science, while raising awareness and boosting behavioural change processes. For these reasons we decided to also include self-reported opinions and attitudes as indicators to be part of the assessment. According to the available literature we called them **qualitative indicators**.

4. Selecting areas and implementing indicators

Indicators development, implementation and testing is part of NEWSERA tasks. Work Package 5 (WP5) “Evaluation and impact assessment: the legacy of NEWSERA [2]”, will focus on the evaluation of the results emerged from the implementation of the co-designed strategies from the #CitSciComm Labs, within the selected Citizen Science projects, serving as NEWSERA pilots, as its main objective. To these ends, WP5 will **quantify indicators as the specific objectives and conduct an iterative analytical process for the assessment** on the basis of current recognition, informed by the literature review and on the theoretical and methodological considerations developed here.

The **multi-level framework that characterises NEWSERA methodology** for the integrated assessment of engagement, inclusivity and impact of CS projects communicative strategies is based on the three packages described in section 3.1.

These were further **enriched by the dimensions of the indicators**. Qualitative and quantitative, as well as output and outcome distinctions, can potentially cover most of the variety of the communication strategies, obtained under the co-creation path of #CitSciComm Labs.

WP5 will develop on the basis of the following area we adopted from the three packages considered so far. Below, we report the three levels with a non-exhaustive list of indicators inspired by previous experiences from other projects (MoRRI, Super-MoRRI, ACTION) (Tables 2 and 3) as well as NEWSERA’s research tools (e.g. NEWSERA survey, Kampal social) (Table 4).

Table 2. *Indicators covering RRI areas adapted from MoRRI and Super-MoRRI projects (*Meijer, I., and van de Klippe, W., 2020; van de Klippe, 2019).

RRI pillars	Areas	SubAreas	Indicators	Output/ Outcome	Qual / Quan
1.1 Public engagement	1.1.a Recruitment strategies	1.1.a.1 Advertisement	1.1.a.1.1 Presence of advertisement campaign	Output	Quan
		1.1.a.2 Target	1.1.a.2.1 Presence of methods for being representative of targeted population	Output	Qual
			1.1.a.2.2 Presence of methods for assessing representativeness of targeted population	Output	Qual
	1.1.b Citizen Scientist contribution	1.1.b.1 Citizen scientist role	1.1.b.1.1 Are citizen scientists asked to contribute in tasks other than monitoring and sensing?	Output	Qual
			1.1.b.1.2 Are citizen scientists represented in a sounding board?	Output	Qual

[2] See https://newsera2020.eu/workplan/

			1.1.b.1.3 Do citizen scientists contribute in defining the research design?	Output	Qual
			1.1.b.1.4 Citizen scientists asked to communicate, spread, share results?	Output	Quan
	1.1.c Public meetings	1.1.c.1 Activities carried out	1.1.c.1.1 Number of public meetings and events	Output	Quan
			1.1.c.1.2 Percentage of online public meetings and events	Output	Quan
		1.1.c.2 Attendance	1.1.c.2.1. Average attendance rate of project's public meetings	Outcome	Quan
		1.1.c.3 Attendants composition	1.1.c.3.1 Project's public meetings composition: age classes, educational attainment	Output	Quan
1.2 Gender equality	1.2.a Project's gender balance	1.2.a.1 Leadership	1.2.a.1.1 Presence of female PI	Outcome	Quan
		1.2.a.2 Gender balance among researchers	1.2.a.2.1 Ratio of female researchers within the project	Outcome	Quan
	1.2.b Participant Gender balance	1.2.b.1 Gender balance within projects participants	1.2.b.1.1 percentage of female participants within the project	Output	Quan
		1.2.b.2 Gender balance among project participants compared with gender balance in academic bachelor degree within the same research domain.	1.2.b.2.1 Difference between female presence within a project and the number of female graduated students in the same or linked scientific areas (expressed in percentage) within the same country.	Outcome	Quan
	1.2.c Gender dimension in the content of research	1.2.c.1 Gender data collection	1.2.c.1.1 Sex- and/or gender-disaggregated data collected	Outcome	Quan
		1.2.c.2 Gender-sensitive participatory methods	1.2.c.2.1 Have gender dimension and intersectionality been considered when developing strategy?	Output	Qual
1.3 Science education	1.3.a Interest and competence in science and technology among CS participants	1.3.a.1 Interest in science and technology contents	1.3.a.1.1 Selfreported interest in science and technology developments recorded through a Likert scale (5 grades). It should be included in an ex-ante/ex-post assessment design	Outcome	Qual
		1.3.a.2 Informedness about the topic addressed by CS project	1.3.a.2.1 Self Reported feeling about the topic addressed by the CS project informedness recorded through a Likert scale (5 grades) on a bundle of main issues connected to project's activities. It should be included in an ex-ante/ex-post assessment design	Outcome	Qual
		1.3.a.3 Informedness about the science and technology contents	1.3.a.3.1 Self Reported feelings about science and technology informedness recorded through a Likert scale (5 grades) on a bundle of current main issues (TBD, since they may vary across countries). It should be included in an ex-ante/ex-post assessment design	Outcome	Qual
		1.3.a.4 Competence in science and technology	1.3.a.4.1 Answer to standard questions about science and technology literacy	Outcome	Quan
	1.3.b Educational programs	1.3.b.1 Project engagement in education	1.3.b.1.1 Number of hours dedicated to citizen scientists to training for the project's topic	Output	Quan
	1.3.c Training for professional scholars and higher education	1.3.c.1 Project engagement in promoting CS in	1.3.c.1.1 Number of hours dedicated to university students for training in CS as research approach	Output	Quan

		higher education	1.3.c.1.2 Self-reported interest in CS as research approach towards open-science developments recorded through a Likert scale (5 grades). It should be included in an ex-ante/ex-post assessment design	Outcome	Qual
		1.3.c.2 Project engagement in promoting CS among professional scholars	1.3.c.2.1 Self-reported interest in CS as research approach by professional scholars towards open-science developments recorded through a Likert scale (5 grades). It should be included in an ex-ante/ex-post assessment design	Outcome	Qual
1.4. Open access	1.4.a Data policies	1.4.a.1 Open access	1.4.a.1.1 Are data available in open access?	Output	Qual
		1.4.a.2 Repository used	1.4.a.1.2 Which repository is used for open access?	Output	Qual
		1.4.a.3 Use of data produced by the project	1.4.a.1.3 Published research using project's open data	Outcome	Quan
1.5. Ethics	1.5.a Ethical issues	1.5.a.1 Ethical issues management	1.5.a.1.1 In case of presence of ethical issues addressed by the project: presence of a protocol	Output	Qual
	1.5.b Ethical board	1.5.b.1 Composition of ethical board	1.5.b.1.1 In case of presence of ethical issues addressed by the project: presence of ethical board	Output	Qual
			1.5.b.1.2 In case of presence of ethical board: composition of ethical board include at least one third of CS	Output	Quan
			1.5.b.1.3 In case of presence of ethical board: composition of ethical board has a balanced gender presence	Output	Qual
		1.5.b.2 Role of ethical board	1.5.b.2.1 The ethical board has a consulting role	Outcome	Qual
			1.5.b.2.2 The ethical board validates procedures of data collection and analysis	Outcome	Qual

Table 3. *Indicators covering CS dimensions as defined by the ACTION project (adapted from Kieslinger, et al., 2017).*

	Criteria	***Supporting questions***	***Output/ Outcome***	***Qual/ Quan***
2.1 Scientific dimension	***Process and Feasibility***			
	Scientific objectives			
	Relevance of scientific problem	*2.1.a.1. Does the project adhere to the definition of citizen science? E.g. Does it include citizens in the scientific process?*	*Output*	*Qual*
		2.1.a.2. Is the scientific objective generally apt for citizen science and why?	*Outcome*	*Qual*
		2.1.a.3. Does the scientific objective show relevance for society and does it address a socially relevant problem?	*Outcome*	*Qual*
		2.1.a.4. Are the scientific goals sufficiently clear and authentic?	*Output*	*Quan*

		2.1.a.5. What are the scientific gains of the project and how are these defined?	Outcome	Quan
	Data and Systems			
	2.1.b Ethics, data protection, IPR	2.1.b.1. Does the project have a data management plan, IPR strategy and ethical guidelines?	Output	Quan
		2.1.b.2. Is the data handling process transparent? E.g. Do citizens know what the data is used for, where the data is stored and shared?	Output	Qual
		2.1.b.3. Are data ownership and access rights clear and transparent? How is the publication of data handled?	Output	Quan
	2.1.c Openness, standards, interfaces	2.1.c.1 Does the project have open interfaces to connect to other systems and platforms?	Output	Qual
		2.1.c.2. Is the generated data shared publicly and under which conditions, e.g. anonymized, metadata, ownership, consent, etc.?	Output	Qual
		2.1.c.3. Is the data understandable to the policy makers?	Output	Qual
	Evaluation and adaptation			
	2.1.d Evaluation and validation of data	2.1.d.1. Does the project have a sound evaluation concept, considering scientific as well as societal outcomes?	Outcome	Qual
		2.1.d.2. Is evaluation planned at strategic points of the project?	Output	Qual
		2.1.d.3. Does the validation of citizen science data match with the scientific question and the expertise in the project?	Output	Quan
		2.1.d.4 Are indicators and evaluation methods defined? Are all stakeholders considered?	Output	Quan/Qual
		2.1.d.5 What processes are defined to guarantee high data quality?	Outcome	Quan
	2.1.e Adaptation of process	2.1.e.1. Does the project include a scoping phase?	Output	Qual
		2.1.e.2. Does the project have an appropriate risk management plan?	Outcome	Qual
		2.1.e.3. Are project structures adaptive and reactive?	Output	Qual
		2.1.e.4. Does the project include feedback loops for adaptation?	Outcome	Qual
	Collaboration and synergies			
	2.1.f Collaboration and synergies	2.1.f.1 Does the project collaborate with other initiatives at national or international level to enhance mutual learning and adaptation?	Outcome	Qual
		2.1.f.2 Does the project link to experts from other disciplines?	Output	Qual
		2.1.f.3 Does the project build on existing citizen science expertise in the specific field of research?	Output	Quan
		2.1.f.4 Are there plans for sustaining the collaboration between citizens and scientists?	Output	Qual
	Outcome and impact			
	Scientific Impact			

	2.1.g Scientific knowledge and publications	*2.1.g.1. Does the project demonstrate an appropriate dissemination strategy?*	*Output*	*Quan/qual*
		2.1.g.2. Are citizen scientists participating in publications or is their engagement recognized?	*Output*	*Quan*
		2.1.g.3. Did the project contribute to adult education and life-long-learning?	*Outcome*	*Qual*
	2.1.h New fields of research and research structures	*2.1.h.1. Did the project generate new research questions, new projects or proposals?*	*Output*	*Qual*
		2.1.h.2. Did any cross-fertilization of projects take place?	*Outcome*	*Qual*
		2.1.h.3. Did the project contribute to any institutional or structural changes?	*Outcome*	*Qual*
	2.1.i New knowledge resources	*2.1.i.1. Does the project ease the access to traditional and local knowledge resources?*	*Outcome*	*Qual*
		2.1.i.2 Does the project foster new collaborations amongst societal actors and groups?	*Output*	*Qual*
		2.1.i.3 Does the project contribute to a mutual understanding of science and society?	*Outcome*	*Qual*
2.2 Citizen scientist dimension	***Process and Feasibility***			
	Involvement and support			
	2.2.a Target group alignment	*2.2.a.1. Does the project have specific communication plans for target groups?*	*Output*	*Qual/Quan*
		2.2.a.2. What engagement strategies does the project have (e.g. gamification)?	*Output*	*Qual*
		2.2.a.3. Are the options for participation and the degree of involvement diversified?	*Output*	*Qual*
	2.2.b Degree of intensity	*2.2.b.1 In which project phases are citizens involved?*	*Output*	*Qual/quan*
		2.2.b.2. Are citizens and scientists equal partners in the knowledge generation process?	*Outcome*	*Qual*
	2.2.c Facilitation and communication	*2.2.c.1. Are support and training measures adapted to the different participant groups?*	*Output*	*Qual*
		2.2.c.2. Are objectives and results clearly and transparently communicated?	*Output*	*Qual*
		2.2.c.3. How interactive is communication and collaboration between scientists and citizens organised?	*Output*	*Qual*
	2.2.d Equal opportunities	*2.2.d.1. Are the participation options and the degree of involvement diversified?*	*Output*	*Qual*
		2.2.d.2. Do the strategies guarantee equal opportunities for participants?	*Output*	*Qual*
		2.2.d.3. Does the project reflect a gender balance?	*Outcome*	*Qual*
		2.2.d.4.Does the project reproduce stereotypes (usually students who attend hard science faculties are men) or does it offer a new overview of the composition of the target?	*Outcome*	*Qual*
	2.2.e Collaboration and synergies	*2.2.e.1 Does the project involve organizations that provide relations and communication structures with citizens?*	*Output*	*Qual*

		2.2.e.2 Does the project collaborate with local organizations already known in the environmental and social field?	Outcome	Qual
		2.2.e.3. Does the project use informal and formal communication tools to get connection, upgrade and inform the citizens?	Output	Quan/Qual
	Outcome and impact			
	Individual development			
	2.2.f Knowledge, skills, competences	*2.2.f.1. What are the specific goals to be achieved by the participants?*	Output	Qual
		2.2.f.2. What are the learning outcomes for the individuals?	Outcome	Qual
		2.2.f.3. Do individuals gain new knowledge, skills and competences?	Outcome	Qual
		2.2.f.4. Does the project contribute to a better understanding of science?	Output	Qual
	2.2.g Attitudes and values	*2.2.g.1. Does the project influence the values and attitudes of participants regarding science?*	Output	Qual
	2.2.h. Behavior and ownership	*2.2.h.1. How much involvement and responsibility is offered to the participants?*	Outcome	Quan/qual
		2.2.h.2. Does the project foster ownership amongst participants?	Output	Quan/qual
		2.2.h.3. Does the project contribute to personal change in behavior?	Outcome	Qual
	2.2.i. Motivation and engagement	*2.2.i.1. Does the project raise motivation and self-esteem amongst participants?*	Outcome	Qual
		2.2.i.2 Are participants motivated to continue the project or involve in similar activities?	Outcome	Qual
		2.2.i.3 In the case of younger students, do they consider a scientific career?	Output	Quan
2.3 Socio-ecological/ economic dimension	***Process and Feasibility***			
	Dissemination & Communication			
	2.3.a Target group and context alignment	*2.3.a.1. Does the project have a targeted outreach and communication strategy?*	Output	Quan
		2.3.a.2. Does the project include innovative means of science communication and popular media (e.g. art)?	Output	Quan
	2.3.b Active involvement, bi-directional communication	*2.3.b.1. Does the communication strategy include hands-on experiences and bi-directional communication?*	Output	Qual
		2.3.b.2. Is the engagement strategy clearly communicated and transparent?	Output	Qual
		2.3.b.3. Are the project objectives and results clearly and transparently communicated?	Output	Qual
	2.3.c. Collaboration and synergies	*2.3.c.1. Does the project seek collaboration with science communication professionals?*	Outcome	Quan
		2.3.c.2. Does the project leverage civic society organizations for communication and synergies?	Outcome	Qual
	Outcome and impact			

	Societal impact			
	2.3.d Collective capacity, social capital	*2.3.d.1. What are the societal goals of the project and how are they communicated?*	*Output*	*Quan*
		2.3.d.2. Does the project foster resilience and collective capacity for learning and adaptation?	*Outcome*	*Qual*
		2.3.d.3. Does the project foster social capital?	*Outcome*	*Qual*
	2.3.e Political participation	*2.3.e.1. Does the project stimulate political participation?*	*Output*	*Qual*
		2.3.e.2 Does the project have any impact on political decisions?	*Outcome*	*Qual*
	Ecological impact			
	2.3.f Targeted interventions, control function	*2.3.f.1. Does the project include objectives that protect and enhance natural resources?*	*Output*	*Qual*
		2.3.f.2. Does the project contribute to higher awareness and responsibility for the natural environment?	*Outcome*	*Qual*
	Wider innovation potential			
	2.3.g New technologies	*2.3.g.1.Does the project foster the use of new technologies?*	*Output*	*Quan*
		2.3.g.2. Does the project contribute to the development of new technologies?	*Outcome*	*Qual*
	2.3.h Sustainability, social innovation practice	*2.3.h.1. Does the project have a sustainability plan?*	*Output*	*Quan*
		2.3.h.2. Are the project results transferable and to what extent?	*Output*	*Qual*
		2.3.h.3. Does the project contribute to social innovation?	*Outcome*	*Qual*
	2.3.i Economic potential, market opportunities	*2.3.i.1. Does the project have any economic potential to be exploited in the future?*	*Output*	*Qual*
		2.3.i.2. Does the project include any competitive advantage?	*Output*	*Quan*
		2.3.i.3. Does the project have any cooperation for exploitation, e.g. with social entrepreneurs?	*Output*	*Qual*
		2.3.i.4. Does the project generate any economic impact, e.g. cost reduction, new job creation, new business model, etc.?	*Outcome*	*Qual*

Table 4. *Indicators covering Communicative dimensions as developed for the NEWSERA survey (see D2.1) and Kampal social.*

	3.1.a New media communication	3.1.a.1 Social media presence through the count of accounts	Output	Quan
		3.1.a.2 Instant messaging accounts	Output	Quan
		3.1.a.3 Social media manager	Output	Qual
		3.1.a.4 Increase in community reach on social media	Outcome	Quan
		3.1.a.5 Increase number of followers on social media	Outcome	Quan

	3.1.b Other media communication	3.1.b.1 Self reported project presence on TV, or radio/podcasting or newspapers or magazine	Output	Quan
		3.1.b.2 Project reported on google news	Outcome	Quan
3.2 Bidirectional communication	3.2.a Through project website	3.2.a.1 Project's website has interactive features	Output	Qual
	3.2.b Social media	3.2.b.1 Project's social media accounts interaction scores	Outcome	Quan
	3.2.c Perception and feeling of interaction on Citizen Scientists' side	3.2.c.1 Self reported feeling of being part of a community	Outcome	Qual
		3.2.c.2 Self reported feeling of being listened	Outcome	Qual

Taken together, the indicators listed above **offer a broad overview of the potential impact provided by CS projects from a communication point of view**. Indeed, the indicators may also provide information regarding both the **strategy** and the way through which **each project performs its communication** and the - potential - **content** of their messages.

For instance, from Table 3, selecting indicators from the package about scientific impact may be of interest for assessing the effectiveness of communication strategy for those projects that turn towards stakeholders such as academic scientists or policymakers as the main communication target. Furthermore, **while some indicators offer the opportunity to investigate the current status of a project, some others may provide hints on the evolution or trend of impact** according to some intervening variable, as for instance a renovated communication strategy.

Currently, **some of the indicators listed in the tables are reported as questions**. Those questions have a **double value:** on one hand, they bring the information of who will be able to fill the answer thus providing the data; on the other, they show that some indicators are still underdeveloped.

In a first instance, **indicators for NEWSERA should not be interpreted only as tools for an external audit, rather they should be also self-assessment resources that will represent the legacy of NEWSERA as #CitSciComm evaluation tools.** This will contribute to equip projects in the future with a **toolkit of continuous self-assessment**; therefore project managers might be required to collect data through short questionnaires to participants; this may further **promote a culture of impact assessment** also to CS projects that do not enjoy funding from EU schemes or national grants. In a second instance, **some indicators may require refinement** in order to be properly applied for the assessment of #CitSciComm in real-life. As mentioned, this will be developed in WP5, but some general observations are being offered here.

4.1 Combinable impact assessment packages and potential criteria for selecting indicators

The general design of the impact assessment as proposed in this review can **exploit the variety of potential combinations rather than blindfondly apply the full array of indicators.** On the one hand, as said, some indicators may be useful to assess impact across time. This means that the same indicator (see for instance 2.3.i.1 and 2.3.i.2 on political participation stimulated by projects as reported on Table 3) can be applied iteratively to assess the impact of some changes of Communication Strategy within the lifespan of the project. On the other hand, some areas covered by the indicators reported in the tables above may not fit with the actual configuration of the projects.

To give a further example, some indicators are precisely based on social media communication campaigns: although social media are of chief importance in our current society, this does not mean that each project should obligatory invest in social media campaigns. This case may sound paradoxical but it is an extreme case for those projects which are more active on a local basis and may be more interested in investing in direct contact or face-to-face activities.

Indeed, it is very likely that low scores on the bundle of social media indicators (see area 3.1.a. and output indicators 3.1.a.1, 3.1.a.2, 3.1.a.3 in Table 4) may be connected to low scores on connected outcome indicators (Table 4, indicators 3.1.a.4., 3.1.a.5 and 3.2.b.1). For this reason some indicators thought for assessing social media presence would not provide any indication except the low rates on that indicator. The same applies to indicators defined mainly for the assessing potential economic impact: it is not unlikely that CS projects can profit from their activities nonetheless, also according to ECSA ten principles of Citizen Science (Robinson *et al.*, 2018), economic profit should not be the main aim.

We could go further with examples, but the main point here is the **recommendation to follow a hierarchical order for selecting indicators and combine tailored packages**. Indeed, this is not a matter of accuracy, rather it is related to the pertinence: some of the indicators we provided in this outline are quite sophisticated, nonetheless it is crucial to select the most pertinent ones according to the mission of the project.

While some areas related to public engagement are **almost unavoidable according to RRI** (e.g. to public engagement) **as key features of #CitSciComm, a good pack of indicators should rely on the specificities of projects' topic and objectives in order to be selected.** As #CitSciComm is mainly a communicative process, a second level to be taken into account when defining criteria for indicators' selection should be the clear **identification of stakeholders as communicative targets.**

Figure 5. *Sequential logic for indicators selection to be adopted for #CitSciComm impact assessment.*

The order should be as the one proposed in Figure 5, with the topic of the CS project that may already orient the choice of indicators among the three packages.

Also, the stakeholders as communicative targets orient the choice since some communication strategies should not be implemented indifferently; in the context of limited resources (as pointed out before), investing in tools in order to reach some venture capitalists or key firms in the industrial sector may not work adequately for engaging academic scientists. Again, we are proposing perhaps extreme examples, but they are extreme of a wide array of potential combinations.

Such a **variety calls for avoiding a predetermined combination of packages** to be used for the impact assessment of CS. **Tailored solutions** according to the topic and stakeholder as communicative targets should orient the selection of indicators, thus guaranteeing that they will be measurable and useful for the CS projects.

5. Conclusion

What we provided so far is the starting point for addressing a critical issue, the matter of discontent, as we called it. As Schäfer *et al.* (2021) clearly stated in reviewing some key experiences in assessing impact for CS projects, they admitted that it implies dealing with a complex object, always in evolution since the same CS is far from being univocal. **Therefore, it is also hard to provide an univocal interpretation of the different dimension that CS entails**. We tracked the same kind of criticalities also in Science Communication especially in dealing with public engagement (Jensen, 2014; Chilvers and Kearnes, 2016). Both practices and the connected research areas face the issues of impact assessment that is primarily a matter of defining which dimensions should be considered and how to record them.

The NEWSERA project takes stock of the different experiences collected so far, as resumed in the previous paragraphs. **We first stressed the similarities between CS and Science Communication, not only highlighting the limits but also tracing the points in common in the current quest for Open Science**, as required by many funding schemes. Therefore we propose an **operationalization for the new concept #CitSciComm as a way to interpret the issues of impact assessment for the two research traditions,** such as Science communication and CS.

As shown, the several points in common that the two traditions share can be traced in the RRI framework, as a clear reference for both (public engagement, open access, science education). Besides the **points in common,** we have highlighted the **shared problems** connected to impact assessment. Tools for the assessment are currently not totally satisfactory since the complexity of research projects in the real-world is much higher than modellisations.

Therefore, the **NEWSERA proposal calls for enlarging the number of dimensions to be considered.** We propose a **multi-level perspective that brings together RRI, CS and Science Communication;** such perspective is translated into three impact assessment packages of indicators considering experiences already developed across different H2020 project (MoRRI, SuperMo-RRI, ACTION) and the same tools deployed within the NEWSERA consortium, during the first 15 months of activities.

Connecting these packages also implies to **interpret assessment, conveniently tailoring indicators combination, according to the project's characteristics.** Such a perspective does not make things easier, since the potential width of dimensions to be addressed will be other than synthetic. However, relying on the local knowledge of CS projects itself, may reduce the risk of overlooking or, even worse, overemphasize features that are not central to their interests. Next steps will involve a **co-creation campaign with CS projects** that already took part in NEWSERA activities in order to apply the current framework and start testing the NEWSERA multi-level impact assessment packages.

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