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Profiling European citizen scientist: Evidence from Poland

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Abstract. This article investigates the profile of citizen scientists in Poland who actively participated in a project to inform the Polish government's strategic objectives for 2050. While citizen science, involving public collaboration in scientific research, has been extensively studied in various countries, a notable gap exists in understanding the characteristics of citizen scientists in Poland. Employing a methodology that integrates both qualitative and quantitative approaches, the study utilises a collaborative survey and online deliberations to gain insights into the profiles of Polish citizen scientists. The article's primary focus is on delineating the demographics of Polish citizen scientists and comparing them to the characteristics of their peers' established profiles in other European countries. Intriguingly, our analysis reveals that the environment and green transition theme predominantly attracted male citizen scientists, deviating from prevailing literature that typically associates environmental citizen science with higher female involvement. Additionally, the key findings suggest a portrait of Polish citizen scientists as an older, educated cohort with a discernible concern for societal issues. The article emphasises the importance of these insights for

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shaping the landscape of citizen science in Poland and provides guidance for similar future initiatives.

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JEL Classification: O20, I25, I31, J18, O52, Q56

1. INTRODUCTION

Citizen science (CS) refers to collaborative research efforts between professional researchers and lay citizens, serving as a valuable avenue for expanding scientific knowledge and science education. This approach encompasses a range of activities such as co-creating research, jointly collecting and processing data, popularising science, and sharing knowledge (Vohland, 2021). Such numerous, seamlessly interwoven collaborations across diverse fields necessitate a meticulous methodological framework. This involves adopting an ex-ante research plan or protocol that incorporates guidelines and assumptions to guide the activities of the implemented project without losing the research rigour.

Traditionally, most citizen science projects (CSPs) are rooted in biology-related fields (Tauginienė et al., 2020). However, lately, there has been a discernible surge in interest in this methodology across diverse disciplines, including social sciences and humanities. It appears that addressing current social challenges requires a different approach or "toolbox". It is increasingly evident that comprehending and analysing urgent social issues may no longer be feasible from the traditional "ivory tower" perspective but rather requires active support and involvement of the so-called "ordinary people". Citizen science, therefore, introduces this crucial "human dimension" to the research process by expanding the methodological spectrum and rendering it more contemporary.

In this article, we present the results of our citizen science project (CSP) conducted online in Poland between May and September 2022. The project aimed to empower the voice of lay citizens, in particular citizen scientists, in the co-creation of Poland's long-term development strategy, namely the "National Development Concept 2050" (in Polish: Koncepcja Rozwoju Kraju 2050, KRK 2050)[1]. The project consisted of several complementary elements. Firstly, a website that was the main source of information about the study, methodology, and the research team available to the participants and the wider public. Secondly, a Facebook campaign that allowed us to actively communicate with the study participants and stimulate the discussions using sponsored posts. Thirdly, a pilot and four stages of collaborative research with citizen scientists.

A key measure of impact of our project is that it reached 1,140.661 Facebook users who jointly accounted for around 3 million post views. In addition, the citizen scientists completed 2,064 extended questionnaires in which they shared their local knowledge and consulted on local and national developmental needs. Considering the citizen science methodological assumptions that require intellectual effort and time investment by citizen scientists, these numbers appear highly satisfactory and in line with our expectations.

A good understanding of the characteristics of citizen scientists is crucial for strengthening their involvement and making it more meaningful and effective. The still scarce European research in this area provides us with some points of reference (Strasser et al., 2023). According to Strasser et al. (2023), West et al. (2016), Geoghegan et al. (2016), and Peter et al. (2021), a European citizen scientist is a person who is

[1] The KRK 205 relies very much on SDGs. There are other, similar to our research approaches to define the citizens' needs and to make various stakeholders involved in SDGs' implementation process, for example: Nassar et al., 2023; López-Concepción et al., 2022.

either quite mature (over 65) or under the age of adulthood (under 18), more often male than female, generally with a background in science and with a high level of education. The main aim of our research is to examine whether Polish citizen scientists share similar demographic characteristics as their European peers. The research question that stems from that goal is, therefore, to understand what demographic characteristics a typical Polish citizen scientist has and if they are similar to the traits of a typical European citizen scientist. The data we have collected allows us to look at a wider range of demographic features and thus investigate the importance of a place of residence (urban-rural) or the subject area of the study itself as factors that may influence the involvement of citizen scientists.

As a result of our research, we were able to profile a typical Polish citizen scientist. A preliminary portrait reveals that he/she belongs to an older, educated cohort with a discernible concern for societal issues which is broadly consistent with a profile of a typical European citizen scientist. Our citizen science initiative attracted significantly more women than men, although the topic of environment and green transition turned out to be more popular with males. The higher engagement rate of women in general appears to stand out when compared to studies in other European countries. When it comes to occupation and place of residence, a typical citizen scientist in our project is either employed or retired and lives in a town or city. Most participants lived in households with two or more members. We also observe that demographics of participants varied across the four stages of the project which suggests that different topics or areas of interest attract different types of individuals, depending on the issues that are close to them. For example, participants in the stage dedicated to education were characterised by lower average age and living in larger households, thus likely households with children or youth. Therefore, we can reason that those who actively took part in this stage of the study could be in education themselves, have children in education, recently have had children in education, or expect to be in such a situation in the future. In contrast, older people were more willing to participate in the stage discussing the quality of life.

The structure of our article is as follows. The next section discusses the literature describing the main characteristics of European citizen scientists. The one that follows describes the setup of our citizen science project as well as the main data collected during each of its stages. The main results of the project are discussed in detail in the next sections. We make conclusions in the final section.

2. ENGAGEMENT OF EUROPEAN CITIZEN SCIENTISTS: LITERATURE REVIEW

Initiatives that confer expert status upon "lay citizens" seem to be a response to the recent erosion of trust in political elites and traditional experts, posing a significant challenge to the legitimacy of democratic policymaking. Krick (2022) distinguishes between three main types of citizen knowledge: “local knowledge”, “service user involvement” and “citizen science”. However, according to Krick, it is the citizen expertise that “is epistemically particularly valuable when it is based on distinct, non-ubiquitous experiences and collective, not just individual, insights. It contends that representativeness is key to the democratic legitimacy of citizen experts in the policy context and points to the key role of organised civil society in establishing the required accountability relationships” (Krick, 2022, p. 996). She underscores the merits of citizen science and, highlights its advantages such as enhancing social competencies among citizen scientists and promoting more effective attainment of the Sustainable Development Goals within the three pillars. Indeed, citizen science has the potential to enhance the well-being and literacy of participants (the social pillar), expedite and economise research efforts (the economic pillar), and mitigate negative environmental impacts through heightened awareness, increased knowledge levels, and the design of concrete actions (the environmental pillar) (Cappa et al., 2022). It is noteworthy that the integrative nature of citizen science, i.e., requiring no specialised or prior knowledge to participate, serves as a crucial incentive for participation and finds

popularity in various local contexts. Residents are primarily motivated by the prospect of exerting more influence on issues affecting their immediate environment (Cappa et al., 2020).

Schrögel and Kolleck (2019) distinguish three dimensions of citizen science: (i) participation selection, (ii) communication and decision and (iii) authority and power. In line with the first dimension that defines the essence of citizen science, it is crucial to look at the participant selection mechanisms to understand who is eligible to participate. The most inclusive approach involves inviting anyone interested to participate in the project. Despite being relatively underrepresented in the social sciences, citizen science presents a valuable and constructive research proposition for a broad spectrum of implementations in public policy. Examples of the effectiveness and relevance of this approach, particularly in the Polish public policy on the local level, can be found in Gawrońska-Nowak et al. (2022) and in the "beehive model" by Gawrońska-Nowak et al. (2021). The "beehive model" boldly combines expert knowledge transfer and extensive participation as essential for the contemporary design and implementation of policies aimed at social conflict resolution and quality of life improvement through sustainable development.

When considering the quality and availability of data in citizen science projects, it should be noted that citizen science is still developing as a research tool and methodology. Although it has been gaining importance and popularity in recent years, it is still in the process of establishing its position in the research world. More importantly, citizen science databases primarily contain ecological information collected by citizen scientists, such as Volunteered Geographic Information (VGI). Therefore, most of the academic literature using citizen science data deals with the taxonomy of citizen science projects and describes the quality of data collected and analysed by citizen scientists at the national or local level (e.g., Fraisl et al., 2020; La Sorte et al., 2020; Turbé et al., 2019). There are relatively few articles studying the demographic characteristics of the citizen scientists themselves, however (e.g., Strasser et al., 2023; West et al., 2016; Geoghegan et al., 2016; and Peter et al., 2021).

Strasser et al. (2023) concentrated on three of the most prevalent practices carried out by citizen scientists across diverse projects and analysed data on over 14 million accounts of citizen scientists. This comprehensive dataset facilitated the profiling of citizen scientists, including their fundamental demographic characteristics. Detailed comparisons with our findings are presented in Tables 1-4. Of particular interest and contributing to a broader contextual understanding of both their research and ours is the observation that the number of European citizen scientists is notably high and is similar to the number of US citizen scientists. Nonetheless, the proportion of participants from other OECD countries is experiencing dynamic and intense growth (Strasser et al., 2023).

West et al. (2016) and Pateman et al. (2021) focus their research on the barriers to people's participation in citizen science projects based on two surveys. In the Omnibus study, 8,220 individuals were asked whether they had ever participated in a citizen science project, with 613 individuals (7.5%) responding affirmatively. We compare our study to this group of individuals in Tables 1-4. It is worth noting that those most willing to participate in citizen science projects have higher/intermediate managerial, administrative, and professional occupations, while those less likely to participate tend to have semiskilled and unskilled manual occupations or be unemployed.

In Geoghegan et al. (2016), a citizen scientist's profile is based on a survey of 147 individuals conducted on behalf of the UK Environmental Observation Framework (EOF). The main results suggest a higher proportion of men in the EOF than in the Omnibus study and significantly greater participation of older individuals. A comparison of both studies to ours can be found in Tables 1-3.

Peter et al. (2021) present a comprehensive international study encompassing participants from 63 biodiversity projects in Europe, Australia, and New Zealand. Participants were primarily tasked with identifying and recording species and submitting that data to the project database. A total of 1,160 citizen scientists participated in the project. The study provides a broad demographic characterization of citizen

scientists, including their employment and place of residence, allowing us to make comparisons with our project in these areas (Tables 1-2 and 4). The citizen scientist profile emerging from the research indicates an individual, male or female, over 50 years old, living in a small town or rural area, with higher education, and either currently employed or retired.

Table 1. Gender diversity in citizen science projects

Projects	Biodiversity	SETI@home	GalaxyZoo	iNaturalist	Foldit	Omnibus	EOF	Our project*
Female	53%	5%	23%	37%	27%	53%	56%	57%
Male	47%	95%	75%	63%	73%	47%	44%	39%

Note: The table presents the share of respondents of certain gender. The shares of male and female participants do not sum up to 100% due to variations in gender categories across studies.
*Average across all stages.
Sources: Strasser et al. (2023), West et al. (2016), Geoghegan et al. (2016), Peter et al. (2021).

According to Table 1, the most pronounced gender inequality is evident in the SETI@home project, characterized by its strictly technical nature and the requirement for participants to contribute their own computers for calculations in, for example, astronomy or climate change studies. Conversely, projects with less technical focus exhibit greater diversity and approach gender parity. This pattern is also reflected in our project, where, during the most technical stage, "environment and green transition", male participation was notably higher. The "social relations" stage, on the other hand, recorded the highest participation of women among all the projects we examined. This appears to align with the observed trend of increasing female activity in the field of science.

Another demographic aspect that defines citizen scientists is their age. Due to varied methodological approaches leading to different age ranges being utilized in the study, the data are presented in two tables (Tables 2 and 3).

Table 2. Age diversity in CS projects (part 1)

Projects	Biodiversity	SETI@home	GalaxyZoo	iNaturalist	Foldit	Our project
10 -29	3%	42%	60%	57%	65%	14%
30-39	6%	28%	17%	9%	20%	15%
40-49	14%	17%	9%	11%	8%	16%
50-59	24%	9%	8%	11%	4%	19%
60-69	36%	3%	3%	8%	3%	22%
70+	17%	1%	1%	4%	0%	15%

Note: The table present the share of respondents of certain age.
Sources: Strasser et al. (2023), Peter et al., 2021.

Table 3. Age diversity in CS projects (part 2)

Projects	Omnibus survey	EOF Study	Our project
16-24	14%	2%	10%
25-34	9%	14%	12%
35-44	18%	17%	15%
45-54	16%	17%	17%
55-64	16%	31%	21%
65+	27%	20%	26%

Note: The table present the share of respondents of certain age.
Source: West et al. (2016), Geoghegan et al. (2016).

Comparing the demographic characteristics of citizen scientists across different projects, it becomes evident that in initiatives aimed at the entire population, older individuals tend to predominate, while projects specifically tailored for young people attract a predominantly youthful demographic. Another noteworthy factor is the subject of the study itself. In our research, we observed a higher propensity for young people to engage in the „education" stage, while older individuals exhibited a greater inclination to participate in the „quality of life" stage. Furthermore, in our study older individuals were significantly less likely to participate in the „social relations" stage, adding an interesting dimension to the demographic dynamics of participation.

Table 4. Place of residence in CS projects

Projects	Biodiversity projects	Omnibus survey	Our project
Urban	58%	81%	82%
Rural	42%	19%	10%

Note: In our project, data do not sum up to 100% due to 8% lack of responses.
Sources: West et al. (2016), Peter et al. (2021).

According to Table 4, the nature of the project significantly influences the demographic composition of citizen scientists in terms of their place of residence. In both our project and the Omnibus project, urban areas host the predominant group of citizen scientists; however, this demographic structure is more evenly distributed in biodiversity projects. This equilibrium is undoubtedly connected to the nature of the tasks undertaken by citizen scientists. The identification of species and the collection of environmental data are likely more accessible for individuals residing in rural areas.

3. DESCRIPTION AND THE SET-UP OF THE CITIZEN SCIENCE PROJECT

Between May and September 2022, we implemented a citizen science project aimed at engaging local communities in diagnosing Poland's development needs and challenges. The results of the projects were meant to contribute to the creation of Poland's Development Concept 2050 initiated by the Polish Government. One of the primary goals of our project was to enhance the level of social participation in the process of shaping the country's development policy and contributing to its form. The idea was to tap into residents' perceptions, preferences, and expectations regarding specific areas of development that were defined by the Government. The reference points for our project were the UN Sustainable Development Goals, the concept of doughnut economics by Kate Raworth (2012), and the development goals declared in official documents by the Ministry of Funds and Regional Policy (KRK 2050, Society and Quality of Life[2]). Actively and frequently ceding the initiative to residents, we conducted online discussions on the desired directions of changes within the areas defined by the mentioned source documents. In line with the spirit of citizen science, we replaced the traditional social experiment method, according to which the subjects cannot interact with scientists, with a new participatory formula that seems better suited to the contemporary realities of Polish society. This approach allows for the discovery of new data sources, enriches the process with alternative ways of verifying hypotheses and methods, facilitates educational activities, and fosters trust between experts and residents (Bedessem et al., 2021; Mitchell et al., 2017; Van Vliet & Moore, 2016).

[2] All information on the government programme is available on the dedicated website: https://krk2050.pl/

Due to the specificity of the methodological approach of citizen science described above, the structure of the study proved to be more intricate compared to studies employing traditional methods. The main goal was not merely to reach a wide audience, but, above all, to reach those people who would be willing to get involved in the project itself and devote their time to think about the researched issues and, what is more important, would want to share these thoughts with the research team. Therefore, we meticulously planned several online co-creation activities involving residents from various regions of Poland. These activities included discussions, quizzes, and online games with the citizen scientists.

Also, the design of our project's website has been carefully thought out in such a way as to provide visitors with as much comprehensive information as possible about the research team and the project details, as well as to describe the citizen science methodology. We aimed to establish genuine communication and trust between the research team and citizen scientists, hoping that this collaboration would increase their influence on shaping and implementing of future development policies, a fundamental assumption guiding the entire research project.

A vital tool for cultivating participants' commitment to the project was the "Polska Marzeń" Facebook page. Its primary purpose was to foster appropriate conditions and environment for developing a community of citizen scientists who would actively engage in discussions and share their opinions. However, this did not happen without challenges. Despite the technical support provided by a professional marketing agency, Facebook frequently blocked the groups we created, thus constraining the freedom of discussions, which we deliberately did not want to moderate or limit when creating the groups.

Ultimately, we managed to collect enough textual material. This material consisted mostly of statements posted in response to various discussions, quizzes, and games related to the issues raised in the subsequent stages of the research. Additionally, we designed the citizen science collaborative questionnaires that incorporated a substantial number of open-ended questions to provide citizen scientists with a platform to express their opinions. Despite the common hesitance among typical survey respondents to engage with extensive and complex questionnaires, the engaged citizen scientists seemed to appreciate activities that demanded considerable intellectual effort. Through these tasks, they brought significant value to the project.

The choice of the slogan for our citizen science project, "Design Poland of your dreams", was influenced by two considerations. Firstly, from the marketing perspective, we aimed for a name with positive associations. Secondly, its choice was intended to direct the focus of community participants not merely towards the current state of the country but rather towards envisioning its potential future.

Operating under challenging conditions, such as the full-scale invasion of Ukraine by Russia which had captured everyone's attention at the time, including the virtual space of social media and other online platforms, we managed to conduct the project pilot and several waves of research on four main topics related to Poland's development. The main goal of the pilot was for the citizen scientists to choose four out of eight[3] main developmental areas to be later deliberated upon in more detail. The decision to incorporate only four main areas into the project was motivated by the limited time and financial resources. Based on the result of the pilot presented in Table 5 citizen scientists decided to consider the following development areas in the subsequent stages: education, quality of life, environment and social relations.

[3] In line with the Strategy of Poland's Development 2050, the main eight development areas are demography, education, work, social relations, quality of life, transformation of the economy, environment and green transformation, and new technologies (https://krk2050.pl)

Table 5. Results of the citizen science project pilot

Development areas	Answers to the question: How important is each of the following areas to you? One means not very important, and 5 - very important (in percentages)				
	1	2	3	4	5
Education	1.7	0.8	5.9	14.2	77.4
Quality of life	1.3	3.4	7.1	13.4	74.8
Environment and green transformation	6.7	3.8	11.3	18.5	59.7
Social relations	2.9	4.6	13	21.8	57.6
Demography	6.8	4.2	17.8	18.6	52.5
Work	2.9	3.8	16.7	28.5	48.1
Transformation of the economy	3.8	4.6	16.9	28.3	46.4
New technologies	5.9	8.9	23.2	28.3	33.8

Note: the sample included 240 citizen scientists.

Moreover, information about each stage of our collaborative research reached 228,000 users on average, accounting for more than 600,000 post views per stage. The "quality of life" stage attracted the most attention (see Table 6). Excluding the pilot, posts associated with each subsequent stage garnered an average of 20,000 reactions, including shares, likes, comments and various other forms of engagement. In essence, our research achieved substantial outreach and elicited meaningful online interactions with citizen scientists throughout its duration.

Table 6. Engagement metrics of the project's stages on social media (Facebook)

	Total reach (unique users, thousands)	Number of post views (in thousands)	Activity under posts (in thousands)	Visits to the website	Number of survey participants
Stage 1 (pilot)	157	211	-	2240	240
Stage 2 (education)	172	611	30	15752	511
Stage 3 (quality of life)	343	932	20	7248	380
Stage 4 (environment)	225	617	16	5217	391
Stage 5 (social relationships)	243	604	14	5068	364

4. RESULTS

The project managed to successfully attract 1,653 citizen scientists throughout its four main stages (excluding the pilot). Moreover, the number of participants' activities under the Facebook posts (e.g. discussions, games, quizzes etc.) exceeded 80 thousand in total (see Table 2). Given that no personal data was collected during the study, we cannot determine whether the same individuals participated in the subsequent stages or if each stage attracted unique participants. The four research stages were designed to align with the expectations and attitudes typical of citizen scientists, emphasising intellectual effort, freedom of expression, and a heightened sense of commitment and responsibility for shaping the study. This was achieved by including many open-ended questions in collaborative questionnaires to allow participants to express themselves.

An analysis of the participants' demographics reveals that engagement in the study was higher among individuals with higher education. As shown in Table 7, 73% of all citizen scientists have higher education,

surpassing the country's average of 23%. This observation aligns with the broader characteristics of participants in similar European citizen science projects as discussed earlier. Interestingly, in the stage focused on the environment (Stage 4 in Table 3), individuals who identified as men constituted 50% of the sample, compared to 46% of female participants. In contrast, the stage centred around social relations (Stage 5 in Table 7) saw a much higher participation rate among women, with 63%, compared to only 34% of men. In addition, we observe that around a third of participants in our study (32%) identified themselves as retired or in receipt of incapacity benefits. This rather large number significantly exceeds the 24% share of this group in the national population, suggesting that citizen science projects such as ours have the potential to mobilise the elderly and disabled to actively participate in local or national activities and debates and make their voice heard.

Table 7. Demographic characteristics of citizen scientists in Poland

Research stages	Gender*		Occupation			Higher education	Average age
	Men	Women	Employed	Pupils and students	Retired		
Stage 1 (pilot)	39%	58%	51%	10%	35%	68%	51
Stage 2 (education)	37%	59%	59%	14%	30%	74%	50
Stage 3 (quality of life)	36%	61%	56%	9%	36%	75%	51
Stage 4 (environment)	50%	46%	59%	9%	31%	72%	51
Stage 5 (social relationships)	34%	63%	61%	9%	26%	74%	48
Average for all stages	39%	57%	57%	10%	32%	73%	50
Average for Poland**	48%	52%	56%	16%	24%	23%	42

Notes: * Percentages do not sum to 100 as some participants did not disclose their gender or occupation. **Data comes from Statistics Poland (2023).

The geographical distribution of the project participants closely mirrors the structure of the Polish population across voivodeships (see Figure 1). The most significant difference can be noticed in the Masovian voivodeship, where 20% of citizen scientists come from, while only 14% of the total population of Poland lives there. In general, residents of voivodeships in the central regions of Poland exhibited greater willingness to participate in the study, although this difference is not very high.

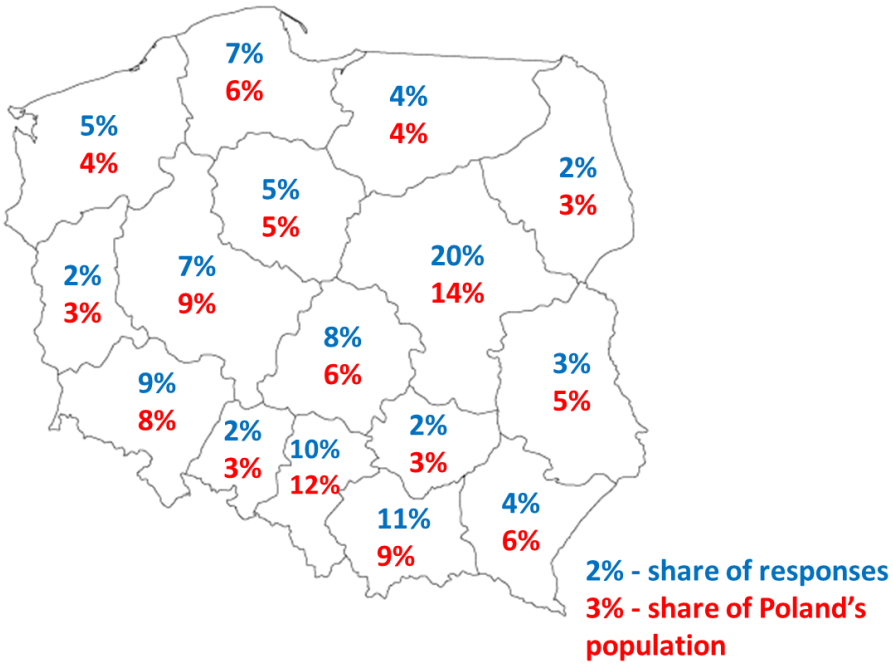

Figure 1. Distribution of citizen scientists by voivodeship.

Most citizen scientists who took part in our research lived in smaller cities (see Table 8). They constituted 45% of all participants in all stages. Interestingly, the topic of "social relations" attracted 45% of residents of large urban centres (i.e. voivodship capitals) such as Warsaw, Kraków, and Poznań, while only 32% of them took part in the "quality of life" stage. The latter attracted the most attention in smaller towns and cities accounting for 53% of all participants in that stage. The participation of inhabitants of rural areas in all stages of the research was between 8 and 11%.

Table 8. Place of residence of citizen scientists

Research Stages	Number of participants				% of total*				Total
	Voivodship capitals	Other towns and cities	Rural areas	No response	Voivodship capitals	Other towns and cities	Rural areas	No response	
Education	196	230	50	42	38%	44%	10%	8%	518
Quality of life	120	200	31	29	32%	53%	8%	8%	380
Environment and green transformation	136	174	39	42	35%	45%	10%	11%	391
Social relations	162	142	40	20	45%	39%	11%	5%	364
Total	614	746	160	133					1653

Note: * percent of citizen scientists relative to the total number of participants in each respective stage.

The distribution of participants by educational attainment and gender is displayed in Table 9. The presented results suggest that more women with higher education took part in all stages of our research than the same cohort of men. Depending on the stage the difference is between 10% and 12%. Interestingly,

a higher share of men with vocational qualifications took part in all stages of our research compared to the same share of women. Also, there were slightly more participants with secondary or primary education who identified as male compared to the number of participants identifying themselves as female with the same educational attainment.

Table 9. Citizen scientists by gender and education

Research Stages	Men				Women				Other/Prefer not to say			
	Higher	Secondary	Primary	Vocational	Higher	Secondary	Primary	Vocational	Higher	Secondary	Primary	Vocational
Education	69%	3%	4%	24%	80%	2%	1%	17%	50%	14%	5%	32%
Quality of life	67%	1%	3%	30%	76%	0%	1%	22%	50%	0%	0%	50%
Environment and green transformation	64%	2%	4%	30%	76%	0%	2%	22%	77%	8%	8%	8%
Social relations	67%	2%	5%	26%	79%	1%	2%	18%	45%	9%	0%	45%

Note: The table shows the percentages of citizen scientists with a specific educational attainment relative to the total number of participants in each respective gender category. For example, x% in the "Higher" education category in the "Men" column indicates that x% of men taking part in this research stage had higher education.

In Table 10 we consider the average age of citizen scientists taking part in the study and the size of their households. As shown in the previous tables, the vast majority of the study's participants held a higher education degree. They also constituted the oldest group in two out of four stages of the project. In the other two stages, individuals with vocational qualifications had a higher average age. The representatives of these two groups were likely to be either retired or have established professional careers. This does not seem to be the case for participants with primary and, to some extent, secondary education who appeared to be significantly younger on average. This is expected as many of them were still pursuing education at the time of the study: 48% of individuals with primary and 24% with secondary education declared they were still attending school or university. Another observation here is that the study attracted few young citizen scientists as only 9.3% of participants were below 25 years of age. Thus, although as previously noted such projects might be a good conduit for activating the older parts of the society, researchers engaging in citizen science should re-think their approach to recruiting younger cohorts to elicit contributions, opinions and experiences that are representative of a wider spectrum of the society.

Table 10 sheds some light on the citizen scientists' household size which appeared to vary across the research stages. For example, in the stage dedicated to education, nearly half of the respondents lived in households with three or more members. Those additional household members are likely to be children or youth in education (although the data prevents us from confirming this with certainty) and thus such participants may have a keener interest in the condition and future development of the education sector. This argument is corroborated by the lower age of citizen scientists participating in the education stage – indicating that those individuals may currently be in education themselves, have children in education, recently have had children in education, or expect to be in such a situation in the future.

Table 10. Citizen scientists' age by education and household size

Research Stages	Average age				Household size (% share)		
	Higher	Secondary	Primary	Vocational	Single person	Two persons	Three or more persons
Education	52	44	31	49	14%	34%	46%
Quality of life	54	53	45	60	27%	41%	30%
Environment and green transformation	49	44	38	53	23%	42%	33%
Social relations	54	49	39	46	17%	36%	41%

Note: The left-hand side panel of the table shows the average age of citizen scientists by their level of education and research stage. The right-hand side panel displays the percentage shares of citizen scientists by the size of their households (the percentages do not sum up to 100 because some participants did not declare their household size).

Looking at the distribution of our citizen scientists' occupation by gender (in Table 11), we notice that a lot more retired women than men took part in all but the "education" stage. This difference is the highest in the "quality of life" (11% more retired women compared to retired men among the participants) and "social relations" (13% more retired women compared to men among the participants) stages. Interestingly though, when we look at his picture is reversed in the "Employed" column, we observe that around 10% more employed men took part in all, but the "education" stage compared to the share of employed women. The "education" survey attracted slightly more participants identifying as male (15% of men vs. 11% of women). Most participants who preferred to either not disclose their gender or identified as "other" are either employed or students/pupils.

Table 11. Citizen scientists by gender and occupation

Research Stages	Men				Women				Other/Prefer not to say			
	Employed	Retired or on a disability pension	Student or pupil	Unemployed	Employed	Retired or on a disability pension	Student or pupil	Unemployed	Employed	Retired or on a disability pension	Student or pupil	Unemployed
Education	54%	30%	15%	2%	56%	29%	11%	4%	50%	4%	29%	17%
Quality of life	59%	28%	10%	3%	48%	39%	6%	6%	85%	0%	0%	15%
Environment and green transformation	56%	32%	7%	5%	46%	42%	7%	5%	33%	33%	33%	0%
Social relations	65%	18%	11%	6%	56%	30%	6%	8%	38%	8%	46%	8%

Note: The table shows the percentages of citizen scientists with a specific occupation relative to the total number of participants in each respective gender category. For example, x% in the "Employed" occupation category in the "Men" column indicates that x% of men taking part in this research stage were employed. Participants could have chosen several categories, for example, the same person may be in the "retired" and "student" categories at the same time.

Table 12 presents the characteristics of citizen scientists by their educational attainment and place of residence. It turns out that the vast majority of participants (around 90% in all stages of research) with higher education live in cities and towns, while only 10-12% reside in rural areas. This means that highly

educated citizen scientists prefer to reside in cities and tend not to be suburban dwellers. Interestingly, 60% to 78% of citizen scientists with vocational qualifications live in smaller cities and towns and none of those taking part in the "education" stage reside in voivodship capitals, while 36% live in rural areas. Finally, most participants with secondary or primary education live in smaller cities and towns.

Table 12. Citizen scientists by education and place of residence

	Higher			Secondary			Primary			Vocational		
Research stages	Voivodship capitals	Other towns and cities	Rural areas	Voivodship capitals	Other towns and cities	Rural areas	Voivodship capitals	Other towns and cities	Rural areas	Voivodship capitals	Other towns and cities	Rural areas
Education	46%	44%	10%	27%	60%	12%	33%	67%	0%	0%	64%	36%
Environment and green transformation	43%	45%	12%	33%	59%	9%	0%	67%	33%	22%	78%	0%
Quality of life	38%	52%	10%	24%	71%	6%	0%	100%	0%	17%	67%	17%
Social relations	53%	36%	12%	33%	55%	12%	0%	83%	17%	40%	60%	0%

Note: The table shows the percentages of citizen scientists by their place of residence relative to the total number of participants in each respective educational attainment category. For example, x% in the voivodship capital category in the "Higher" education column indicates that x% of participants with higher education taking part in this research stage resided in the voivodship capital.

5. CONCLUSIONS AND DISCUSSION

The focus of this article has been to investigate the characteristics of individuals who engage in citizen science in Poland and to compare them to the characteristics of citizen scientists in other European projects and countries. As the basis for profiling a Polish citizen scientist, we use the key demographic data on participants in a citizen science project that was intended to inform the Polish government's strategic development objectives for 2050. The study that was run online in 2022 focused on four primary areas of development that were indicated by citizen scientists at the project's outset. They included education, social relations, quality of life, and environment and green transition.

As shown in the literature review, various citizen science projects tend to attract slightly different types of participants, depending on the project's nature and topical focus. However, certain common tendencies and trends can be observed. The picture emerging from our project paints a Polish citizen scientist as someone older and more likely to be either employed or retired than the country's population average. They are also three times more likely to have a higher degree than an average Pole. These characteristics are broadly consistent with those observed in the comparative European citizen science initiatives. What makes our project stand out is a much higher participation of women than men (57% to 39%, respectively). In most of the other studies we consider, males tend to be the largest group. Even in the few discussed projects where more females participated, the differences are not as striking as in our case. Thus, at first look, it appears that Polish women are more likely to be drawn to citizen science projects. However, this result may be just a consequence of the project's topical focus. We observe a possible pattern that more technical or technological projects attract more men whereas projects that are less technical in nature and have a more societal focus attract more gender-diversified groups. This can be observed both in the studies we review as well as in our own project. We observe that the topic of environment and green transition, the most technical of our areas, turned out to be more popular with males. In contrast, social relations and quality of life, more society-focused issues, attracted the greatest share of female participants. When it comes to the place of

residence, a citizen scientist in our project lived in a town or city, most frequently in a household of multiple occupants.

We also observe that demographics of participants varied across the four stages of the project which suggests that different topics or areas of interest attract different types of individuals, depending on the issues that are close to them. This may be driving the already mentioned gender-based differences but can also be observed when considering other characteristics. For instance, we noted that citizen scientists contributing to the stage dedicated to education were on average younger than contributors to the other stages of the project. They also lived in larger households, thus likely households with children or youth. It is possible that those who actively took part in this stage of the study could be in education themselves, have children in education, recently have had children in education, or expect to be in such a situation in the future. In contrast, older people appeared more interested in participating in the stage dedicated to the quality of life.

By identifying the characteristics of citizen scientists and some patterns behind their active engagement, this article contributes to the understanding of citizen science and sheds light on who is attracted to such projects, especially in the Polish context. However, it also identifies some knowledge gaps that citizen science practitioners need to tackle in their future research endeavours if they want to make citizen science more inclusive and more representative. Although the need for inclusivity and representativeness may be less important in technical sciences, they are acutely important in the field of social science. Future research should put more emphasis on engaging inhabitants of rural areas, individuals with lower educational attainment and younger people. Neglecting those groups and relying predominantly on highly educated city dwellers is likely to produce biased results, and that one-sided perspective may consequently exacerbate social problems rather than solve them.

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REFERENCES

Bedessem, B., Gawronska-Nowak, B., & Lis, P. (2021). Can citizen science increase trust in research? A case study of delineating Polish metropolitan areas. *Journal of Contemporary European Research*, *17*(2), 305-321.

Cappa, F., Franco, S., & Rosso, F. (2022). Citizens and cities: Leveraging citizen science and big data for sustainable urban development. Business Strategy and the Environment, 31(2), 648-667.

Fraisl, D., Campbell, J., See, L., Wehn, U., Wardlaw, J., Gold, M., ... & Fritz, S. (2020). Mapping citizen science contributions to the UN sustainable development goals. *Sustainability Science*, *15*, 1735-1751.

Gawrońska-Nowak, B., Gubański, K., & Kaleyeva, V. (2021). Czy dane pozyskane metodą citizen science mówią nam więcej? W kierunku nowego modelu lokalnego zarządzania. *Problemy Rozwoju Miast*, *71*, 57-68.

Gawrońska-Nowak, B., Lis, P., & Zadorozhna, O. (2022). Delineation of Metropolitan Areas in Poland: A Functional Approach. *Economics & Sociology*, *15*(4), 80-113.

Geoghegan, H., Dyke, A., Pateman, R., West, S., & Everett, G. (2016). Understanding motivations for citizen science. *Final report on behalf of UKEOF, University of Reading, Stockholm Environment Institute (University of York) and University of the West of England*.

Krick, E. (2022). Citizen experts in participatory governance: Democratic and epistemic assets of service user involvement, local knowledge and citizen science. *Current Sociology*, *70*(7), 994-1012.

KRK2050. (n.d.). Retrieved January 20, 2023 from https://krk2050.pl/.

La Sorte, F. A., & Somveille, M. (2020). Survey completeness of a global citizen-science database of bird occurrence. *Ecography*, *43*(1), 34-43.

López-Concepción, A., Gil-Lacruz, A. I., & Saz-Gil, I. (2022). Stakeholder engagement, Csr development and Sdgs compliance: A systematic review from 2015 to 2021. *Corporate Social Responsibility and Environmental Management*, *29*(1), 19-31.

Mitchell, N., Triska, M., Liberatore, A., Ashcroft, L., Weatherill, R., & Longnecker, N. (2017). Benefits and challenges of incorporating citizen science into university education. *PLoS One*, *12*(11), e0186285.

Nassar, S., Tóth, Z. N., & Vasa, L. (2023). Economic empowerment as a result of achieving SDGs with resource access: A comparative research between Gaza Strip and Hungary. *Journal of International Studies (2071-8330)*, *16*(2).

Pateman, R. M., Dyke, A., & West, S. E. (2021). The diversity of participants in environmental citizen science. *Citizen Science: Theory and Practice*.

Peter, M., Diekötter, T., Höffler, T., & Kremer, K. (2021). Biodiversity citizen science: Outcomes for the participating citizens. *People and Nature*, *3*(2), 294-311.

Raworth, K. (2012). *A safe and just space for humanity: can we live within the doughnut?*. Oxfam.

Schrögel, Philipp, and Alma Kolleck. (2019). The many faces of participation in science: Literature review and proposal for a three-dimensional framework." *Science & Technology Studies* 32.2, 77-99.

Strasser, B. J., Tancoigne, E., Baudry, J., Piguet, S., Spiers, H., Luis-Fernandez Marquez, J., ... & Lintott, C. (2023). Quantifying online citizen science: Dynamics and demographics of public participation in science. *Plos one*, *18*(11), e0293289.

Tauginienė, L., Butkevičienė, E., Vohland, K., Heinisch, B., Daskolia, M., Suškevičs, M., ... & Prūse, B. (2020). Citizen science in the social sciences and humanities: the power of interdisciplinarity. *Palgrave Communications* , *6* (1), 1-11

Turbé, A., Barba, J., Pelacho, M., Mugdal, S., Robinson, L. D., Serrano-Sanz, F., ... & Schade, S. (2019). Understanding the citizen science landscape for European environmental policy: an assessment and recommendations. *Citizen Science: Theory and Practice*, *4*(1).

United Nations. (n.d.). 17 Goals to Transform Our World. www.un.org/sustainabledevelopment/

Van Vliet, K., & Moore, C. (2016). Citizen science initiatives: engaging the public and demystifying science. *Journal of microbiology & biology education*, *17*(1), 13-16.

Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., ... & Wagenknecht, K. (2021). *The science of citizen science* (p. 529). Springer Nature.

West, S., Pateman, R., & Dyke, A. (2016). Data submission in citizen science projects report for DEFRA (Project number PH0475). *Stockholm Environment Institute, University of York*.