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White paper: Themes, objectives and participants of citizen science activities

D4.2

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Executive summary	With this summary, CS Track briefly summarises the main characteristics of the themes, objectives and participants of citizen science activities. This introduction to these topics will inform the development of policy recommendations and best practice manuals for the vastly expanding citizen science field.

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1. A short introduction to citizen science

In short, citizen science (CS) refers to the production of scientific knowledge by non-professionals, for example by amateurs who work as a part of a larger community (Leach et al., 2020). CS activities typically include gathering samples, classifying pictures, analysing data, discussing results or managing CS projects. The extent of amateur science is vast: for example, volunteers observe air quality in Helsinki's heavy traffic areas, locate invasive plant species in their backyards in Brussels and report symptoms of possible COVID-19 infections in Madrid. In short, the diversity of CS reflects the diversity of those who practise it and their societies. A classic example of citizen scientists are birdwatchers, whose efforts on tracking the movements of populations have been an invaluable part of our scientific understanding of birds throughout the 20th and 21st centuries. Indeed, through most of written human history, science has been practised and progressed by non-professional enthusiasts.

Originally, the term citizen science originated from two independent concepts: 1) CS as a tool for social justice, public engagement, equity and democratising science; and 2) CS as projects to which non-professional scientists voluntarily contribute scientific data. However, there is still no one agreed meaning for CS, and the terminology describing volunteer contributions to science is very diverse. Further study of the CS concept can be found in D1.1 (Strähle & Urban, to be published).

CS projects are helping us to further understand phenomena that are complex, labour-intensive and global. For example, with projects like Foldit (https://fold.it/), individuals can further their own and the science community's understanding of the structure of viruses like COVID-19 in an engaging game format. Projects like ISeeChange (https://www.iseechange.org/), provide a platform to report and share unusual local weather phenomena, thus helping to better combat the catastrophic effects of the climate crisis on human societies and on Earth's ecosystems. At its best, CS is a powerful tool that enables

humanity to use its diverse skills in thinking and observation to aid global and cross-species well-being.

In this paper, we introduce the main and emerging themes of CS (section 2), the objectives of CS projects (section 3) and the people involved in CS (section 4), based on existing literature and the grounding theoretical work conducted in CS Track (D1.1).

2. Main and emerging themes of European CS projects

In the last two decades, the use of CS has markedly increased, both in amount and the attention it has received from professional scientists and policymakers (Liu et al., 2017). The main CS project themes tend to be from agricultural, biological and environmental sciences, but there are a growing number of other disciplines in the field (Figure 1). An increasing number of projects are hosted virtually or have online components and technology implemented in them, which adds to the diversity of the field. Modern technology has not only increased the attention CS has received but also increased participation rates (Aristeidou et al., 2017).

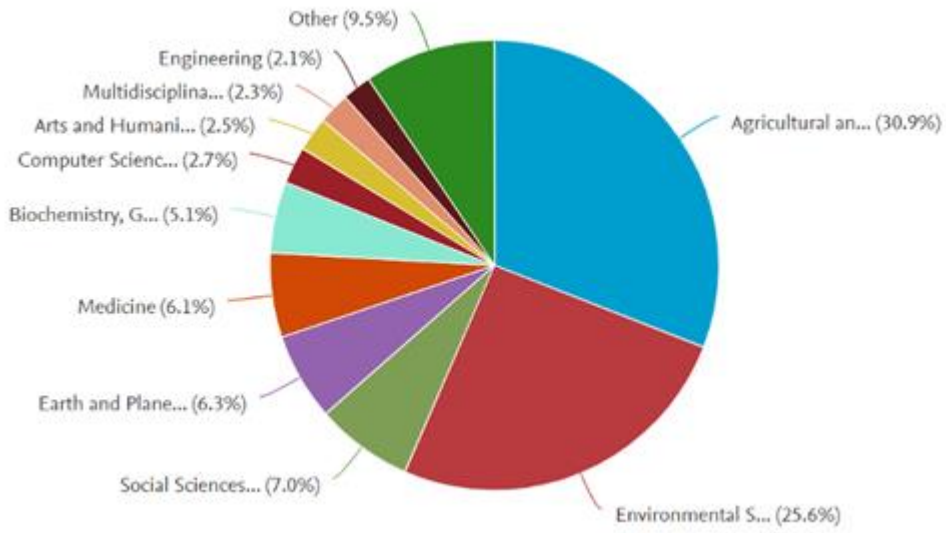

Figure 1: Thematic distribution of review articles in Scopus, as displayed in the D1.1 see subsection 4.4.2 Enablers, barriers, incentives, disincentives for the mainly involved persons by Lampi, Lämsä and Hämäläinen (to be published).

Some scientific fields are especially dependent on research by amateurs. For example, environmental sciences place a strong emphasis on the production of knowledge by amateurs, enthusiasts and hobbyists. The preservation of endangered large mammals, such as wolves, often rests on the information gathered by enthusiasts. Currently, there are simply insufficient financial resources available to collect the vast amounts of data needed without the help of unpaid citizen scientists (Kobori et al., 2016). Keeping this in mind, citizen scientists' work is a crucial link in the production of scientific knowledge, which may also be used to advise research-based policy decisions.

CS and CS activities have been boosted [or invigorated] by the widespread availability of smartphones and related technologies. Nowadays, CS often requires no equipment besides a smartphone. This ever-present device is a boon, especially in fields that benefit from reporting while on the move or for projects that utilise photos alongside GPS data. Accordingly, CS activities have diversified, and new project themes have emerged in addition to birdwatching and amateur astronomy, which have historically been at the forefront of citizen science projects. These emerging themes include applied sciences like engineering, medicine, and government policy-related fields (Leach et al., 2020; see Figure 1). For example, in healthcare, citizen scientists are teaching computer programs to recognise diabetes-related damage to the retina to prevent and diagnose this disability-causing condition. Citizen scientists are also reporting small, everyday things that support and uphold crucial public infrastructure, such as mapping potholes.

A survey conducted by CS Track in the first quarter of 2021 investigated citizen science activities in Europe and beyond. Preliminary results from this survey show that citizen scientists are working in emerging fields like engineering and in other multidisciplinary fields. For example, in the CitieS-Health project, citizen scientists are working to find out how pollution in their environment affects their health (https://citieshealth.eu/). In the CrowdWater project (https://crowdwater.ch/en/welcome-to-crowdwater/), citizen scientists are observing and logging data concerning floods and droughts to better understand their mechanisms and effects. Projects like these have benefited greatly from new platforms and

apps, which enable the gathering of data in unforeseen ways and quantities. Moreover, instead of being restricted to monodisciplinary CS projects, solving wicked problems (such as pandemics or climate change) requires multidisciplinary research collaboration. This multidisciplinary nature of research groups is also manifested in existing CS projects, as shown by the CS Track project's ongoing research (Manske, 2021).

Taking part in CS can also work as a low-barrier introduction to various fields of science that might otherwise be out of reach or difficult to approach. Doing CS in one's chosen field also indisputably contributes to lifelong learning, which has myriad benefits, including, but not limited to, social inclusion, active citizenship and possible professional competitiveness. In the following section, we discuss the objectives of CS projects from the viewpoints of different stakeholders.

3. Objectives of CS projects

CS has enormous potential for advancing and addressing complex social and environmental problems; it benefits society, communities and participants alike. Scientists are able to conduct time-consuming and expensive projects that cannot be done without the support of citizen scientists, and citizen scientists can gain a better understanding of scientific processes. This understanding of scientific principles might prove especially helpful in times when trust in scientific processes creates social unrest, e.g., in COVID-19 related misinformation and the anti-vaccine movements. Additionally, by taking part in science, citizen scientists can further develop their skills and competences and make an impact on society and political decision-making. Generally, CS projects address multiple and overlapping goals that vary from monitoring and research to education, public outreach, social justice and societal change.

The general objectives of CS can be considered from various different viewpoints. First, citizens are participants in CS projects, which can include anything from wildlife observation in one's local area to folding proteins in a gamified manner from the comfort of one's own home. Second, from the viewpoint of researchers and research institutions, both have a stake

in CS activists to produce, process and manage data that can later be used in scientific research. Third, the goals of societies, policymakers and local communities benefit directly and indirectly from the communication and mutual learning between lay and professional people. For a more in-depth discussion of CS, the reader is encouraged to consult D1.1 Framework Conceptual Model by Strähle & Urban (to be published).

3.1 Participants

To maximise the benefits of CS projects for all involved parties, it is vital to understand why people participate. For many people, the reasons are related to general interest in the theme or topic (e.g. environmental projects), a desire to help and personal growth. Additionally, meeting new people, engaging in a community and feeling like an integral part of a team or scientific process is an important motivating and engaging factor. Especially for projects that support participants' values, the opportunity for groups to come together and participate in collective change efforts can be empowering (see Table 1).

Interest in theme or topic	Desire to help	Social recognition
Monetary reward	Personal growth	Engaging in a community
Contributing to scientific research	Values	Fun and enjoyment
Benefit for career	Sharing existing knowledge with others	Possibilities to learn

Table 1. Common reasons for participating in CS projects (Lampi et al., 2020)

However, it is important to note that different people have different motivations for participating in CS; participants may hold many motivations at once, and the significance of different motivations varies across projects. Therefore, careful planning, designing and implementation of the project plays a major role in creating accessible, motivating projects that benefit everyone involved.

3.2 Scientists and research institutions

In recent years, professional scientists and research institutions have started to notice the great potential of CS at international, national and local levels (Liu et al., 2017). Using the help of citizen scientists is an opportunity to collect large amounts of information that would otherwise be costly, time-consuming or difficult to acquire. Advances in technology also allow more effortless interaction between professional and citizen scientists and enable new ways to analyse, collect and discuss ideas and practicalities related to the project. CS is also a way to enhance social interaction.

3.3 Society

Educational and outreach perspectives, which are often seen as major goals of CS programmes, are closely intertwined with societal changes and political decision-making. Goals could consist of creating data to provide evidence to influence politics, launch legal processes and advocate for local concerns, as the scope of CS can be broad enough to be relevant for issues such as conservation. Especially in the field of environmental sciences, engaging citizen scientists in research processes has often led to practical actions and positive impacts in local communities. From an educational perspective, some projects mainly aim to share knowledge or enhance informal science education.

4. People involved in CS

Science done by enthusiasts has historically been an integral part of increasing and improving scientific understanding. This holds true even in today's age of compartmentalised scientific disciplines and paid employment of professional scientists (Leach et al., 2020). Citizen scientists are not homogenous groups: they engage in CS activities for various reasons, motives and backgrounds (Ceccaroni et al., 2017), and it goes without saying that different themes, objectives and designs attract different types of people. However, understanding who participates in CS and who does not is important, as limited information restricts our understanding of the issues related to the opportunities, the barriers, the diversity and the welcoming aspects of CS.

Existing information on citizen scientists' demographics (e.g. age, gender, race, ethnicity and socioeconomic status) is very limited and hence inadequate for clear conclusions. Most studies have focused on a single project or programme, which may result in biased data: in astronomy projects, for example, an older male audience tends to be typical (Price & Lee, 2013). Moreover, some groups (such as youth) are underrepresented in the available data, which further biases the data (Pandya & Dibner, 2018). More research on the topic is much needed to better understand CS and those who take part in it.

Despite the limited research, the existing data indicates that well-educated, affluent participants seem to outnumber less affluent participants, and in many programmes male predominance has been observed. Typically, citizen scientists seem to be white, middle-aged, scientifically literate or generally interested in science or scientific topics (Blake et al., 2020; Curtis, 2018; Pandya & Dibner, 2018). At least in agricultural, biological and environmental science-based programmes, the participants have often been found to be scientists themselves, science teachers or students, conservation group members, backpackers or hikers or other outdoor enthusiasts – in other words people who enjoy nature (Cohn, 2008).

It is equally important to note who or which groups do not participate in CS. Even if projects are welcoming to everybody, certain societal or age groups may be missing from the projects – for example, the number of minority participants in CS projects is generally relatively low, making it less likely for them to reap the benefits of CS (Evans et al., 2005). Additionally, community and youth citizen science projects are underrepresented in the available data (Strähle & Urban, to be published).) Unfortunately, current data does not indicate how or if the project's scientific area is related to participant demography (Strähle & Urban, to be published).

Poor representation of genders, societal or age groups is not consistent with a democratic approach to science, and a limited diversity of citizen scientists might result in issues related to equity, diversity and inclusion (Pandya & Dibner, 2018). Obviously, the participants and who they are shape the ultimate outcomes of the project (Blake et al., 2020).

5. Conclusions

Citizen science is a complex, multi-layered phenomenon that offers a variety of opportunities for participants, scientists and societies. In addition, the CS field is equally diverse in its themes, objectives and the participants' socio-demographic backgrounds. Research into the participant demographics is crucial to maximise the potential and benefits of CS, as noted by Strähle & Urban (to be published). One of the many ways that CS track project remedies this is by conducting a survey to investigate the current state of CS and its participants in Europe and beyond. This online survey enables us to acquire much information from a large sample of people (n=1057), providing state-of-the-art knowledge about themes, such as citizen scientists' socio-demographic backgrounds. The survey results will be available in summer 2021. These results together with other CS track studies (e.g. vast data collections and analysis) will further illustrate the current state of the art regarding the themes, objectives and participants of CS activities.

References

Aristeidou, M., Scanlon, E., & Sharples, M. (2017). Profiles of engagement in online communities of citizen science participation. *Computers in Human Behavior*, *74*(1), 246–256.

Blake, C., Rhanor, A., & Pajic, C. (2020). The demographics of citizen science participation and its implications for data quality and environmental justice. *Citizen Science: Theory and Practice*, *5*(1), 21.

Ceccaroni, L., Bowser, A., & Brenton, P. (2017). Civic education and citizen science: Definitions, categories, knowledge representation. In L. Ceccaroni & J. Piera (Eds.), *Analyzing the role of citizen science in modern research* (pp. 1–23). IGI Global.

Cohn, J. P. (2008). Citizen science: Can volunteers do real research? *BioScience*, *58*(3), 192–197.

Curtis, V. (2018). Patterns of participation and motivation in Folding@home: The contribution of hardware enthusiasts and overlockers. *Citizen Science: Theory and Practice*, *3*(1), 5.

Evans, C., Abrams, E., Reitsma, R., Roux, K., Salmonsen, L., & Marra, P. (2005). The Neighborhood Nestwatch Program: Participant outcomes of a citizen-science ecological research project. *Conservation Biology*, *19*(3), 589–594.

Kobori, H., Dickinson, J. L., Washitani, I., Sakurai, R., Amano, T., Komatsu, N., Kitamura, W., Shinichi Takagawa, S., Koyama, K., Ogawara T., & Miller-Rushing, A. J. (2016). Citizen science: A new approach to advance ecology, education, and conservation. *Ecological Research*, *31*(1), 1–19.

Lampi, E., Lämsä, J., & Hämäläinen, R. (2020). *D4.1: Towards understanding the forms of participation and knowledge-building activities in citizen science projects*.

Leach, B., Parkinson, S., Lichten, C., & Marjanovic, S. (2020*). Emerging developments in citizen science: Reflection on areas of innovation*. RAND Corporation.

Liu, H. Y., Grossberndt, S., & Kobernus, M. (2017). Citizen science and citizens' observatories: Trends, roles, challenges and development needs for science and environmental governance. In G. Foody et al. (Eds.), *Mapping and the citizen sensor* (pp. 351–376). Ubiquity Press.

Manske, S. (2021). Are citizen science projects multi-disciplinary research activities? https://cstrack.eu/graphical-article/cs-projects-multi-disciplinary-research-activities

Price, C. A., & Lee, H.-S. (2013). Changes in participants' scientific attitudes and epistemological beliefs during an astronomical citizen science project. *Journal of Research in Science Teaching*, *50*(7), 773–801.

Strähle, M. , & Urban, C. (to be published) *D1.1: Framework conceptual model*.