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Technological Innovations for Citizen Environmental Participation: Case of Poland

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Abstract: Citizen science is a social innovation that has recently been recognized by social initiatives as a possible tool to increase participation, build knowledge, and raise civic awareness. In order to work efficiently, citizen science requires the adoption of proper technological solutions by a critical mass of people. According to the Unified Theory of Acceptance and Use of Technology, people are more likely to adopt a technology that is compatible with their norms, values, and beliefs. In our research, we studied technological solutions that Polish environmental civic initiatives are using in order to diagnose their potential to implement citizen science projects and increase citizen participation. We interviewed 28 board representatives, managers, and initiators of social movements and conducted desk research of 65 social movements in Poland. Every technological solution was recorded and later categorized. The diagnostic analysis of the technological advancement of grassroots movements in Poland reveals that the full potential for launching citizen science projects has not yet been reached. First of all, the recognition of the citizen science approach is still low. Secondly, grassroots movements operate using standard and easily accessible technological solutions, rarely developing tailored and more advanced technologies that would enable people to be involved in citizen science projects.

Keywords: technology; technology innovation; citizen science; environmental grassroots movements; non-governmental organizations; polish environmental NGOs

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1. Introduction

Citizen science is a practice that utilizes the ability and willingness of citizens to be involved in the process of knowledge creation. In citizen science projects, citizens who are not scientists gather information about themselves or the elements of their environment to generate new knowledge that can be used to build awareness among members of the local community or to create tailored solutions to the local problems. Through bottom-up, joint action, citizens learn how to use the scientific approach to gain better understanding of local needs and make data-driven decisions. In that way, citizen science is an example of social innovation, in which citizens take an active role in changing the world around them. They influence the design and implementation of novel practices which aim to improve the welfare and wellbeing of individuals and communities. This understanding of citizen science satisfies the definition of social innovation set by the Stanford Center for Social Innovation [1] or OECD [2]. Moreover, it meets the criterion developed by Brandsen et al., who find social innovations as 'those that, created mainly by networks and joint actions in social realms beyond business and government routines, at any given moment, raise the hope and expectations of progress towards something "better"' [3] (p. 6).

The navigation of joint actions and networks has recently become simpler than ever. 'Widespread adoption of Information and Communication Technologies (ICT), in particular smartphones and social media, allows for easily accessible and innovative ways for disparate and numerous voluntary and professional researchers to work together' [4]. And citizen science is a social innovation that requires the adoption of the proper technological solutions by a critical mass of people in order to work. If people are not familiar with the

technological solutions that citizen science projects require, extra effort to convince them to join the project could be necessary. In such a scenario, the initiator of the citizen science project needs not only to get people interested in the problem that the project refers to but also to promote the adoption of an unknown technology.

According to the Unified Theory of Acceptance and Use of Technology [5], the perceived likelihood of adopting a technology depends on four key constructs, including facilitating conditions: 'the degree to which an individual believes that an organization's and technical infrastructure exists to support the use of the system' [5] (p. 453). Facilitating conditions can be understood as the compatibility of an innovation with the norms, values, and beliefs of the targeted population. People are more likely to accept technological innovation if it feels familiar, as it is perceived as less risky. Compatibility with past experience, values, and norms is also listed as one of predictors of behavioral intentions to use innovation in Rogers' Diffusion of Innovation Theory [6]. If the innovation is very different from what people in a given region have been using so far, the adoption process might take longer (or even not happen at all) than if the innovation fits in with the current practices. Users' perspective on technology is one of the most significant factors influencing the adoption and usage of mobile data collection technologies [7].

In Europe, tech-based citizen science projects are heavily implemented in topics relating to both the physical and natural environments, but as Sanabria-Z et al. [8] pointed out, there is a great need for the development of native/in-house technologies. In our article, we first demonstrate the kinds of technological solutions that grassroots movements in Poland are using in general, then we focus on social activists' attitudes toward technology and citizen science as a social innovation, and finally we discuss how the existing technology can be used in managing citizen science projects. It is an explorative study showing how well grassroots movements are prepared to be active initiators of grassroots knowledge production that engages members of local communities and what kind of technological technologies they accept. Additionally, we investigate the convictions of social activists about citizen science initiatives in order to explore if grassroots movements' representatives share the optimism of authors such as Mahajan et al. [9] or Roger et al. [10] on the subject.

We analyze NGOs and grassroots movements that operate in Poland because Poland is a relatively new democracy in which civil society is just emerging. Although Poland has been a member state of the European Union since 2004, it was transformed into a democratic republic only in 1989. Before 1989, Poland was in the Soviet sphere of influence and was ruled by a communist government which did not allow for the formation of civil society. Currently there are 138,000 formally registered NGOs in Poland [11]. By comparison, in France, which is almost twice as large in terms of population, there are 1,100,000 associations, i.e., ten times more [12]. The level of activity in the field of volunteering remains rather average when compared to some other European countries, like Denmark, France, or Switzerland. In Poland, 15% of respondents declared that they conducted volunteer work in the last 6 months, while in Norway it was 47% [13]. The lowest score of 6.7% belonged to Serbia. Poland took 24th place out of 36 European countries that were included in a study. Citizens of Ukraine, Italy, Romania, Slovakia, and Hungary declared a similar level of engagement in volunteer work. Most of the mentioned countries, just like Poland, belonged in the past to the Soviet sphere of influence.

1.1. Role of Citizens in Citizen Science

Citizen science has gained its popularity in many different fields, for example, in biology, where people collect data on the movement and habitats of different species [14]; environmental studies, where citizens monitor water pollution [15]; education, where students acquire practical knowledge on science and technology [16]. Recently, citizen science has been noticed by policymakers and activists as a tool for enhancing participation of citizens in the public sphere [17,18]. 'The effort to share, negotiate, and translate science so it can be used by policy and society has become an area of growing interest to academics and practitioners' [19] (p. 293). The rationale behind the idea is that citizens should not

only be allowed, but also encouraged to get involved in knowledge-building processes. The participation of citizens in such initiatives is believed to have a positive influence on local communities. It is supposed to 'help in addressing societal issues in a collaborative manner' [9] (p. 3) and build trust [20,21], understanding, engagement, and a sense of agency, to name just a few.

Many examples show that 'citizen science has the potential to provide a monumental shift in our ability to monitor the environment while simultaneously increasing understanding and trust in science within the broader community' [10] (p. 449). However, the positive effects of involvement in citizen science depend on the character of said involvement. The level of citizen engagement differs among projects. In some projects, people are only asked to collect data, while in others they are encouraged to formulate research questions and analyze data. Several scientists have attempted to divide citizen science projects according to the level of citizen involvement [22]. Haklay [23] identified four types of citizen science from the least to most engaging ones. In the first, participants act just as "sensors" (crowdsourcing); in the second, citizens can also make interpretations of results (distributed intelligence). In the third type, citizens are additionally asked to define the problem by themselves and choose the method (participatory science). In the most engaging type of projects, citizens actively participate in the entire scientific process (extreme citizen science). In a similar manner, Boney et al. [24] divided citizen science projects into three types: contributory (where participants collect data for scientists), collaborative (where participants do not only contribute the data, but also submit their own ideas or help with data analysis), and co-created projects (where citizens are actively involved in each step of the scientific process).

The most common types of citizen science projects are those that involve citizens on a basic level, where their participation is limited to data collection [25]. In these kinds of projects, the potential of participants is not fully used [23] and does not contribute to the empowerment of communities. Meanwhile, Shirk and collaborators [26] have argued that a co-created approach is crucial in the process of building empowered communities.

1.2. The Role of Technology in Citizen Science Projects

The practice shows that citizens can be involved in any stage of the research process, from designing the research question to publicizing the results. However, no matter what kind of involvement from citizens is sought by the initiator of the citizen science process, the execution of engagement would be hard without proper technological solutions. Technology facilitates any step of the research process. It helps to spread the information about the initiative among citizens, collect data in a systematic manner, access databases, and analyze the data. Previous study on water management has shown that 'The development of a shared understanding on complex [. . .] issues requires technical access to data and knowledge, a shared process memory (knowledge and dialogue platform) as well as stakeholders who are sufficiently open-minded to find new solutions' [27] (p. 11). With proper technology, citizens are able to do all of this in just a few clicks. A well-designed platform or a mobile app is essential for maintaining long-term citizen science projects [28].

The practice and, most of all, data show that the third sector is aware of the advantages that proper technology gives [29]. Specific technologies like computer vision, acoustic monitoring, radar, and molecular methods revolutionize the monitoring of insects [30]. Blockchain technology contributes to geospatial data-point sharing and validation [31]. Widespread usage of ICT enables monitoring food prices in Africa in real time [32] or observing invasive alien species, which allows for visualizing the spatial distribution of these species [33]. The development of biosecurity surveillance technologies and citizen science initiatives also contributes to the understanding of forests and tree health biosecurity [34]. Without this technological advancement, citizens would struggle to deliver results in a coordinated manner.

1.3. The Role of Technology in NGOs and Grassroots Movements

Access to new technological solutions changed not only the functioning of citizen science projects but also the work of grassroots movements and NGOs. It had a great impact on the third sector [35–37]. In particular, Jaskyte et al. [36] noticed that using information technology (IT) can increase the organization's capacity for accountability, benefit relationships with stakeholders, and positively influence the organization's public image. Bach and Stark et al. [38] stated that even such common technological tools as the Google search engine can allow non-profit organizations to collaborate more efficiently. They also came to the conclusion that digitized tools facilitate aggregating and analyzing data, which can be later transformed into inclusive and accessible knowledge. Raman et al. [37], on the other hand, researched how the adoption of SMAC (social media, mobile, analytics, cloud) helped organizations meet their mission goals and improve organizational effectiveness.

Recently, many scholars have focused their research on the role of social media in the activities of non-governmental organizations [37,39,40]. According to Namisango et al. [39], social media facilitated the work of the third sector and helped obtain better results. Social media is a low-cost technology [36] that enables to reach multiple audiences such as potential donors, volunteers, or the local community [40]. Moreover, social media empowers marginalized groups with limited resources and gives them the opportunity to tell their story without any intermediaries [41]. It can facilitate networking and establish cooperation with various entities, such as local governments or other non-governmental organizations [39].

In addition to basic information technologies, there are cases where NGOs use more advanced technologies such as VR, but they remain rather limited. Visual technologies are intended to provide viewers with a "see for yourself" kind of experience, which may allow for donors to see the presented problem in a more empathetic way [42]. The potential of using VR in citizen science is great, however, still underexplored.

In other words, research shows that non-governmental organizations adopted social media quite fast and in an effective manner. They know how to use technology to reach out to people and manage coordinated processes with its help; therefore, they might seem like natural initiators of citizen science projects. However, these projects require specific tools that support all the steps of the research process, from the development of research questions to the dissemination of outcomes through the collection of data and its analysis.

In our work, we examine how technology used in NGOs and grassroots movements facilitates citizen science.

2. Materials and Methods

Two research methods were employed to diagnose the level of technological innovation of non-governmental organizations: desk research and semi-structured interview. We started with desk research of grassroots movements working for the protection of the environment in Poland, with particular emphasis on formal organizations and non-formal bottom-up movements dealing with the protection of biodiversity in Poland, mainly trees. Initially, we identified 45 non-governmental organizations and social movements using the Google browser and Facebook. All identified grassroots movements had a website and/or page on social media platforms. The search was conducted from April 2021 to May 2021. The following keywords were used: non-governmental organizations, NGOs, environmental organizations, non-governmental environmental organizations, and nature protection organizations. By applying the snowball sampling technique, we expanded the initial list of Polish environmental NGOs on organizations and initiatives suggested by either social media algorithms or interviewed representatives. Finally, we compiled a list of 65 formal and informal environmental grassroots movements, including 30 associations, 17 foundations, and 18 social initiatives from different parts of Poland (almost all Polish regions, except for Łódzkie Voivodeship) with a diversified scope of activities related to urban greenery, sustainable cities, protection of tree alleys, forests, natural reserves, national parks, and rivers, as well as environmental education and nature inventory

(see Supplementary Materials for a complete list of organizations). The vast majority of organizations/initiatives operated locally (65%), while the remaining 35% were operating nationwide. The studied organizations/initiatives differed in terms of their experience, counted in years of activity from 2 to 35 (on average 12 years).

In order to deepen our understanding of the technological solutions used by grassroots movements, we sent emails/text messages through social media platforms to organizations with a request to participate in the interviews. In the invitation, we introduced ourselves and the aim of the study and asked our respondents to sign a consent form if they agreed to participate in the study. A total of 27 out of all organizations/movements expressed their willingness to take part in the interviews.

The interviews were conducted with a total of 28 people from 9 foundations, 10 associations, and 8 informal groups (including two members of one informal group) from 28 February to 18 April 2022, via the Zoom platform (22 interviews), a mobile phone (5 interviews), and Microsoft Teams (1 interview). In the case of one informal group, we interviewed two of its members. The interviewees were board representatives, managers, and initiators of the formal and informal organizations. Altogether, 15 men and 13 women took part in the study. The interviews lasted from 27 min to 152 min.

The semi-structured interviews included five sections. In the first section, we gathered general information about the organization, like its size, areas of activity, aims, and most frequently undertaken actions. Questions in this section allowed us to screen out organizations that did not fit into the characteristics of the organizations we aimed to study. In addition, from the responses in this section, we were able to evaluate the level of variation between studied organizations. All of the organizations operated in the area of nature protection, but they acted in various geographical locations. The second section is devoted to the examination of the technological solutions used by the organizations. Here, we were interested in finding out (a) the general approach of the interviewee to the adoption/application of technology in the activities of the third sector, (b) the role of technology in their activities (whether they use technology and what for), (c) which technology is used to collect and aggregate data, (d) existing practices on sharing the collected data with other entities, (e) the innovativeness of technological solutions—the extent to which the grassroots movements were using existing solutions and/or custom-made applications.

The third section of the interview was designed to provide us with information about people involved in the activities of the organizations, both formal and informal. We were interested in identifying actions in which volunteers most willingly got engaged and tasks they were ready to take on. Here, we also examined the volunteers' motivations and the potential benefits of non-profit activities.

The fourth section included a series of questions about cooperation with various entities, including state institutions, media, and other non-profit organizations. We wanted to find out the extent to which technological solutions are transferred from one organization to another.

Finally, in the fifth section, we were asking the interviewees if they are familiar with the citizen science term/concept.

Every technological solution identified in desk research and analysis of interview transcripts was recorded in the database and later categorized. We used the six-step research process as a framework for categorization, which is a modification of Kothari's [43] research process. Kothari's research process consists of seven major steps that a researcher needs to take in order to effectively carry out research. These are (1) definition of the research problem, (2) literature review, (3) formulation of hypothesis, (4) design of research, (5) data collection, (6) data analysis, (7) interpretation of data and reporting. In our framework, the first step of the research process is (1) the development of the research question and hypothesis, which is backed by the literature review, followed by (2) choice of the study design, (3) data collection, (4) processing and analyzing of data, (5) formulation of conclusions, and (6) communication of results. We divided Kothari's seventh step into two because the interpretation and dissemination of data require different tools. By using the

proposed research process, we could diagnose which steps of the research process in citizen science can be supported easily by technological solutions that are already in use by NGOs in Poland and which ones are missing.

The coding process consisted of two stages: initial coding and focused coding [44]. Initial coding was conducted to identify all possible themes related to technology and citizen science. During the focused coding, we identified specific technologies, attitudes toward technologies, and attitudes towards citizen science.

3. Results

In order to show the technical advancement of studied grassroots movements and their potential to facilitate citizen science projects in the future, we divided the results into four subsections. First, we report on technologies that are used by grassroots movements. Secondly, we describe the experience of social activists in running citizen science projects. Thirdly, we depict the attitudes of interviewees towards technology and technological innovations. Last, we show to what extent technologies that interviewees are familiar with can support different stages of the citizen science process.

3.1. Overview of Technological Solutions and Their Purpose

Altogether, in text materials obtained from websites and interview transcripts, we found and coded 45 different technological solutions. Most of them (78%) accounted for software. The software used in grassroots movements differed in terms of novelty and specificity. Some were very well-established and widely used technologies like emails, social media platforms, or newsletters, while others were unique, tailor-made applications, like an application for tracking barriers on rivers. Examples of hardware that appeared in the analyzed material were much rarer and mainly referred to tools that could be used for collecting and recording data, for example, drones, camera traps, voice recorders, or NO_2 sensors.

The technological solutions served different purposes in researched organizations/initiatives and met diverse needs, e.g., the need for communication, organization of events or protests, spreading information, promotion, self-organization, activating citizens, education, collecting data, and data visualization. Many of the technological solutions are multifunctional (they serve various purposes at the same time), so it is hard to split them into separate subsets. However, we have managed to distinguish two rough subsets: (1) technologies used for communication, activation, and self-organization and (2) technologies used for building knowledge and civic awareness.

The most popular tools used for communication, activation, and self-organization were social media platforms that facilitate widespread and open communication between an unlimited number of people (Table 1), like Facebook, Instagram, or YouTube. The popularity of social media platforms is so high among NGOs and grassroot movements that one-quarter of them do not even use more traditional media to disseminate information about their activities, like websites. Surprisingly, technologies used for the management and exchange of messages are much less adopted by NGOs and grassroots movements. Beyond Messenger and e-mails, only a few researched respondents reported the use of technologies like Slack or Zoom (six organizations mentioned using Zoom and four said they were using Teams). Even after the COVID-19 pandemic, the popularity of tools that could support online management and work organization is quite low.

It should be noted here that the number of NGOs and grassroots movements using technologies for messaging and team management may be underrepresented in our study, because organizations/movements do not always publish online information on these particular technologies. Therefore, it is advised to look at these counts taking into account the number of interviewed representatives of organizations/initiatives, i.e., 27 rather the number of identified organizations/initiatives, i.e., 65.

Table 1. A list of technologies used for communication and information spread.

Technology *Text Messaging and Management*	**N of GMs** [1]	**Technology** *Social Media*	**N of GMs**	**Technology** *Other*	**N of GMs**
Messenger	19	Facebook	64	Website	47
E-mail	61	Instagram	20	Newsletter	1
Zoom	6	Youtube	17		
Teams	4	Twitter	16		
Signal	1				
Slack	1				
ClickMeeting	1				
Secret communicator for activists [2]	1				

[1] GMs stands for grassroots movements and NGOs. [2] The interviewee did not want to reveal the name of the communicator.

The activation of citizens is a very important role in many grassroots movements and NGOs. They see the strength in collective actions. In order to receive support in an organized manner, some NGOs and grassroots movements use helpful tools like platforms for online petitions (6), crowdfunding platforms (2), and internet browser extensions that highlight online retailers, allowing their consumers to deduct and donate a small percentage of their payment to the NGOs of their liking (1).

The second subset of technological solutions is composed of tools that support educational/research activities carried out by NGOs and grassroots movements. We have identified 30 such technologies. They differ a lot and serve various means. Some are based on materials prepared solely by experts, like webinars, podcasts, and infographics (Table 2). A webinar is the most popular method. Others require active engagement and an influx of data from external stakeholders, like companies, public institutions, and citizens. In this case, the richness of knowledge depends on the quantity and quality of data incorporated into the database.

Table 2. Technological solutions that support grassroots movements/NGOs (GMs) in the dissemination of knowledge prepared by experts.

Technology	**N of GMs**	**Technology**	**N of GMs**
Webinar	14	Online games	2
Podcast	3	Game based on Minecraft (Eco craft)	1
Infographics	4	E-learning platform	1
Story map	1		

In order to facilitate the gathering and visualization of data, NGOs and grassroots movements use special tools, like online maps. In the studied sample, we found out that 21 organizations (32%) used a geographic information system and online maps for the visualization of the gathered data (Table 3). The most popular tool for that was the free-of-charge Google Maps followed by ArcGIS and GEO-SYSTEM.

Table 3. Tools used for visualization of data on maps.

Technology	**N of GMs**	**Technology**	**N of GMs**
Google Maps	13	Open Street Map	5
ArcGIS	9	Geoportal	1
GEO-SYSTEM	2		

Sometimes, NGOs and grassroots movements adopt very specific applications that allow all citizens or specific groups to collect data or study data gathered by others (Table 4). In these applications, users can add their recorded observations of nature (e.g., trees, dams on rivers, animals, weather, soil) to existing databases and see what others have added.

Most applications of this type we identified were internationally recognized for citizen science projects like Amber (https://portal.amber.international, accessed on April 2022) or GLOBE program (https://observer.globe.gov, accessed on April 2022). Only two apps were locally developed: Radomskie Drzewa app and the Water Dam app.

Table 4. Specific applications for collaborative data collection and visualization.

Technology	N of GMs	Technology	N of GMs
CheckTrees	3	GLOBE Observer app	1
iNaturalist	2	Water Dam app	1
Radomskie drzewa *	2	Natura List	1
Amber App	1		

* An application for mapping trees in the city.

The data must be gathered before being visualized; therefore, sometimes NGOs and grassroots movements invested in technological solutions that enabled data collection and documentation of the state of nature (Table 5). Photo cameras were the most typical tool. More advanced equipment, like NO_2 sensors or endoscope cameras, were used only by a few organizations.

Table 5. A list of technologies used for data collection.

Technology	N of GMs	Technology	N of GMs
Photo camera	18	Dictaphone	2
Smartphone	9	NO_2 sensor	2
GPS	9	Telemetry devices	1
Camera trap	3	Endoscope camera	1
Drone	2	Mini video camera	1

3.2. Experience and Attitude towards Citizen Science Projects

In this section, we present data revealing the attitude of civic activists towards citizen science. Because it would be hard to analyze the online material in this respect, we report here only the data from the interviews we carried out with social activists. In particular, we show how many interviewees were familiar with citizen science initiatives, what their opinion was on the subject, and whether their organization has implemented or is planning to start any activity in that field. In case the interviewee had not heard about citizen science before, we described it to them and asked their opinion on the idea. We explained the term to them as a collaborative project in which citizens collect and analyze data with professional scientists.

Our analysis revealed that the concept of citizen science is not yet fully recognized by NGOs and grassroots movements. Only a small majority (56%) of the interviewed members of the organizations were familiar with the concept before the interview, while 41% did not know anything about it (one respondent could not answer the questions regarding citizen science because of the time constraint).

Most interviewees, even those who had not encountered the term "citizen science" before, were positive about it (93%). They thought that such projects could play a very important role in activating/empowering citizens, especially those from marginalized groups, who are not involved in current processes of decision making in the public sphere. One of the interviewees said:

> *"I think it is something that gives a chance to participate to people who do not have opportunities to get involved in other ways [. . .] It is certainly a huge benefit for people who need a goal and want to feel useful [...]. I also think that if a volunteer gets caught up in an initiative and starts looking for various data, he or she can identify another problem that can be processed and solved in a bottom up manner. I think the spectrum of possibilities is really gigantic."* (Interviewee U)

Interviewees also believed that projects like these can contribute to building critical thinking skills, public debate, and civic awareness among citizens:

> *"I rate this idea very highly. Citizen science can promote a culture in which one has to support their own views with facts, be able to defend their opinions, but also be ready to move away from them to some extent."* (Interviewee H)

> *"I see a great value in expanding knowledge and awareness. This awareness and knowledge can increase people's willingness to actively engage in nature conservation."* (Interviewee I)

> *"I perceive it [citizen science] not only as a method of gathering knowledge in a given field, but also as an opportunity for gaining analytical skills, which is an important characteristic of civil society that should be able to make more rational election decisions."* (Interviewee W)

What interviewees also like in citizen science projects is that they can serve kids in their education and scientists in their pursuit of knowledge. With the help of numerous citizens, research that requires vast data collection can be conducted relatively fast, e.g., some declare that species inventories in particular can be prepared faster and more accurately. The positive effects of outsourcing data collection on speed of performing research were often underlined.

> *"From a strictly scientific perspective, data collection by citizens is helpful on many levels.[...] When there are more people, like in cities, who use these applications, species are well researched, especially those more interesting for people, such as bird species or some larger insects. I see a lot of value in this."* (Interviewee I)

> *"Citizen science allows studying many things that a normal, single scientist would not be able to do."* (Interviewee D)

> *"[Citizen science] can speed research up, I don't know if it started with the observation of celestial bodies, but there are so many of these stars that when someone focuses on one, they cannot see what is happening with the other, so when there are more pairs of eyes, it can all be done faster."* (Interviewee W)

Although the majority of comments on citizen science were positive, some interviewees expressed their concerns regarding the quality of the data that are collected by non-professionals:

> *"[...] this data is to some extent unverifiable. And when such information is collected by a specialist, he or she does it at the right time, writes it down in a proper manner and even takes photos that are legible. Very often I have seen data of very poor quality collected by residents, people uploaded photos that were unreadable."* (Interviewee C)

> *"[...] I wonder if processing of specialized data by non-specialists is not burdened with too much error [...]."* (Interviewee D)

> *"I would say so intuitively that it makes no sense. Who would correct it, who would check it and who would check the credibility of these sources, as if to verify everything. [. . .] I am not convinced of this method, but I am not against it. I don't know, maybe I'm old fashioned."* (Interviewee R)

Another risk identified by the respondents is a low level of participation among citizens. If not enough data are gathered, the conclusions can be biased or no conclusions can be made at all.

> *"[...] I remember a project where people for Greenpeace Poland were supposed to photograph bees and send photos... Nothing good came out of it. It was impossible to analyze it, probably not enough people sent these photos."* (Interviewee K)

Out of 26 social activists we interviewed, only 4 (15%) declared that they had done projects that could be defined as citizen science. In two cases, these were activities dedicated

to everyone, while in two others just to children. The first one, The Natural Forests project, targeted all citizens. It was a project in which citizens were encouraged to mark forests that they personally valued on a map.

> *"[...] for example the National Forests, that is, [an initiative] in which citizens point to forests that are valuable in their subjective opinion. We would not be able to find this out by ourselves [. . .] Data that people provide shows us what they like, so it is also definitely a citizen science."* (Interviewee D)

The other project was a swift counting initiative. The citizens were willing to help mark swift nest locations on Google Maps.

In the case of two other organizations/initiatives, these were more educational projects that were implemented in schools. The first one was a part of an international project, GLOBE Observer. Students, with the help of teachers, catalogued nature elements like soil and water in their vicinity using the GlobeApp. Data from Poland, together with data from many other countries, were entered into a public database.

The second project was conducted in the area of Dolnośląskie Voivodeship. Children in this area were involved in activities connected to observing climate change. Students, with the help of teachers, monitored different species or measured the level of air pollution in their neighborhood. Later, they presented the results to their classmates. From what the interviewee said, the students did not use any particular technology to collect the data.

At the time of the interview, two organizations (7%) declared that they are planning to implement some kind of citizen science project in the future. One member stated that as soon as they receive funding, they will start taking action related to citizen science. The other said that they have already tested an application (iNaturalist) and want to use it during planned nature walks with residents.

3.3. Attitude towards Technology

Most of the interviewees spoke positively about technology (17). They believed that technology is offering many opportunities to improve the work in the third sector. For example, it facilitates collecting, aggregating, and processing data (8) and also enables the transfer of knowledge in a simple and transparent way for the receiver (8).

> *"[Radomskie Drzewa application] allows you to integrate information about the condition of city trees on one server. [...]. An ordinary user may [...] report that the tree has been cut down. And [...] we have this information right away."* (Interviewee N)

> *"[...] We deal with data in geographic information systems (GIS). Geoportal is an interface through which this data can be viewed or compiled. [...] You can create a Geoportal where this data is not provided with complicated descriptions, but you can simplify the content [...] and show it in a very popular and illustrative way."* (Interviewee A)

The interviewees mentioned that technology, mainly social media, greatly facilitates communication and establishing cooperation with other entities (n = 5). Additionally, it enables the promotion of projects carried out by the organization, publicizing important issues and activating people (n = 11).

> *"[W]hen it comes to establishing cooperation, social media is a great help and a very powerful medium."* (Interviewee C)

Respondents also appreciated the hardware itself, which not only improved their work but also allowed them to collect the evidence needed for administrative proceedings (n = 3).

> *"[W]e are very protechnological and it definitely helps in many of our activities [...] We started using a drone and flew this drone into places that we could not enter [...]."* (Interviewee D)

However, despite most interviewees being positive about technology, lack of financial resources and time prevented some NGOs and grassroots movements from using specific technology tools (n = 3).

> *"Anything that can improve the work [...] is very much appreciated, but unfortunately it all costs money. Drones are very cool, you can attach a camera to the drone with various great functions, but it costs tens of thousands of zlotys. [...] So it is a question of funding."* (Interviewee C)

Running social media accounts requires time and commitment from members of the organization. If enough resources are not devoted to the account, it will affect the site's reach.

> *"Even the closest friends often do not see our posts. [...] I do not know exactly how it works, but I feel something is wrong, someone has switched something off, and that if you do not pay, the posts will not reach many people. [...] Certainly, the algorithms limit us."* (Interviewee X)

Some respondents admitted that they do not rely on more complex technological solutions that could help them do their jobs (n = 4).

> *"[I]n the case of an ordinary tree inventory, we mainly use tape to measure trees, a voice recorder, a rubber mallet and sometimes a probe, so very simple tools."* (Interviewee C)

> *"[W]e do not use any sophisticated technologies, because they are not needed for anything. [...] The only technological equipment we use is actually related to communication."* (Interviewee J)

The COVID-19 pandemic played an important role in the extent of the use of technology in NGOs and grassroots movements. Some members of the organization admitted that they started using certain technological tools because they had no other option. For example, due to health risks, they began to meet and discuss important issues via videoconferencing applications.

> *"We tried through the Internet, via Zoom and so on, but it made me very nervous, and it wasn't like a real conversation. Real conversation is more natural and not so fake."* (Interviewee X)

Although some members of the organizations noticed the shortcomings and limitations of technology, no respondents refused to implement it. Only one interviewee reported that he did not fully understand how Facebook algorithms work and had objections to using videoconferencing applications. However, he spoke positively about the hardware (cameras and drones) and admitted that it facilitates their data collection. Another social activist found it easier to get people interested in a real face-to-face conversation. However, this did not mean that she was against the implementation of technology. Her organization used Facebook to inform residents about their actions.

3.4. Technological Solutions That Might Support Citizen Science Process

Citizen science projects apply a traditional research process which can be divided into six stages: (1) development of the research question, followed by (2) choice of study design, (3) data collection, (4) processing and analyzing data, (5) formulating conclusions, and (6) publishing the results. In the most inclusive variant of citizen science, it should be possible for citizens to engage in any stage of the process. The coordination of the interaction of citizens in citizen science cannot be done without proper tools. In this subsection, we explore the capacity of technological solutions that NGOs and grassroots movements in Poland use to support different stages of the research process.

Stage 1. Development of research question. We found out that only a few technological solutions used by NGOs and grassroots movements might support the first stage of the research process (Table 6). These are the technologies that facilitate the exchange of information and discussion among large groups of people, like Signal, Messenger, or Zoom.

Among the technological solutions, we can differentiate those that support video conferences/meetings (ClickMeeting and Zoom), simple exchange of text messages (Messenger, e-mail, Signal, and secret communicator), and those that allow for managing group work (Teams and Slack). The most popular technologies among studied NGOs and grassroots movements were email (27) and Messenger (19). Neither of these technologies seems to be effective for developing research questions with a large group of people, as they offer barely any structuring or organization of messages. It is hard to make any voting with these tools or to conduct a discussion in which the content could be divided into threads. In that sense, Slack or Teams, adopted by only five organizations (19%), seem to be more suited for the goal.

Table 6. Technologies that could support research question development.

Technology	N of GMs	Technology	N of GMs
Messenger	19	Signal	1
E-mail	27	Slack	1
Zoom	6	ClickMeeting	1
Teams	4	Secret communicator for activists *	1

* One interviewee did not want to provide the proper name of the communicator because of the security reasons.

The lack of specific tools that could be used for discussing research questions might be why NGOs and grassroots movements prefer to define the topic of their explorations by themselves. They are open to suggestions, but they make a final call on whether or not they will pursue them by themselves. The discussion on the issue of the research question or topic is reserved to a rather narrow group of members who have the power of making such a decision. With such an approach, NGOs and grassroots movements do not utilize full grassroots potential, nor do they fully empower local communities [23].

Stage 2. Choice of study design. The second stage—the choice of study design—is similar to the first one, because it requires a technology that could support an exchange of views within a large group of people. Potentially, the discussion on the study design could be covered by the same technologies that are able to facilitate the first stage of the research process. However, the discussion on the choice of the study design should be constrained by the technologies for data collection (stage 3), as well as the processing and analysis of data (stage 4) that can be used by citizens on a mass scale. The past experience of NGOs and citizens with technologies for collecting data will affect the probability of using them in future studies.

Stage 3. Data collection. In citizen science, data collection is a stage of the research process that engages a high number of active participants. The higher the number of citizens collecting the data, the more accurate the analysis. Therefore, the technology used for data collection by citizens should be easily available, cheap, and user-friendly to be able to attract anybody potentially interested in this kind of activity and should not discourage those who have already decided to participate. Moreover, interaction with technology should be intuitive for people with lower technical skills and limited time for engagement.

NGOs and grassroots movements chose to use camera traps, GPS locators, and of course smartphones most often. These tools alone enabled gathering a lot of nature-related data like photos, voices, videos, geographical coordinates, and direct data transfer. The grassroots movements use different technologies for data transfer. It can be either an app that guides citizens' actions step by step or it can be an email address to which citizens can send their data. In the studied sample, nine organizations used applications that allowed citizens to enter the collected data directly into the database. They used six technologies listed in Table 4, all except for Radomskie Drzewa. These technologies support the active interaction of citizens with data, i.e., entering and curation of data. The access to the tools might be restricted to those with authorization.

In two cases, the studied organizations prefer the data to be sent to them via email so they could first review it before publication in the database or on the map. The data quality management is a big issue and can consume a lot of resources [45].

Stage 4. Processing and analyzing data. There are two main types of tools that are needed in this stage of the research procedure. First of all, researchers need tools to conduct analysis of the data, either quantitative or qualitative. Secondly, they need tools to visualize the data. Some of the studied NGOs and grassroots movements collected data with geographical coordinates for which they used geographic information systems like ArcGIS (9) or GEO-SYSTEM (2). For the visualization, organizations used online maps, like Google Maps (13), OpenStreetMap (5), or Geoportal (1). The mobile apps and www interface systems that NGOs and grassroots movements used to support citizen participation often had built-in maps like OpenStreetMap.

Altogether, one-third of studied organizations used online maps for visualization, but only 17% used proper geographic information systems. The usage of maps can have positive effects on the local community, as it helps its members to develop a common understanding of the situation. Moreover, interactive maps have been indicated by Borowski-Maaser et al. [27] as a method of building trust within the community. Sullivan et al. [46] also reported that the decrease in the gap between data reportage and presentation of results increases citizens' (fishermen, in their case) willingness to invest in the process of citizen science.

Stage 5. Formulating conclusions. Discussion is the most important element in the process of formulating conclusions. People review the outcomes of the research in light of existing knowledge on the subject. In the case of citizen science projects, there might be potentially many participants in such a discussion; therefore, the tools used at this stage should support the evidence-based communication of many stakeholders. Only two technological solutions that are currently used by NGOs and grassroots movements seem to be appropriate for such tasks: Teams and Slack, and they are used by only five organizations/movements.

Although this stage is a crucial one for the development of cognitive comprehension of the problem among members of the local community and building a common vision that enables a synchronized reaction, it cannot be well-supported on a large scale by any technology we identified. In the absence of technological support for this process, conclusions can be driven by a smaller group of people, which in turn might negatively affect the transparency of the process, level of trust in developed conclusions, and willingness of citizens to get involved in future projects [26].

Stage 6. Publishing results. Publishing the results of the research is a very important step of the process because if done correctly, citizens and policymakers can obtain new knowledge which can be later used for making informed decisions. This stage can take different forms, from publishing simple text or graphics to creating games which utilize knowledge gained from the research. The NGOs and grassroots movements use many tools to communicate the results of their activity to a wider audience. The most popular were social media like Facebook (64) or Instagram (20) or posts published on the website (47). More interactive tools for sharing knowledge, like webinars, are less common—only 22% of studied organizations adopted them. Using other tools, like story maps, infographics, and games (for example, Ecocraft, a game based on the Minecraft engine), was very rare in the studied sample.

4. Discussion

Our research shows how Polish environmental grassroots movements and NGOs perceive citizen science and technology and what technological tools are being used to manage social projects. Such a comprehensive view allowed us to answer the question of to what extent Polish grassroots movements and NGOs are ready to accept and implement technological innovations that enable streamlining all stages of the citizen science process. In many cases, the adoption of novel technology by NGOs and grassroots movements is

a prerequisite for efficient facilitation of high citizen involvement in all kinds of citizen science projects, but especially in the most engaging type of citizen science project, i.e., extreme citizen science, as Haklay et al. named it [23], that engages citizens in all stages of citizen science, from the formation of the problem and development of research questions to the communication of results. The low adoption rates of technological innovations can have negative effects on society. In the for-profit sector, it has been found that low adoption of technological solutions generate a negative impact on social sustainability performance and innovation [47]. The same may apply to the non-profit sector.

The results indicate that in Poland, the concept of citizen science is still new and not fully recognized. The awareness rate in the studied sample was rather average, as only 56% of respondents had heard about the citizen science before the study. The actual implementation rate of citizen science is even lower; only 15% of respondents had carried out a citizen science project in the past. Although two organizations declared that they are planning to implement the citizen science project in the future, the pace of the adoption of the social innovation is rather low.

Nonetheless, once we explained to respondents what citizen science is, they expressed a positive attitude towards it. This positive attitude can in future translate into behavioral intention, according to Ajzen and Fishbein's Theory of Reasoned Action [48]. In particular, the interviewees noticed that citizen science projects could be a key element for empowering citizens and for building ecological awareness, which is consistent with Haywood's [49] remark on the potential of social participation in building a "sense of place" among citizens. The collaborative aspect of citizen science was also seen by interviewees as a great advantage, which confirms the outcomes of Mahajan et al. [9].

Citizen science, in the eyes of respondents, has a positive impact not only on the functioning of the local community, but also on the development of science and education. A significant number of scientists who studied citizen science have reached similar conclusions. For example, Gardiner et al. [50] noticed that involving citizens in research is more cost-effective and has a positive effect on the quality and quantity of the collected data. However, we found out that respondents in our study have some concerns over whether citizen science should be treated as a Holy Grail. The biggest concern was the accuracy of the data. The problem of data accuracy has been already raised by many scientists [19,51] before, especially in the context of policy development [52]. For policymakers and scientists, high-quality data are a necessary condition for taking advantage of citizen science in their practice [53].

The technological advancement of studied non-profit organizations and grassroots movements was rather average, although the overall attitude towards technology was positive. Respondents especially appreciated social media, which facilitate communication and cooperation as well as the promotion of projects. The most popular technological tools among studied organizations are Facebook and Instagram, which are widely used in their activities. Our findings are in line with the results of the Technology Report from 2019 which shows that "90% of NGOs worldwide regularly use social media to engage their supporters and donors and 84% use Facebook" [54]. The third sector communicates and establishes cooperation with other entities through social media but can also use them to share important information, report on their activities, and promote their projects [39].

Respondents also expressed positive views about e-platforms and websites that enabled them to manage data. They also highly valued the hardware, which improved, among other things, the process of collecting data or preparing documents. Once again, the attitude of potential adopters, this time towards technology, does not stand in the way of adopting innovations.

What prevented activists in the past from using certain technological solutions was the lack of time and financial resources. Due to these limitations, some interviewees reported that certain technological solutions that would help them in their work were out of their reach. The financial barrier is commonly listed as an obstacle to innovation, be it business or social [55]. The scarcity of financial resources can also partially explain why NGOs and

grassroots movements rarely use solutions tailored to their particular needs. These might be the reasons why NGOs reach out for easily accessible and low-cost solutions rather than develop tailored ones. As Jaskyte has already noticed, the main advantage of social media is that it does not generate high costs, which might be especially important for NGOs that do not have high budgets [36].We found only two examples of technologies that were developed locally, which does not satisfy the need of native solutions that Sanabria-Z et al. call for [8]. The process of building technological solutions requires skills and financial resources that NGOs and grassroots movements are often lacking.

Apart from social media, Polish NGOs and grassroots movements use software to collect data and convert it into databases accessible to the average user. Most often, they operate on the GIS tool, which enables them to gather, analyze, and present their data. The findings confirm the observation made by Bach and Stark that technologies help NGOs to transform raw data into accessible knowledge [38].

While non-governmental and grassroots organizations use various technological solutions, they did not use any that could comprehensively support citizen science projects, especially in the area of involving citizens in the research process, i.e., from selecting a research question to discussing the results. Currently, it would be hard to reach the highest level of citizen participation defined by Haklay [23], i.e., extreme citizen science, which enables citizens' active participation in the entire scientific process.

The research shows that non-governmental organizations and grassroots movements have the potential to play the role of an initiator of bottom-up knowledge production, and technological innovation might trigger this innovative potential, as happens in for-profit organizations [56]. However, grassroots movements are still at the very beginning of this path. For now, they are effectively using technologies to involve citizens in crowdfunding, signing petitions, or taking part in protests. They prepare educational materials and draw citizens' attention to important issues related to the protection of the environment. Some grassroots movements involve people in a deeper way, for example, to collect data on trees and greenery. However, it is noticeable that their projects often lack cross-sector cooperation and the science aspect.

5. Conclusions

Grassroots movements play an important role in the public sphere. They are often precursors of change, filling the gaps and shedding light on matters that are overlooked by politicians. They make many social, health, economic, and environmental issues relevant for the public by increasing the understanding of the studied matter among citizens and politicians. Moreover, very often the grassroots movements come up with new solutions that aim to improve the wellbeing of individuals and communities. They are the drivers of social innovation. Recently, citizen science has been noticed by some grassroots movements as a tool to build and transfer knowledge.

Although there is a great potential in citizen science [57], there are also many challenges connected to the level of citizen participation (e.g., time requirements), community specificity (e.g., trust level), communication strategy, transparency and accountability in the process, as well as ethics [58]. Our research adds one more element to this list: the technological advancement of citizens and grassroots movements. The technological advancement of grassroots movements is a key aspect in planning citizen science projects because the choice of technology results from digital fluency and competence in the area of existing digital technologies (digital platforms and mobile platforms).

Choosing the right technological tool translates directly into participation. Citizens are used to intuitive, simple tools, and any difficulty or incomprehension may discourage them, especially those least motivated and digitally fluent. The drop off of some specific groups of citizens or an inability of attracting them to the study causes a problem of misrepresentation [59].

The analysis of technological advancement of grassroots movements in Poland reveals that the full potential for launching citizen science projects has not yet been reached. There

are many obstacles that need to be addressed. First of all, the recognition of the citizen science approach is still low. Secondly, grassroots movements operate using standard and easily accessible technological solutions, rarely developing tailored and more advanced technologies that would better suit their needs.

The presented study is just a first step towards understanding the role of citizen science in democratic processes, especially in countries with a shorter history of democracy like Poland. In this paper, we focused on only one actor, i.e., NGOs and grassroots movements, who have great experience in activation and management of social processes. NGOs seem to be natural facilitators of citizen science projects. However, there are more actors on the scene, like local and national authorities, politicians, citizens, companies, and developers, whose impact on the quality and effectiveness of citizen science as a method of finding new solutions to social needs and problems should be studied further. All actors contribute to the success or failure of citizen science, and we find it crucial to understand their role and the way they interact before making final recommendations.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su15065031/s1, Table S1. List of studied NGOs and grassroots movements (N = 65).

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