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Citizen Science in Germany as Research and Sustainability Education: Analysis of the Main Forms and Foci and Its Relation to the Sustainable Development Goals

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Abstract: Many citizen science projects are in the thematic area of species observation and natural environment monitoring but, in recent years, projects in other areas and disciplines have increasingly been using citizen science approaches. It is assumed that citizen science could potentially contribute to an increase in environmental awareness and to advancing knowledge about environmental change and sustainability issues. In this article, we present a review of 127 citizen science projects listed on the German platform, "Bürger schaffen Wissen", with the aim of analysing whether the main focus of most projects is on the scientific results or on educational aspects and how citizen science projects are connected to the SDGs. The results show that many citizen science projects overlap with SDG 4 *Quality Education*. Of these projects, a larger proportion entail higher levels of involvement than those projects with a stronger focus on the scientific results, in which the participation of the citizen scientists is mainly standardised and at low levels. An even greater number of projects in the sample are linked to SDG 15 *Life on Land* and, thereby, are in line with the traditional focus of citizen science. Additionally, the analysis reveals that forms of education used in citizen science projects are much more diverse than those included in SDG 4.

Keywords: citizen science; Sustainable Development Goals (SDGs); sustainability

1. Introduction

Many citizen science projects operate within the area of the natural sciences, especially biology, and deal with topics such as the occurrence of species (e.g., the British Trust for Ornithology's projects) [1]. The results from projects such as the study on the extinction of insects by the entomological association Krefeld, Germany [2], have contributed both to scientific knowledge and to the public discussion on anthropocentric environmental degradation. However, many citizen science projects focus on environmental education, scientific communication and other areas (e.g., [3,4]). Studies in the fields of social sciences and humanities are also increasingly adopting the citizen science approach (e.g., [5,6]).

In addition to the direct research results, citizen science can raise awareness about the environment amongst the citizen scientists themselves through data collection, species observation and other activities [7]. In addition, the practical outcomes of citizen science could possibly contribute to sustainable development by protecting animals (e.g., project "Striped AmBASSador") [8], removing plastic waste from rivers (e.g., project "Plastikpiraten") [9] or generating new knowledge about a species and its protection (e.g., projects "TurtleSAT","MantaMatcher") [10,11].

Many of these topics—biodiversity, the occurrence of certain species and education itself (often environmental)—are the focus of the Sustainable Development Goals (SDGs), such as SDG 15 *Life*

on Land, SDG 4 *Quality Education* or SDG 11 *Sustainable Cities and Communities* [12]. The 17 SDGs are part of the United Nations "Agenda 2030 for Sustainable Development", which superseded the Millennium Development Goals. In September 2015, the member states of the United Nations agreed on this agenda and the goals and, in doing so, pledged to promote inclusive sustainable development. Sustainability as a goal had already been recognised at the Rio Earth Summit in 1992 and in the World Commission of Environment and Development's 1987 report, "Our Common Future". In that report, sustainable development was defined as an approach "to ensure that it meets the needs of the present without compromising the ability of future generations to meet their needs" [13]. The role of the local level and the participation of NGOs and citizen groups were highlighted at these early conventions on environmental protection and sustainability (e.g., Agenda 21) [14]. Although at that time citizen science was not overtly discussed at the conventions, it became a possible means of collecting the necessary environmental data and a potential route for public participation. Since the adoption of Agenda 2030 in 2015, the agenda itself and the 17 SDGs are frequently used as reference material for sustainable development in the context of politics, civil society projects and research.

To identify to what extent citizen science projects currently relate to topics mentioned in the SDGs, how the thematic foci are distributed over the 17 goals and which forms of citizen science are used, we take an in-depth look at a sample of German citizen science projects.

This article aims to analyse how citizen science projects in Germany are connected to the SDGs and which SDGs they mainly impact. Is the main focus of most citizen science projects the actual scientific results or the educational aspects? Both focal points could help to achieve the SDGs by creating new knowledge about species, as well as by increasing awareness of species protection and education. In order to answer the research questions and to find out more about how citizen science links to the SDGs, the article presents the results of an analysis and comparison of the 127 citizen science projects listed on the German citizen science platform, "Bürger schaffen Wissen" [15] ("citizens create knowledge", own translation) to reveal their potential impact on the SDGs.

The following chapter gives an overview of common definitions and categorisations of citizen science, as well as relevant findings about their advantages compared to other research approaches. Section 3 gives a short overview of the connections and potential overlaps between citizen science and sustainable development. The criteria for the analysis deduced from the citizen science literature and the research approach and methodology of this article is then briefly explained in Section 4, before Section 5 presents the results of the analysis, followed by a summary and discussion of the results.

2. Citizen Science as a Participatory Research Approach

2.1. Origin and Characteristics of Citizen Science

The citizen science approach is characterised by the participation of citizens in research processes [7,16]. In citizen science, the participants are not just the objects of investigation or respondents to questionnaires; they perform scientific tasks. In other words, citizen science is "scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions" [17]. In recent years, internet and new technologies have made data collection and processing, as well as the communication between citizen scientists and professional scientists, much easier [7,18–21]. Citizen science originates in the area of natural sciences and originally described projects where citizens played a role in data collection, e.g., on the distribution of species or by observing and identifying comets and asteroids [19,22]. In such cases, citizens support science by collecting data, but citizen scientists can be involved more deeply than simply in terms of data collection. The Greenbook for the German Citizen Science Strategy 2020 outlines the different approaches and intensities of participation and defines citizen science as:

> "[. . .] the engagement of people in scientific processes who are not tied to institutions in that field of science. Participation can range from the short-term collection of data to the intensive use of leisure time in order to delve deeper into a research topic together with scientists

> and/or other volunteers. Although many volunteer scientists do have a university degree, this is not a prerequisite for participating in research projects. However, it is important that scientific standards are adhered to. This pertains especially to transparency with regard to the data collection methodology and the open discussion of the results." [23] (p. 13)

This highlights a number of important characteristics of citizen science, which will be considered further in this article: the fact that citizen scientists use their leisure time to work as volunteers in research projects; the prerequisites of the participants, especially educational background; and the scientific quality criteria and communication of the research results. In the following paragraph, issues surrounding the type and intensity of participation will be further discussed.

2.2. Types of Citizen Science and Forms of Participation

To distinguish between the different forms and intensities of involvement, Haklay [22] identifies four levels of participation in citizen science projects: crowdsourcing, distributed intelligence, participatory science and extreme citizen science. Crowdsourcing is at the lowest level of participation, where participants provide the computational power of their personal computers or the sensors of their smartphones for a research project but are not involved cognitively. In projects using the distributed intelligence approach (the classic type of citizen science), volunteers collect or interpret data according to a specified classification defined by the professional scientists. This type of citizen science is also called contributory citizen science and is the most familiar [5]. Participatory science, the third level, requires deeper engagement by the citizen scientists, as they are involved in the problem definition and the choice of data collection method. The analysis and interpretation of the data are carried out with the assistance of scientists. This approach is also called collaborative citizen science [5]. In the case of extreme citizen science or co-created citizen science [5], the citizens are involved in all stages of the research process from the problem definition to the publication of the results. This can sometimes even take place without the involvement of professional scientists [22].

The higher the level of participation, the greater the levels of engagement and understanding required from the participants [5]. The participants are often already interested in the issue, have prior knowledge and want to learn more about the topic. According to Haklay [22], more men than women participate in citizen science, most of them have a good educational level and a comparably high income. Often, extreme citizen science and participatory science, which require deep involvement by the participants, are easier to conduct in applied research and in areas close to the everyday experience of participants as this motivates them to participate and develop research questions and solutions with the professional scientists [22].

To identify whether a project qualifies as citizen science research, or is simply information collected by citizens on a certain topic, Haklay [22] recommends that projects should be considered to be citizen science where the participants themselves frame the research as citizen science and where they follow established scientific methods. West and Pateman [5] define citizen science projects as those where the focus lies on the collection or processing of scientific data through volunteers. In addition, depending on the scientific community and the type and intensity of involvement of the citizens, the concept of citizen science also has similarities, and in some cases overlaps with, other research approaches such as transdisciplinarity [19,24].

2.3. Aims of Citizen Science and Critical Reflection of the Approach

The main goals of citizen science are described as the production of scientific knowledge, positive outcomes for the participants (such as learning new skills and knowledge) and positive effects on social and ecological systems (such as animal protection, influence on management or political decision making) [7,25]. For each goal, a certain type of citizen involvement may be helpful; for example, standardised contributions in term of data collection may be useful for setting up large datasets [25]. Co-created approaches could empower citizens to address questions relevant to their

communities and develop adequate solutions [20]. However, Chase and Levine [18] observe that in many cases the different project goals of education, research and policy are difficult to combine and may produce trade-offs.

Several authors note reservations and doubts concerning citizen science and the quality of the data collected. However, they argue that by using standardised approaches to data collection, training the participants and employing other methods of quality control, results from citizen science projects should not be considered as less reliable than data collected without the involvement of non-professional scientists [20,21,26,27].

Many citizen science projects also aim to create a positive effect on the public perception of science. However, to date only a few studies have dealt with this issue. Brossard et al. [28] analysed the effect of a bird observation project and were unable to find evidence of a positive impact on the perception of science or scientific processes and, therefore, formulated recommendations about how to increase such potential positive impacts of citizen science.

3. Citizen Science and Sustainable Development

In terms of the link between citizen science and sustainable development, Pettibone et al. [19] assert that, "Although not explicitly oriented towards sustainability outcomes, citizen science takes place in relevant areas, such as biodiversity and climate change". In addition, according to the "White paper on citizen science for Europe" [29], stronger connections between science, society and politics are needed to deal with global challenges such as sustainability issues. Strengthening citizen science as a type of science–society interaction could be one possible path. In this context, the authors of the white paper emphasise that schools and pupils are an important target group for citizen science projects.

West and Pateman [5] also see the potential for citizen science to contribute to sustainability and highlight three areas where citizen science could help to achieve the SDGs. Firstly, citizen science could help to define national and subnational targets and metrics for each SDG. Secondly, with the help of volunteers, citizen science could contribute by monitoring progress towards achieving the goals. This aspect is also mentioned by other authors who argue that huge datasets are required to accurately measure such progress, which is time intensive and costly. Citizen science approaches make it possible to gather large datasets, which would otherwise be broadly unfeasible [7,20,26,27,30]. Thirdly, West and Pateman [5] expect that participation in citizen science projects would have a positive effect on the environmental awareness and behaviour of the volunteers. Citizen science could help to increase awareness and change behaviour concerning sustainability and to motivate citizens to further engage in sustainability issues. The studies by Evans et al. [31] and Toomey and Domroese [32] also show positive impacts on the civic engagement and environmental awareness of participants in citizen science projects. In addition, Richter et al. [16] demonstrate that in many cases where there is intense interaction between the citizen scientists and the researchers, the citizen scientists show higher environmental awareness after participating in the projects. This raised awareness is produced both through rational learning and through the emotional and personal experience with the issue. Other studies (e.g., [28]), do not indicate significant changes in the environmental awareness of participants.

This third area points to the educational aspect of many citizen science projects, especially environmental education, which shows some overlap with SDG 4 *Quality Education*. The issue of learning and education is also included in other goals. Target 12.8 in SDG 12 *Ensure Sustainable Consumption and Production Patterns* demands that, "By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature [12]."

There is not a specific SDG that focuses on research itself; however, certain areas of applied research are included in several of the SDGs as a way of enhancing knowledge about certain issues, such as medical innovations, new power production techniques or improvements in educational systems [12]. These and other research-related targets are mentioned in SDG 2 (agricultural research),

SDG 3 (medical and pharmaceutical research), SDG 7 (renewable energy research and energy efficiency), SDG 9 (increased research spending and support of research in the area of technology and innovation in developing countries), SDG 12 (support scientific capacity of developing countries, research on sustainable consumption and production, tools to monitor sustainability impacts of tourism) and SDG 14 (marine research).

4. Method and Sample for the Review of Citizen Science Projects

To establish how most citizen science projects are connected to the SDGs, which goals they impact the most and if the focus of most citizen science projects is on the scientific results or on the educational aspects, we reviewed the 127 citizen science projects listed on the German citizen science platform, "Bürger schaffen Wissen" (see buergerschaffenwissen.de/projekte). Citizen science projects can be added and project descriptions changed by the project coordinators continuously. The analysis is based on the status on 6 June 2019 with 127 projects listed (for the full data, see Table S1). Our analysis was oriented towards Schreier's [33] description of qualitative content analysis (QCA) and involved looking at a number of assumptions mentioned in the literature. We chose the platform "Bürger schaffen Wissen" as our sample because it contains a large number of citizen science projects in Germany in different research areas, scientific institutions and time frames with comparable project descriptions formulated by the partner institutions themselves. Therefore, it provides a good overview of the existing citizen science projects in Germany, their aims, target groups and possibilities for participation by citizen scientists. The project descriptions are formulated by answering a number of questions, which means they are standardised to a certain degree. In the analysis, these project descriptions were reviewed and analysed deductively in terms of the following aspects: degree of involvement of the citizens, openness/prior knowledge required of the citizen scientists, target group for the scientific results, project focus, relation to one or several SDGs and type of research (see Table 1).

The degree of involvement was categorised following the four types described by Haklay [22] (see Section 2), ranging from projects using distributed computing techniques (crowdsourcing), projects where citizens collect or code data according to standardised and very detailed instructions (distributed intelligence), participatory science (where citizens are involved in all or most steps of the research process), to extreme citizen science (where professional researchers are not involved at all). If a project incorporated several of these approaches, it was categorised according to the most intense level of participation used.

To find out whether the observations of Haklay [22] and Bonney et al. [20] were applicable to our sample—that forms of citizen science with a higher degree of involvement are easier to conduct in areas of applied research than in fundamental research areas, while standardised forms of contribution are seen to be more useful for setting up large datasets, and co-created approaches, such as participatory or extreme citizen science are more adequate for solution-oriented research (see Section 2)—we additionally categorised the projects in terms of fundamental and applied research. Based on the OECD definitions [34], we understand applied research to mean scientific knowledge generation "directed primarily towards a specific practical aim or objective", while basic or fundamental research has no specific intended use.

As many authors (e.g., [22,23]) observe that many citizen scientists have a high level of education and are already interested in the project topic, we also looked further at the required prior knowledge or assets of the citizen science projects to find out whether most of them address specific groups or whether they are open to everyone. We categorised this into two groups: (a) projects open to all, which do not require any specific knowledge or assets; and (b) projects addressing a specific group with prior knowledge or assets. In addition, two other aspects mentioned in the literature were also considered [5,7,23] (see Section 2). These were, firstly, the target groups of the scientific results, i.e., if the results were shared with the public and the citizen scientists or only published in academic journals; and, secondly, the focus of the research project. This aspect was included because several authors, e.g., [7,18,25] mention both the scientific results and educational aspects as goals of citizen science,

but Chase and Levine [18] specifically observe that these could produce trade-offs. We assume that citizen science projects with an educational focus would tend to demand higher degrees of involvement than projects with a strong focus on high quality scientific results. In order to analyse this aspect, we categorised the projects in the sample into (1) projects with a focus on the research results and (2) projects with the research process as a learning process and the capacity-building of its participants as their main goal.

Table 1. Categories of analysis.

Category	Subcategory	Example
Overlap with, or intended effects on, SDGs	SDGs 1–17	Attribution to an SDG does not mean that the SDG is explicitly mentioned, but that issues mentioned in this SDG are also mentioned as project goals. For example: SDG 4 *Quality Education*: research-based learning in the case of "KölnErforschen" [35] SDG 13 *Climate Action*: research on trees for cities in times of climate change in "TreeChecker" [36] SDG 15 *Life on Land*: collecting information on different neophyte species in "Erforsche Neophyten mit!" [37]
Degree of involvement of the citizens [22]	Crowdsourcing	Distributed computing in "Seti.Germany" [38]
	Distributed intelligence	Animal observation and recording in "Stadtwildtiere Berlin" [39]
	Participatory science	Joint development of research design, research question and data collection in "Patient Science - Patienten schaffen Wissen" [40]
	Extreme citizen science	Research conducted independently by non-professional researchers as in "KölnErforschen" [41]
Type of research [34]	Fundamental research	Collecting information on insects in "Insektensommer" to produce scientific knowledge on insects [42]
	Applied research	Researching plastic waste on the coast to develop solutions for the global plastic waste problem in "Dem Plastikmüll auf der Spur" [43]
Openness in terms of the participants	Open—no required prior knowledge or assets	Anybody with a smartphone living in Europe can participate in "FotoQuest Go" [44]
	Closed—specific assets or knowledge required	Only people with bee colonies, up to three pollen traps, colour vision and internet access can participate in "C.S.I. Pollen" [45]
Target group for the scientific results	Narrow	Scientific results are only used by researchers in "Chimp&See" [46]
	Medium	Scientific results are available on the project homepage in "Citclops" [47]
	Large	Scientific results are presented at an online conference and published on a website in the case of "Jetzt ist Zähltag!" [48]
Focus of the project	Research	Research results are the focus and are used for further scientific work in "Die Apfelblütenaktion" [49]
	Education	Students develop solutions to social, economic or ecological problems in "YES! Young Economic Summit", with the aim of increasing their competencies [50]

To code the 127 projects listed on the platform, one researcher read all the project descriptions and coded the projects qualitatively according to the abovementioned criteria, which was later validated by a second researcher. After starting the coding process, it was reviewed to adapt the codes and the coding rules where necessary. Two modifications were implemented regarding the project focus

and the type of research. After completing the qualitative coding process, the codes were quantified and interpreted in order to see, e.g., the distribution of the projects to the SDGs and indications for possible correlations between the categories, e.g., between the degree of involvement and the research focus. However, as we conducted a QCA with a non-representative sample, we cannot claim proven correlations. As the analysis revealed differences between the forms of education mentioned in the SDGs and in papers such as the "White paper on citizen science for Europe" [29] and the forms used in the projects of the sample, we further looked at this aspect in our data analysis.

The aim of the review was to analyse how the citizen science projects are connected explicitly or implicitly to the SDGs and where potential contributions to meeting the SDGs lie. Are there any SDGs which are addressed in most of the citizen science projects? Due to its origins in natural sciences and especially biology, one of our hypotheses was that there is a focus on SDG 14 *Life below Water* and SDG 15 *Life on Land*. In addition, because learning through participation in citizen science projects (both environmental education and a general increase in knowledge and skills) is often mentioned as a goal of citizen science [7,25] (see Section 3), it was our aim to find out how citizen science projects link to SDG 4 *Quality Education* and in which thematic areas such education takes place.

5. Results

5.1. Relation of the Citizen Science Projects to the SDGs

The analysis of 127 citizen science projects listed on the platform, "Bürger schaffen Wissen", showed that 12 of the 17 SDGs are addressed by at least one project (see Table 2). Issues relating to SDG 7 *Affordable and Clean Energy*, SDG 8 *Decent Work and Economic Growth*, SDG 10 *Reduced Inequalities* and SDG 16 *Peace, Justice and Strong Institutions* were not addressed in any of the project descriptions. The two SDGs most commonly addressed by the citizen science projects were SDG 15 *Life on Land* (48 projects) and SDG 4 *Quality Education* (33 projects). Consequently, the results reflect both the origin of the citizen science approach in areas such as biology and its strong connection to educational aspects.

Table 2. Number of projects dealing with issues relating to each SDG.

	SDG	Number of Associated Projects
1	No Poverty	0
2	Zero Hunger	3
3	Good Health and Well-being	11
4	Quality Education	33
5	Gender Equality	1
6	Clean Water and Sanitation	1
7	Affordable and Clean Energy	0
8	Decent Work and Economic Growth	0
9	Industry, Innovation and Infrastructure	7
10	Reduced Inequalities	0
11	Sustainable Cities and Communities	10
12	Responsible Consumption and Production	5
13	Climate Action	21
14	Life below Water	7
15	Life on Land	48
16	Peace, Justice and Strong Institutions	0
17	Partnerships for the Goals	1

Note: A single project could be a linked to several SDGs. For categorisation see Section 4.

5.2. Sustainability Education and Scientific Results

Looking in more detail at the projects in the sample, most of those with a focus on education are in the area of education for sustainable development, such as "Plastikpiraten" [9]. Education for sustainable development is mentioned in target 4.7 in the Agenda 2030. The other targets of SDG 4 focus

on institutionalised education in schools and universities and, as mentioned above, the European white paper on citizen science calls for a focus on schools as a target group for citizen science projects [29]. However, the citizen science projects in our sample generally focus on less structured forms of learning; only 11 of the 127 projects in the sample are specifically designed as school projects.

In the SDGs, these other forms of education (such as lifelong learning and upskilling) are only mentioned in the context of education for sustainable development but, in our sample, a few projects focus on topics such as learning about local history or culture. Overall, the analysis shows some overlap between the education focus of the citizen science projects with the SDGs; however, the areas and forms of education are more diverse in the citizen science projects than in the SDG 4 targets.

According to their project descriptions, most of the citizen science projects in the sample seem to focus on scientific results rather than on education and learning through participation. In terms of the research focus and the goal of producing new knowledge through citizen science, the analysis showed that most citizen science projects are in the area of applied research (118 of 127 projects). Only a few can be categorised as fundamental research. This also fits with the Agenda 2030, as research per se is not included in the SDGs, but an increase in—and the support of—applied research in the areas of agriculture (target 2.a), medicine and pharmaceuticals (target 3.b), renewable energy (target 7.a), technology and innovation (targets 9.5 and 9.b), sustainable lifestyles (target 12.8) and the marine environment (target 14.a) are included. Another target of the Agenda 2030 is the support of research in developing countries. This aspect, however, is not addressed in any of the citizen science projects in the sample.

5.3. Levels of Participation

The analysis shows that most projects with a higher degree of participation are applied research projects, while the few projects in the area of fundamental research use only low levels of citizen participation, i.e., crowdsourcing and distributed intelligence. This observation is in line with the assumption formulated by Haklay [22] that applied research and topics close to the everyday life of participants provide more straightforward opportunities for participatory science and extreme citizen science than topics that are more abstract and distant from participants' experiences. Concerning the potential contribution of citizen science to the SDGs by either defining specific targets or by monitoring progress [5], there was no clear evidence of this in any of the projects. It is, nevertheless, possible that some projects could indirectly contribute in this area by species observation and the collection of large datasets.

Looking at the sample, many more projects are categorised as crowdsourcing and distributed intelligence projects than as participatory or extreme citizen science projects with the associated higher levels of involvement (see Table 3). This means that the classic form of citizen science, where participants help with simple but cognitive activities such as bird observation, is still representative of the majority of projects in the sample. However, we assume that crowdsourcing will become easier and more common because of new technologies and the increasing use of computers and smartphones.

Table 3. Levels of participation in the citizen science projects.

Level of Participation	Number of Associated Projects
Crowdsourcing	42
Distributed intelligence	68
Participatory science	15
Extreme citizen science	2

Levels of participation: Haklay [22]. For categorisation see Section 4.

In addition, the analysis indicated a connection between low levels of citizen scientist involvement (e.g., distributed intelligence) and a strong focus on high quality scientific results. In contrast, it also showed that many of the projects with high levels of involvement (e.g., participative science) focus on

educational aspects. Overall, of the projects in the sample, more have low levels of involvement than high levels. In projects with high expectations of reliable scientific results, researchers appear to choose low levels of participant involvement.

One possible explanation why projects focusing on high quality research results avoid a high level of involvement and only allow the participation of non-scientists in clearly structured data collection is because the researchers fear that an open co-design process could reduce scientific quality. On the other hand, in terms of educational goals, researchers appear to assume that these may be better reached with higher intensities of citizen scientist involvement. This question is beyond the scope of this article but offers fruitful opportunities for further research.

A further reason for choosing low levels of involvement could lie in the fact that higher levels require a greater investment of time by the citizen scientists and also, in many cases, higher levels of prior knowledge and skills. In some cases there are also other preconditions for participation; such conditions could include a limited number of citizen scientists or specific requirements, such as being a beekeeper or having access to a garden. These preconditions can limit participation for some but, at the same time, serve as an incentive for participation for those who already spend their leisure time involved in the issue in question.

In addition, looking further at the openness of the citizen science projects in our sample, we observed that low-level participant involvement in the research process, or using only a narrow group of volunteers, did not always correspond to low involvement of non-scientists in the presentation of the research results. In 93 of 127 cases, the research results were available to a wide audience including the citizen scientists; the results were not limited to publication in academic papers for the narrow research community.

6. Conclusions

The analysis indicated that the largest group of citizen science projects focuses on issues relating to SDG 15 *Life on Land*, which reflects the original research area of citizen science. The second largest group of projects deals with aspects linked to SDG 4 *Quality Education*. However, we observed differences in the forms and understanding of education between the citizen science projects and SDG 4. While SDG 4 focuses on institutionalised education in universities and schools, citizen science projects that directly address schools are rare in our sample (only 11 of 127). Target 4.7 in the SDGs refers to education in the broader concept, in the context of education for sustainable development, and here there is some overlap with citizen science projects that aim for lifelong learning and general upskilling also in other than sustainability related issues.

Research is not a goal in itself in the SDGs. However, certain areas of applied research are included in several of the SDGs as a means of enhancing knowledge, some of which are also referred to in the citizen science projects. The vast majority of the projects in our sample are in the area of applied science. Deep involvement of the participants appeared to be easier and more frequent in applied research than in fundamental research. In addition, it was striking that projects with a high level of involvement, such as those using a participatory science approach, seemed to have a tendency to focus more on educational aspects.

In addition, the analysis showed that to date few projects have dealt with two aspects mentioned by West and Pateman [5]: monitoring the progress made in achieving the SDGs and defining specific regional or national targets. However, our research only covers the 127 projects listed on "Bürger schaffen Wissen" at the time of conducting this study; results could differ for other samples. The analysis did not aim to unravel the impact of the citizen science projects on specific targets of the SDGs or on the monitoring process, but to see which thematic areas were addressed by the projects and which research approaches they use. Following our research results, we suggest that greater attention should be paid to aspects such as monitoring progress and defining targets, which are promising areas where citizen science could contribute to sustainable development in future projects. Moreover, we advocate

for future research projects to focus on other SDGs that have not yet been addressed, such as SDG 7 *Affordable and Clean Energy*.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/12/15/6044/s1, Table S1: Sample of citizen science projects.

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