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Citizen Science Application in Times of War, Crises, and Catastrophes

White Paper

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Content

Introduction

During wars, natural disasters, and other crises, when *scientific infrastructure is being destroyed, the lives and well-being of scientists are in danger*, *there may be a need to relocate scientists to other regions, and with decreasing funding for research facilities and projects decreases*, science in general faces negative consequences. Here, *citizen science* may help. It has proven to be an efficient tool for executing projects in biology and biodiversity, astronomy, agriculture, public health, and energetics.

There are currently many successful online platforms, for example, *OpenStreetMap*, *iNaturalis*t, *Geo-Wiki*, *SitSci.org*, *Zooniverse*, *Globe at Night*, and others, that help scientists collect, verify, analyze, and reuse data to do research. Citizen science *can be utilized during catastrophes* and *renewal after conflicts*. Besides, citizen science projects have demonstrated effectiveness *in fighting COVID-19* during the pandemic and facilitating *remote field practices during the quarantine*. In different countries that have suffered from conflicts and catastrophes, various practices involve using citizen science, *usually for monitoring the environment and evaluating damage to nature*. However, the question of citizen science utilization during wars and catastrophes remains open.

Although citizen science isn't well developed in Ukraine, during the Russian full-scale invasion, certain scientists have started to collaborate with citizens in gathering data about the environmental impact of the war.t. For instance, scientists from *the NASU I. I. Schmalhausen Institute of Zoology* are collecting data about dead dolphins, the *Ukrainian Ecological Club "Green Wave" nonprofit organization* is conducting an inventory of green areas, and Ukrainian naturalists continue to document biodiversity findings in *iNaturalist*. The public is also actively involved in documenting environmental crimes with the help of such initiatives as *SaveEcoBot* and *EcoDanger*.

Despite the great potential of citizen science, Ukrainian researchers still do not use the full potential of its instruments for collecting scientific information, and citizens are not

aware of the impact they could make by joining the research. There are still not enough practices of citizen science utilization as well as lack of knowledge about its possibilities and potential during wars, crises, and catastrophes. The mechanisms for integrating and engaging the public are still developing, and scientists lack awareness of effective utilization of citizen science as well as the ways to engage the public effectively.

Research goals:

1. **Analyze the utilization of citizen science during wars, crises, and catastrophes.**
- Form a database of citizen science projects for implementation during wars, crises, and catastrophes.
- Compare successful Ukrainian and world citizen science projects to identify the main tools of raw data collection, verification, and storage.
- Understand data policies in other countries and propose solutions for Ukraine.

2. **Study barriers and obstacles and propose overcoming strategies for citizen science**
- Determine and outline the main risks for citizens and preventive measures. Study the reasons behind utilization and disuse of citizen science among researchers in Ukraine and offer efficient ways to overcome these obstacles.
- Explore methods and values researchers use to encourage citizens to engage in scientific research.
- Define channels and educational methods to ensure the best quality of data collection among interested citizens.

This research is based on quantity and quality research methods, including desk research, expert interviews, and a questionnaire.

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1. What is Citizen Science

Currently, there's no universal definition of citizen science. The first definition *appeared* in 1989, formulated by researchers from the Massachusetts Institute of Technology, and it dynamically changed over time, reflecting the gradual broadening of public engagement in scientific research. For example, *the Cambridge Dictionary* defines citizen science as scientific work, such as data collection done by people without special qualifications to help scientists. The EU White Paper on citizen science *underlines* that citizens can contribute to science by providing researchers with means such as personal computers for computations or other work. Overall, there are *at least 34 different definitions* of citizen science. It's hard to pick up one of them as different scientific fields engage citizens in numerous and various projects. Moreover, a unified definition *can* complicate getting research grants based on different forms of public engagement.

The definition largely depends on cultural differences and the context, in which the respondents (primarily researchers), find themselves. This is evidenced by the desk research by scientists *who did a detailed* literature review and researched the definition of citizen science.

Participants join the research as volunteers and don't receive monetary rewards for their work — this seems to be a common trait of most known definitions of citizen science. Besides that, the SciStarter website founded by the Universities of Arizona and North Carolina that became a world hub for public engagement projects outlines four main criteria of citizen science:

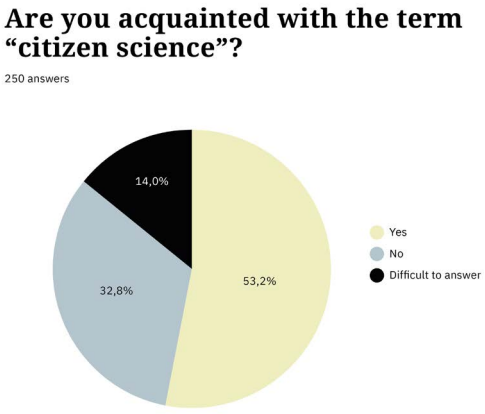
- any volunteer can join the project;
- all participants follow the protocol developed previously by the researchers. This is necessary to ensure data comparability retaining scientific accuracy as much as possible;
- collected data can help researchers reach scientifically significant conclusions;
- a large community of scientists and volunteers collaborate and exchange data, equally accessible to all participants.

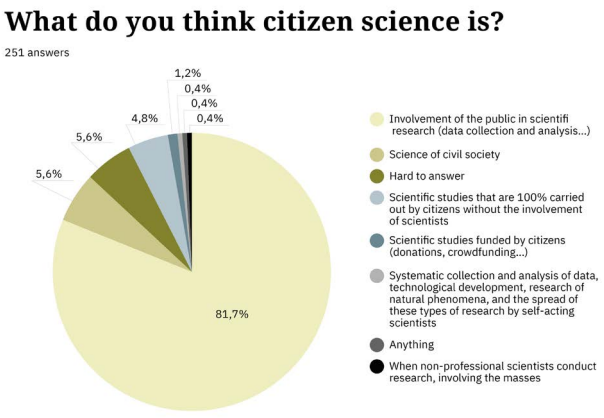
Apart from different definitions, there are various synonyms of citizen science in the literature that mark non-scientific contributions to science, such as *community science*, *participatory science*, *crowd science*, and others.

Not all Ukrainian researchers clearly understand what citizen science is. Ten of the twelve Ukrainian researchers interviewed, who engage citizens in their projects, defined citizen science as the engagement of citizens interested in the topic of collecting raw data which is later analyzed by professional researchers to draw significant conclusions. Four of the interviewed experts don't clearly distinguish between citizen science and popularization. Two experts who use the citizen science principles were unfamiliar with both the Ukrainian or the English terms. Two foreign experts we've interviewed have clearly defined citizen science.

Ukrainians don't have a clear understanding of what citizen science is. The results of our questionnaire (Appendix 3) show that only 53.2% of the respondents are acquainted with the term, 32.8% don't know what it is, and 14% hesitate. This is noteworthy that we've shared our form among people interested in science and nature and engaged in thematic Facebook groups.

Citizen science isn't utilized or popularised enough in Ukraine. This is evidenced by the fact that only nearly half of the respondents interested in scientific research and facts can define citizen science. It is utilized, but only a narrow circle of individuals know about it, and often, even the participants don't always know what to call their activity. For instance, even some of the surveyed experts told us that they started to use citizen science first and found out what it is and what it's called later. However, when the respondents were offered to choose the definition of citizen science from a defined number of options, 81.7% gave the correct definition. Among the rest, 5.6% honestly admitted they found it hard to answer, and 5.6% responded that citizen science was "science about civil society".





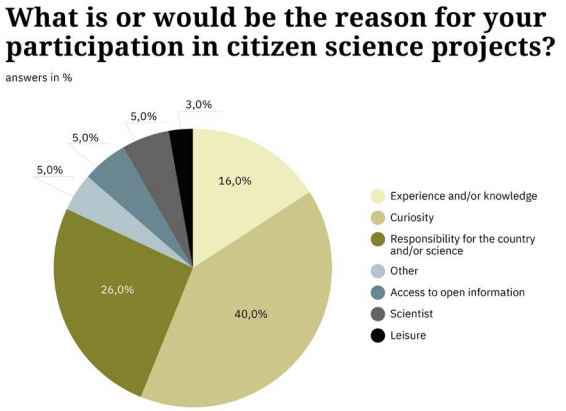
2. Engaging active citizens in science: barriers and motivation

Anyone can join citizen science, regardless of their education background or social status. There are discussions among citizen science researchers around the world on whether it's possible to engage any citizen in such an activity regardless of their initial conditions: education, income level, cultural or ethnic background, etc. For instance, in the USA, white males with higher education *prevail* among citizen science volunteers, leaving other social groups unengaged. At the same time, other researchers report successful data-collecting projects in remote rural areas of the "Third World" (*malaria-fighting project in Rwanda*, *Bird Atlas in Nigeria*, *citizen science projects in Iran*). The experience of the bird-watching school within the framework of the international program BirdID supported by the Nord University in Ukraine, among other countries, demonstrates that anyone from diverse social environments can volunteer, and additional training helps people become the researchers' long-term partners.

The motivation to join citizen science depends on the project type and the participant's personal needs. Evidence from research shows that volunteers may be driven by *a general interest in science* or some project in particular. Some amateurs *want* to make their contribution to scientific research or discovery. People who care about the environment are most likely to *join* environmental protection projects to to influence the situation with their own actions. People who enjoy time outdoors may join a citizen science project to spend time outside.

People naturally need to feel competent and connected to others but autonomous at the same time. This is claimed by *the self-determination* theory used to evaluate the motivations of citizen science volunteers. Participation in citizen science projects *helps satisfy* all three of these needs. According to this theory, volunteer motivation can be categorized as internal and external. People inspired by internal stimuli join the projects to get satisfaction from the activity itself. People who need external stimuli may crave recognition, rewards, competition, or other stimulating factors. However, for most people, internal and external factors work together, reinforcing commitment to participate in the research.

Curiosity, a desire to help the country and pursuit of new knowledge and skills motivate Ukrainians to join citizen science projects. This is evidenced by our survey (Appendix 3) among the citizens interested in science on the Facebook. The access to open scientific information and an opportunity to work with a famous researcher is shared by 5% of the respondents. Only 3% of the respondents evaluate their participation in scientific research as interesting and useful leisure.



Ukrainians are primarily motivated to join scientific research by egoistic factors. According to the classification of motivations of citizen science volunteers *developed* by Israeli researchers, curiosity, experience, and leisure fall under so-called egoistic motivation factors while responsibility for the country, science and the desire for openness of information are,, collectivistic motivation factors. Ukrainians are not unique here, as the *research shows* that egoistic factors mainly motivate people to help researchers.

What's remarkable for Ukrainian society during the August-September, 2023 survey is that the lowest number of respondents are ready to join citizen science as good leisure. For example, in the USA, this interrelation looks different. Researchers from New York have analyzed questionnaires of citizen science participants and *concluded* that quality leisure and satisfaction from participating in a citizen science project are in second place for Americans right after acquiring experience and new knowledge. Other extensive transcontinental research on the farmers' motivation to participate in citizen science projects *shows* that they are similar worldwide — however, sociocultural and socioeconomic factors influence motivation prevalence in society at a given time. Maybe the war has influenced the Ukrainians' priorities. Additional research is needed to check this hypothesis.

Apart from the presence or absence of motivation for citizens to participate in scientific research, citizen science has its own obstacles. For instance, researchers from Washington University, after three surveys of American scientists, have *identified* four main barriers to the utilization of citizen science:

- low level of awareness among science practitioners about the possibilities of citizen science in their field;
- it's currently impossible to utilize citizen science in some fields;
- not all data in citizen science projects is of acceptable quality to be published in prestigious scientific publications;
- some scientists are biased against the volunteers; based on age, gender, educational background, or other factors.

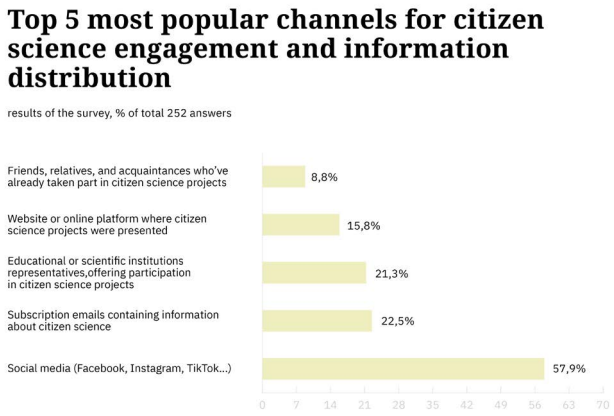
Researchers from the University of Colorado (USA) *researched citizen* science utilization in the countries of the Global South, usually projects . They found that, in some regions, the participants didn't have enough time to participate in the research. Moreover, poor communication between different participants was another barrier.

The strategy of engaging volunteers in citizen science projects has to be complex and multi-tiered. The analysis of our expert interviews shows that not only interested scientists but also institutions, the state, and private entrepreneurs have to collaborate closely to advocate the idea of citizen science.

Original presentation of the research material will help the researcher stir up public interest in the topic, and recognition of the

researchers themselves will increase the level of trust among the citizens. Different platforms can be utilized: social networks, printed and online media, radio, and television. In specific locations of interest for the scientist, posters and flyers can be used to inform the public about the importance of participation in research and its value for science and society.

The best source of citizen science volunteers is amateur communities and forging ties with their members. These people have the biggest potential as they are already interested and motivated. Moreover, they may have their own equipment and good local knowledge. For instance, active birdwatchers often have expensive professional cameras that help them document bird species needed for research.



Clear and straight instructions with a step-by-step action plan will significantly motivate a volunteer to join the project. A person will understand everything and won't feel they are not smart enough. It's important to consider how citizens engage in research and the instruments used here. For instance, when using specialized mobile apps, the instructions within the app are preferred over the ones on a web-site only. In case of spontaneous citizen science engagement, clear posters in specific locations help individuals orient themselves.. For example, the group led by Pavlo Goldin used this to document the mortality of dolphins in the Black and Azov Seas caused by the Russian war against Ukraine. Besides pages on social media platforms, publications in media, and radio announcements, they placed the posters on the beaches of the South of Ukraine with clear instructions on what to do if you see a dolphin on the beach.

Feedback increases the participants' motivation to continue. All the experts in our interviews emphasized this. A person needs to understand not only why they are involved in something but how well they are performing. For example, if a participant succeeded in detecting a rare animal species representative in an atypical location, the researcher has to notify them about it. Some people are even motivated by the fact that their photo of a beetle or a butterfly in the iNaturalist app was of good enough quality to let a specialist successfully identify the species.

It's essential to reward the work. The human motivation system works in waves: the reward fuel the desire to work more, and if absent, the motivation gradually decreases. Rewards may be immaterial, like an interesting lecture or co-authorship in the publication, or material — small presents like books, museum tickets, or other things connected to the research. For many participants of the iNaturalist network, the attention of professional researchers is important — such as identification of species on their photos. Some people find motivation and competitiveness or recognition. For example, for amateur astronomers who take pictures of comets that fall onto the sun during solar eclipses receive recognition when a special commission gives the discoverers' names to the comets. Moreover, when citizens help make an essential discovery, the researchers may make them coauthors of scientific publications. *Data from NASA* shows that around 410 people without special qualifications are co-authors of papers in high-rate scientific publications. *Thus, to choose a reward, one has to clearly understand the needs of the social groups engaged in the research.*

Scientific institutes and universities communities play an important role in

engaging citizens in doing research. In the EU countries, there are Citizen Science Hubs that *help* engage and motivate citizens to participate in research. Currently, there are four such centers in European universities: the University of Twente, the Autonomous University of Barcelona, the Aristotle University of Thessaloniki, and the Vilnius Gediminas Technical University. Their specialists work to make citizen science more visible within the population, popularize it, and adapt it to the needs of the communities. Moreover, these centers constantly monitor the influence of their actions on the population's engagement in citizen science. The European Citizen Science Association website provides *yearly reports* with all the necessary information, which will facilitate the first steps in creating this type of committee.

Having a website is important to unify all the information about the possibilities of citizen science in different regions of the country. This website should contain the following information for the citizens: interesting current projects descriptions, rewards for participation, competition results (similar to the Wiki Loves Earth project), photos, and publication examples with active citizens as coauthors. Moreover, this unified website should include a section for scientists with a list of grants, project examples, available apps and online platforms. Similar resources are available in many *European countries* and the *USA*.

State policy should encourage institutions to utilize citizen science in different ways. First of all, there should be a transparent grant system for citizen science projects that would cover the expenses for project popularization among the citizens and create a network of citizen science centers. However, active involvement of the state in citizen science projects can reduce trust among the population, as highlighted by Azby Brown — one of the key organizers of the Safecast international organization that uses citizen science to monitor the environmental changes in Japan after the Fukushima Atomic Power Plant accident.

Private funds play an important role in developing research with citizen science involvement. Socially active businesses can contribute by awarding grants to teams engaging citizens in research and funding the creation of citizen science hubs.

3. Data collection by amateurs: balancing quantity and quality

Data quality and quantity are ensured by motivation. In most cases, personal motivation is the primary reason for citizens to engage inscience projects. Therefore, the quality of data in citizen science projects is also influenced by motivation. Most amateurs treat collecting data responsibly, but loss of motivation can lead to decreased data quality and reduced participation. At the same time, recognition, acknowledgments, and researchers' feedback not only encourage continued participation but also retain motivation and thus improve data quality. Some researchers, for example, add acknowledgments in their publications to encourage the contributors. It's important to note that maintaining motivation is crucial not just among the citizens but also among the institutions. This is pointed out in the *research on the success factors* of citizen science projects in monitoring water quality.

Efficient coordination, including moderation, communication) is crucial for ensuring quality and quantity of collected data. Open (accessible, direct) communication between amateurs and scientists (experts) can help improve the data. For example, *UkrBIN*, encourages direct communication between experts and users on coordinates, ecological conditions, adequate description or other details of their findings. At *iNaturalist*, users can message each other asking for more details as well (on phenology,captivity or growth conditions, etc.) or make remarks on the quality of the photo. Besides that, there is a Telegram channel for Ukrainian users — *iNaturalist UKR* — where amateurs and specialists can communicate on data quality and integrity.. Communication and coordination facilitate better understanding of the nature and quality of data that should be added to the database. The significance of the communication between scientists and amateurs in ensuring data quality is well documented in different *publications*.

Automation of the data-collecting process doesn't always guarantee quality. Even with highly automated data-collecting processes human participation and specialist verification is necessary. If the users don't fully understand the goal of collecting data and subsequent use, it can influence the

data quality. For example, in the *iNaturalist* app, the process of collecting data about the species' biodiversity is automated. The user only has to take photos and tick some boxes if needed. The app can even identify the species with the help of the AI. However, the quality of data depends solely on the user. They often overlook the required boxes, skip the descriptions, and neglect the geolocation, though with the internet connection problems, leading to errors. The quality of the photo itself (the angle, detailing of certain parts, etc.) isn't always good enough to identify the species. Species identification is a separate topic: the program offers identification, and often, non-professionals using this function make mistakes. Sometimes, only highly trained specialists can confirm the identification of the species in a certain taxonomic group. Automation can surely speed up and simplify the job, but it still lacks algorithms to help avoid errors such as additional verifications or selective access for high-ranked users. **Clear instructions and simple tasks facilitate the collection of quality data.** Explanations of how the instrument works are essential. For instance, iNaturalist has a "held in captivity/ cultivated" box; if one doesn't pay attention to it, the species distribution area gets distorted, and the researchers must spend additional time sifting through the invalid data. Most citizen science projects have such instructions, but its developers should make sure that the user will (easily) find, get acquainted with, and adhere to such instructions.

The balance between amateurs and specialists is important. After all, all the data collected during citizen science projects should be used by researchers. It's the researchers who analyze it, prepare publications, and produce new knowledge based on it. If there is an imbalance, problems arise: a shortage of researchers means that an extensive array of data will remain unprocessed or unverified, impacting the quality and, at the same time, demotivating the users, thus both quality and quantity.

The establishment of amateur communities has a number of benefits. Researchers can continuously engage highly motivated and usually qualified amateurs in citizen science, for example, in joint data-collecting excursions, which can also be used for science popularization, broadening awareness, and facilitating the increase in data quality. Besides that, this lets the researchers engage trusted amateurs in projects with some risks, such as dissemination of critical information about the valuable rare species distribution or archaeological artifacts.

Engaging students can be efficient for the quality and quantity of data. Engaging students in research during field practices is a common practice in Ukraine. This, on the one hand, helps improve their professional skills and, on the other hand, lets researchers collect data of higher quality. Students are interested in participating in actual research to gain experience, and the researchers benefit from their help. It's essential to reward the students who contributed to the research, for example, through acknowledgments. Thus, citizen science utilization in universities has many benefits for both students and citizen science projects.

Incorporating a competitive component can ensure not only quantity but quality. Recognition and rewards are important for people. Thus, organizing a competition with different criteria (for the biggest number of finds, the best photo, a unique discovery, etc.) may be effective. For example, *the Ukrainian Nature Conservation Group* non-profit organized a *competition* at *iNaturalist* to research the biodiversity of the Zhukiv Island preserve, awarding winners with thematic literature. The moderators of the Facebook *Flora of Ukraine* group regularly arrange "Plant of the Month" competition for the best photo, where the winners are awarded with thematic printed material and distinctions. *Wiki Loves Earth*, and *Wiki Loves Monuments*, which regularly host photo competitions where the winners are awarded various prizes.

Sometimes, massive data can hold valuable discoveries, as treasure can be found in the heap of trash. Citizen science may be an excellent investigation tool to find where to "dig". For instance, the users of iNaturalist and UkrBIN can upload thousands of species photos, which, in most cases, are unremarkable for the researchers. Still, sometimes, a certain find can help with documenting new species on the country's territory or identifying a new locality for a valuable or endangered species, resulting in new discoveries. Communicating with users or conducting field trips can help to gather more accurate data that may become a foundation for scientific publication.

In general, the quality and quantity of data are ensured by a complex and systemic approach. Citizen science projects are multi-faceted, an individual approach and a complex of measures. Among others, quality control *actions and measures* include:

- *Triangulation* (collecting data from different sources to study one phenomenon) that combines numerous criteria and methods to ensure the data quality.
- Monitoring — tracking data quality overtime and creating reports about uncertainties and variations.
- Holding educational and training activities for amateurs.
- Abiding by protocols and consistency standards to maintain data consistency and homogeneity.
- Compatible information systems allow to keep, use, and archive data long-term.
- Using international standards, for example, *ISO 8000*, etc.
- Following by the *FAIR* principles of open science and open access licenses.
- Sharing experience and information about data quality assurance practices, to enhance knowledge in this field.

The research analyzing over 50 citizen science projects discovered that most used a combination of methods to ensure data quality. The choice of these methods partially depends on available resources and the project size. This emphasized the importance of scalability in data monitoring during planning and development of citizen science projects.

4. Citizen Science Infrastructure

The development of citizen science needs an appropriate infrastructure. *The conceptual model of citizen science* has to include three main aspects (and their metadata):

- The spread of information about citizen science projects.
- Engagement of people.
- Presentation of the project's results, usually in the form of data visualization and publications.

All of this demands appropriate infrastructure.

The current development of citizen science usually demands digital infrastructure, and most citizen science platforms are digital. Citizen science platforms are web infrastructures, following one or more of *these instructions*:

1. Presentation of active citizen science projects and events.
2. Visualization of citizen science data and information.
3. Offering general guidance and instruments that can be used to support citizen science projects and overall activities.
4. Sharing best practices and lessons learned.
5. Presentation of the scientific results to individuals engaged or interested in citizen science.

Citizen science platforms vary in their main goals and tasks. In particular, these *platform types* are identified:

- Commercial platforms for citizen science initiatives (*CitizenLab*, *SPOTTERON*, *experiment*);
- Citizen science platforms for specific projects or science topics (*Zooniverse*, *Globe at Night*, *i-Naturalist*, *Foldit*, *iSpot*);
- National or regional citizen science platforms supported by government institutions (*CitizenScience.gov*, *eu-citizen.science*, *Citizen Science Portal* (Canada)).

In Ukraine, national government or commercial platforms are absent; platforms for specific projects or topics are preferably used. The most popular citizen science platforms are *iNaturalist* and *UkrBIN* (according to the questionnaire, Appendix 3).

Mobile apps can complement citizen science platforms. Mobile apps have some *benefits*, as they usually have a convenient and straightforward user interface, which allows to engage more people. At the same time, synchronization of the app with the database is essential. Synchronization of several apps with one platform is also a good practice. For

example, *GBIF* uses data from several *citizen science apps* such as *i-Naturalist*, *eBird*, and others.

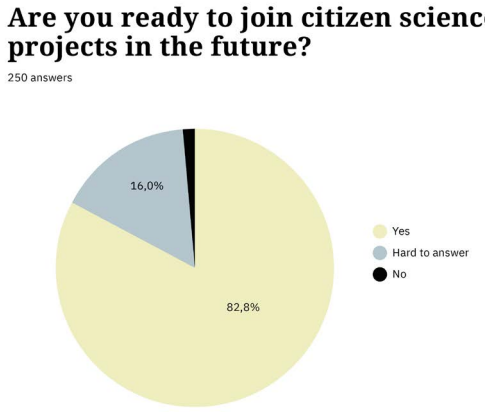
While citizen science platforms are the most efficient instruments of citizen science, simpler and more available means can be used, including online forms, announcements, social media, messengers, etc. There is no need to create a web platform at the very beginning of a citizen science project; a group in social media may serve as a starting pointt. For example, the *Flora of Ukraine* Facebook group created a *photo catalog* of Ukrainian plant life through photo albums, contributing to the *Atlas of Herbaceous Biotopes* (2022). Besides social media, the dolphin mortality data gathering *initiative* utilizes simple messengers like WhatsApp, Telegram, and Viber. Additionally, data can be collected through GoogleForms or their equivalents and via plain announcements and email messages, despite some limitations.

Citizen science is rarely used in conditions of wars, crises, and catastrophes. While analyzing best practices of citizen science utilization (Appendix 4), our desk research has shown that citizen science is rarely used in crisis conditions. Among the nine citizen science utilization practices we've found in Ukraine, only a third are connected with the war — these SaveEcoBot, EcoDanger, and Dolphins of Azov and Black Sea. The rest of them — iNaturalist, UkrBIN, Flora of Ukraine, Mushrooms of Ukraine, Polycam/Backup Ukraine, and Collecting DNA in the Subway, are only indirectly connected to war and crises. Global and national citizen science platforms, like *CitizenScience.gov*, *EU-Citizen.Science*, *European Citizen Science Association*, *Anecdata*, *SciStarter*, *CitSci*, *Zooniverse*, and others don't contain projects about wars, with only a few on adaptation to climate change, natural disasters, or evaluation of of water or air quality.

Citizen science can stimulate social innovation and be a part of corporate social responsibility. *Corporate social responsibility* is crucial for reaching the Goals of Sustained Development, and it has gained popularity among businesses, especially large ones already participating in citizen science projects. Thus, the *Earthwatch* platform actively promotes business engagement in their projects and already has *along-term collaboration history with Starbucks*, advocating eco-friendly agricultural methods in one of the best world coffee cultivation regions.

5. Citizen science experience in Ukraine: successes and gaps

Ukraine has great potential for citizen science. There are at least ten successful citizen science projects in Ukraine (Appendix 4). Survey results (Appendix3) show that the Ukrainian public participates in international projects. We received over 30 variations of answers grouped by similarity. Our surveys and answers from the experts show that citizens are interested in helping scientists. as.



Citizen science projects in Ukraine are unevenly distributed among the fields, deviating from global experience. Similar to global trends, the most significant activity is observed in the fields of environment and biodiversity. However, according to *Manske, 2021*, projects in astronomy and astrophysics, which take second place worldwide, are not as popular in Ukraine, despite numerous clubs of amateur astronomers in Ukraine. The same research shows that a large part of citizen science related to the environment in Europe is connected to remote sensing technologies that are not well-developed in Ukraine. There's also a lack of projects related to biomedical research and social sciences and humanities.

Education defines the success of a project. Volunteer training provides the best results. Prior learning produces higher quality data. Volunteers who invest their time in learning are motivated for a long and sustained collaboration with scientists. The Nord University's experience with birdwatchers in Ukraine (as seen in other countries) shows great feedback. Gathering microbe DNA probes in the Kyiv subway was a relatively simple task, though it still benefits from the protocols, as well as having a biology student in every group, who taught the participants about the process.

In Ukraine there are communities of amateurs in specific fields who are not engaged in citizen science by researchers. The astronomers don't involve astronomy amateurs, lacking organizational and human resources. Geologists rarely engage sportive speleologists and mineral lovers, as they lack funds (for example,poor storage facilities for the specimens). There are communities that recognize texts, such as WikiSources, but historians and philologists don't direct their efforts to their research (though still using it). According to our questionnaire, some volunteers have collaborated with foreign scientific data analysis projects (distributed computing, protein folding, molecular dynamics, etc.). Still, there are no such projects in Ukraine.

The high educational level of Ukrainians allows their engagement in citizen science projects, although this level is slowly decreasing. People with higher education and scientific interests — local history enthusiasts, school teachers, tourist club managers, Junior Academy of Sciences professors, and scientific university faculties alumni who don't work in science can play a significant part in coordinating citizen science projects. At the same time, researchers note the decrease in the educational level of school and university graduates, which means there will be fewer people who understand the principles of the scientific method.

In fields like paleontology or archaeology, citizen science in Ukraine faces limitations due to ethical and legal problems. There are a lot of people who lack understanding of what historical heritage, national treasure, and treasure of humanity are. For them, any valuable artifacts can be sold on the market. That's where "black archaeology" and "black paleontology" come from. Here, we need a gradual transition to citizen science through education and popularization of these scientific fields. Forming values, potentially through a sense of patriotism is vital in this situation.

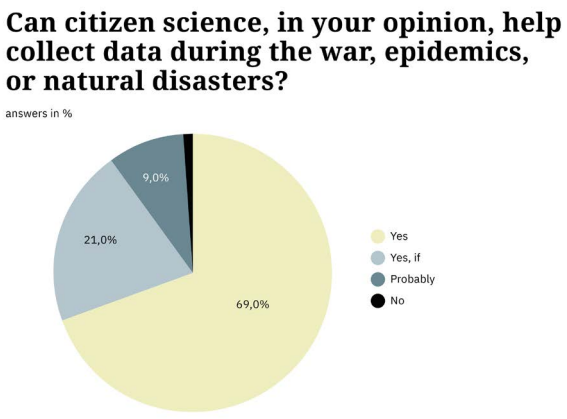
The involvement of donors from small villages and towns creates aboost for citizen science development in localities with lower average educational levels. For instance, the establishment of *the Ecological Research Station "Hlyboki Balyky"* in the Rzhyshchiv territorial community, where the funding of local ecological research has driven the local community to fill in observations in iNaturalist. In the Kryvyi Rih region, since the 1990s, the support from patron Yuriy Myloboh has stimulated the on birds of prey, leading to increased observations. Patrons (enrollment) is especially important for large countries with insufficiently researched regions. For example, while North Macedonia has an index for all the country's villages, Ukraine lacks indexes of small rivers.

Many Ukrainian scientists lack understanding of public engagement. Prejudices such as "We do complex physics; there's no place for amateurs here," are caused by lack of awareness with the possibilities and instruments of citizen science.

In Ukraine, the NGOs play an important role in popularization of citizen science instruments. Thus, *the Ukrainian Nature Conservation Group*, besides using them in their activity, *regularly talks about possibilities* of the *iNaturalist* resource and works on *functionality improvements* for the Ukrainian audience. *The Ukrainian Ecological Club "Green Wave"* focuses on *utilizing and popularizing* the *i-Tree* tools.

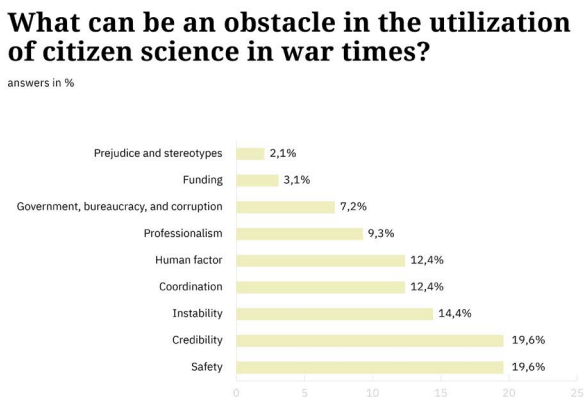
6. Citizen science in times of crises: added value for scientists or risks for citizens

Citizen science can be useful during wars, crises, and catastrophes, but there are obstacles. It can help in data collection during wars, epidemics, or natural disasters. This is believed by 69% of survey participants (Appendix 3). Another 21% noted that it can only help under certain conditions. These conditions, as identified by the respondents, are the safety of all the process participants as well as quality coordination and communication, clear instructions, transparency, and openness. Only 1% of those who answered this question think that citizen science cannot be useful during wars and crises.



Among the obstacles to the use of citizen science during wars, issues of safety (19.6% of the answers) and credibility and quality of data collected in crisis conditions (19.6%) were mentioned most often. Even under ordinary conditions, the quality of data strongly depends on the integrity of the users, and during the war, it may be even more difficult to check and verify obtained data. Instability, particularly the lack of electricity, internet, and telephone communication, as well as changes in the security situation, were named as obstacles to the use of citizen science during war by 14.4% of respondents. About 12.4% of respondents noted that a lack of clear coordination and human factors like emotional burnout, change of priorities, volunteering in the humanitarian sphere, the need to find means of survival, etc., can be significant obstacles in the use of citizen science. The professionalism of both scientists who initiate citizen science projects and the citizens who join them is important for both the development and the slowdown of citizen science, as noted by 9.3% of the respondents. Another 7.2% of survey participants said that obstacles from the government, like the

lack of appropriate laws, bureaucratization, corruption, etc., can significantly slow down the use of citizen science in war conditions. Only 3.1% of respondents mentioned the financial component, and stereotypes and prejudice were noted by only 2.1%.

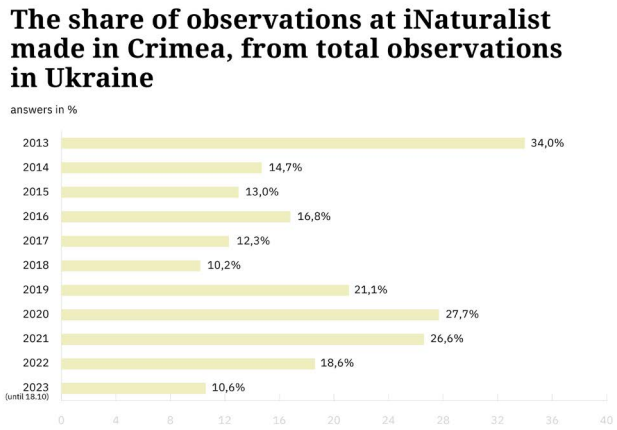


Personal data protection should be especially potent in wartime conditions. Ukrainian resources and platforms often face various types of hacker attacks (DDoS attacks, traffic analyzers, Rootkit, network intelligence, Man-in-the-Middle) aimed at stealing data, sabotaging, and obtaining information about users, etc. To ensure the safety of the citizen science platforms, especially those related to documenting war crimes, secure communication channels are needed.

Under war conditions, and especially under occupation, data verification can be problematic and even impossible. During war and occupation, it may be dangerous even to take simple photos, as both sides can consider this to be intelligence and an attempt to send data to the enemy, rather than for scientific purposes. Particularly in occupied Crimea, many local activists, despite the danger, are ready to transfer data about the situation on the peninsula, but they have to use secure communication channels. Sometimes, this works through “word of mouth” networks through activists, acquaintances, etc. In such conditions, it is not always possible to verify the authenticity of the data, as everything is built on trust. The quality and quantity of data can’t always be ensured as well.

The use of crowdsourcing personal computational power can be dangerous in wartime conditions. Citizen science is an umbrella term that includes citizen cyberscience, where volunteer computations contribute to the use of the computational power provided by volunteers for large-scale scientific computational tasks. An example of such a tool is *CitizenGrid* — an online middleware platform that utilizes cloud computing technologies. However, in Ukraine right now, such a tool can be dangerous (due to malicious software, phishing, geolocation tracking).

Engagement in citizen science by people in occupied territories may be low, but available global platforms may be of help. Global experience shows that citizen science allows for the coverage of hard-to-reach territories (places of active combat, government-level restrictions, quarantine measures) and to obtain massive amounts of information that would be much more expensive to get by traditional means. On the contrary, in Ukraine, citizen science projects usually develop slowly due to martial law with restrictions on visits , due to landmining of territories, active combat, internal displacement of people, and finally, because they are not a priority. Community engagement in citizen science to research nature in Crimea became impossible after 2014 due to the split in the information space, the data collection cannot be organized, but there are still important tasks of documenting crimes against the cultural heritage of Crimean Tatars and violations of human rights as a result of the annexation by russia by a crowdsourcing project (the name of the project currently cannot be shared for safety reasons). Still, there are prospects for more active use of existing global citizen science platforms, even in occupied territories. For instance, the iNaturalist biodiversity documenting platform has been actively used in Crimea since 2013, despite the annexation; it encompasses 10-30% of the total observations in Ukraine, though after 2022, the quantity of observations has decreased.



Updating and prioritizing citizen science fields in Ukraine are of great importance. Citizen science in Ukraine should take into account current challenges to increase engagement, clear and understandable communication (explaining why Ukraine needs it and how it will facilitate and speed up postwar renewal) to justify decision-making. This can concern social sciences, in particular. There are currently crowdsourcing projects in Ukraine on biodiversity, key of which are in botany, ornithology, entomology, malacology, chiropterology, etc., which is quite a narrow area of interest for the public, unlike sociohistorical sciences. For example, the public can participate in transcribing historical documents, audio and video, digitalization of old newspapers and journals, or classification of photos. Gamification of citizen science tools may be an interesting way to increase the participants' motivation and fulfill their curiosity.

In conditions of war and crisis, new spheres of citizen science utilization can develop. With the beginning of the full-scale war, the interest of society in *mental health self-screening* has grown; this is facilitated by the creation of new projects, for example, *MENTAL HEALTH FOR UKRAINE — MH4U*, *Pan-Ukrainian mental health program "How are you?"*, *MARTA* project by Diia, that also uses instruments of citizen science, even though it is not explicitly stated. In Particular, the interest in researching one's heritage has grown, with projects like *MyHeritage*, the *Open List* database of individuals repressed by the state for political reasons from 1917 to 1991, or the list of the repressed by the communist regime by the *Ukrainian National Memory Institute*. There is also the largest database of people who lived in Ukraine from 1650 to 1920 is *Pra.in.ua*, where users can add their own information or edit existing entries. All these resources utilize citizen science tools in some way. Therefore, it is important to broaden the understanding of what citizen science during crises is and identify the areas where it can be useful not only for natural and exact sciences but also for humanities and social sciences.

Engaging different communities in addressing crisis situations can be effective. There are a couple of ways to increase interest in citizen science. In particular, by spreading information about citizen science tools among local communities in their research area, for example, for the study of the frequency of aphantasia among the populace, which is a lack of the ability to create mental images, *Aphantasia Network* has engaged the public to participate in a questionnaire about the vividness of their imagery (VVIQ). The gamification of citizen science increases the participants' motivation to satisfy their curiosity: for example,the *Foldit* online quiz about the folding of proteins, which has existed since 2008. It became especially popular during the COVID-19 pandemic when *the players were offered to look for proteins that would block the virus's penetration into human cell*s. This also is an example of a successful combination of external and internal motivational factors, understanding the public demand for research, and communication with the community. It's important to note that people of all ages, educational levels, and income levels can be engaged in citizen science; as in the case of Foldit, they may not have specialized knowledge but may have an advantage in the number of attempts. Another way to engage the public in citizen science is the creation of new citizen science tools for research in fields where the amount of data is crucial(social and political sciences, humanities, medical sciences). Specifically, the *Ukrainian Registry of Bone Marrow Donors* may

be called a citizen science project in medicine; its goal is the popularization of donorship, registration of potential bone marrow donors, and the formation of a registry, which became more popular during the war.

Eliminating the loneliness factor in crisis conditions may be a motivation for engaging in citizen science. It is not the first priority, but one of the underestimated added values of citizen science is the creation of a community or engagement in it. Under the conditions of displacement within the country or abroad, it's important to engage scientists who continue their work outside the country in citizen science tools to retain and acquire new social contacts and potentially return to their workplaces in Ukraine. The development of website platforms for citizen science may be of use — the platforms for the publication of research where the involvement of the public is needed. An example of such a crowdsourcing project is *Anecdata* for social sciences and *SciStarter*, the world-known citizen science hub. But the most important component of these platforms is systematic and powerful communication with the involvement of the opinion leaders, good moderation, transparent instructions for the authors of research and volunteers, and a strategy for participants' motivation.

Institutional and financial support of citizen science during crises is the key condition of sustainability. Citizen science projects demand sustainability — financial (which covers technical support, moderation, communication, promotion, consultations, server payments, design of the platform) and institutional (including political support, engaging university students in projects, educational programs for implementing citizen science tools, communication in scientific institutions, advocacy of scientists' needs). During the crises, it's essential to communicate about citizen science as a sustainable project, meaning that once completed, the research results will continue to exist, for example, supporting environmental protection, certain scientific groups, more global developments, becoming part of the research all over Ukraine and helping present Ukraine internationally.

Citizen science is important for the restoration of scientific research. According to the *Report on direct infrastructure damages from destructions due to Russia's military aggression against Ukraine for the a since the beginning of the full-scale invasion,* March 2023), preliminary calculations show that 117 objects of movable and immovable property of 34 institutes and other facilities of NAS of Ukraine are destroyed, damaged, or requisitioned by the Ukrainian Armed Forces. The scientific infrastructure bears not only economic losses but also losses of human potential — scientists are unable to continue their research. Data collected through citizen science will help partially restore the research and communicate with the public about this critical component, which will be a win-win for both the public and the sustainable post-war recovery of Ukraine.

Citizen science has accompanying benefits that are important in crises. It promotes science popularization and the spread of public awareness, providing more open and transparent access to data, which is of great importance during wars and disasters. For instance, the *Safecast* platform that appeared after the earthquake and tsunami in Japan in 2011 that led to the accident at the Fukushima Daiichi Nuclear Power Plant, aims to provide open and transparent access to environmental data. A similar goal is held by the initiative *Public Lab*, which appeared after the oil spill near the Mexico Bay coast in 2010l.

Citizen science may help with the rehabilitation of people with PTSD, the integration of refugees, and mental health support under crisis conditions. Some citizen science initiatives may help support people who have experienced severe stress. In particular, during our in-depth interviews, some experts (Appendix 2) noted that, on one hand, amateurs and scientists may experience burnout or change their priorities during the

war, but on the other hand, engagement in citizen science facilitates support and recovery of mental health. One of the users continued to document finds in *iNaturalist* even during the occupation, and it helped him distract from the terrible reality around him. Fields of natural sciences are particularly effective, as they often require *being outdoors*. Besides that, there are practices of using citizen science to integrate refugees. For instance, the Austrian Scientific Fund has introduced the *CitiSEn* project for the social integration of refugees and identifying their needs.

Citizen science provides the opportunity to share results with Western partners. Itcan also bear political interest, particularly through lobbying of fundamental and applied research for Ukraine's sustainability in the postwar future, a discussion to which not only experts but also the public are contributing .

7. Recommendations for Actors

Scientists

1. Talk extensively and interestingly about your own research area, as an engaging presentation and the recognizability of the scientist not only attracts public attention but also builds trust.
2. Actively participate in the life of amateur communities related to the field of your scientific research.
3. Develop clear and understandable instructions for the research participants, and choose an optimal data collection and deposition.
4. Evaluate and clearly articulate/write about possible dangers for citizens during natural disasters, the spread of infectious diseases, or armed conflicts. Develop appropriate instructions for research participants and consistently emphasize the necessity to abide by safety rules.
5. If necessary, ensure the anonymity of the participants as much as possible. Use only secure communication channels.
6. Regularly provide feedback to research participants. Motivate citizens through material rewards, acknowledgments, inclusion as co-authors, or the use of a competitive format.
7. Support other citizen science projects with information and resources to foster an environment favorable for new projects.
8. Emphasize the necessity of public engagement in citizen science as part of science popularization.

Academic and research institutions

1. Create committees at scientific and academic institutions that would systematically work towards engaging volunteers in citizen science projects and increasing scientists' awareness of the possibilities of citizen science.
2. Stimulate scientists in every possible way to start and participate in citizen science projects both informationally and financially.
3. Identify fields and tools in which the application of citizen science can create added value for research.
4. Communicate with school and student communities about citizen science in schools, places of extracurricular activities, and universities.

State institutions

1. Create a unified online resource (platform) with the appropriate functionality, instructions, and all possible information

about the initiatives of citizen science in Ukraine and abroad in which Ukrainians could participate.
2. Develop a clear and transparent grant system for citizen science projects.
3. Establish a unified foundation that would allow the attraction of funds from philanthropists, businesses, and state and foreign sources for citizen science projects.
4. Include citizen science tools in rehabilitation programs for war veterans, refugees, and other social groups, and also in the programs of postwar recovery of the country.

Civil society organizations

1. Include collaboration with scientists and scientific institutions for starting, promoting, and supporting citizen science projects in your strategic goals.
2. Promote and spread awareness about available citizen science tools.
3. Engage in discussions about the potential of citizen science tools in documenting war crimes.
4. Conduct science popularization events in your communities.

Business

1. Include support of citizen science projects in your programs of corporate social responsibility. Support may be full or partial, financial, consultative, or other.
2. Support startups that will promote the development of innovations in the field of citizen science.
3. Provide platforms for communication about citizen science.
4. Contribute to the creation of secure platforms for collecting and processing data obtained during the research.
5. Engage in gamification of platforms for different age categories.

Conclusions

- Despite the fact that there are many different definitions of “citizen science” and synonyms, essential parts of most definitions are voluntary participation which does not involve monetary rewards for participants, and a common goal-providing assistance to scientists.
- The most common motivational factors for participation in citizen science are interest in science in general, curiosity , desire to contribute to research, development of the society, and environment protection—all these motives are found among the participants.
- There are certain obstacles to implementation of citizen science, including insufficient awareness among both scientists and amateurs; biases of practicing scientists; impossibility of application in certain fields ; and sometimes unsatisfactory data quality for publication in prestigious scientific journals. In wartime, critical obstacles include safety or its absence and change of priorities among scientists and amateurs.
- To ensure credibility and high quality of data, a comprehensive approach is needed that would include quality control, monitoring, training, and using standards, as well as communication and feedback. The analysis of various citizen science projects underlines that the best results are reached by combining different data monitoring methods.
- The efficiency of citizen science projects, including data quality and quantity, largely depends on the motivation of both the amateurs and the scientists as well as institutions. Furthermore, coordination and communication between amateurs and scientists, as well as clear instructions contribute to the collection of high-quality data, while automation doesn’t always guarantee their quality without participation and verification by professionals.
- The balance between amateurs and professionals is important for the success of citizen science projects and for ensuring the quality and volume of data. Insufficient involvement of scientists can lead to unprocessed and unverified data, affecting their quality and quantity and, thereby demotivating the users. The creation of amateur communities, engagement of students, organization of competitions, and acknowledgments can be effective strategies for improving the quality and quantity of the collected data in citizen science.
- The modern development of citizen science is mainly connected to digital infrastructure, especially citizen science platforms usually complemented by mobile apps. These web infrastructures are key to spreading information, data presentation, and visualization of the project’s results. At the same time, in conditions of limited resources and experience , it’s possible to use simpler and more accessible methods, like online surveys, announcements, social media, messengers, etc.
- Citizen science has great potential in military conflicts, crisis situations, and disasters. Unfortunately, at present, this potential is utilized only in a limited way, but it can be developed in the future for efficient utilization in emergencies.

Appendix 1. Research methodology

This research is based on quality and quantity research methods. Data collection was conducted from early July to mid-September 2023 and included:

- Desk research: in particular, an analysis of Ukrainian and foreign practices in use of citizen science, taking into account the challenges, obstacles, ways of engagement, copyright preservation, and ensuring data quality in conditions of war, crises, and disasters .
- Semi-structured interviews with representatives of the scientific community to understand the level of awareness of Ukrainian scientists about the possibilities and challenges of citizen science.
- In-depth interviews with expert practitioners who use citizen science tools to understand the state, obstacles, needs, engagement, and use of citizen science practices in Ukraine during the war.
- A questionnaire to identify values that would help engage Ukrainians in citizen science under war conditions.

Desk research, an analysis of citizen science utilization practices	• 10 Ukrainian • 33 foreign
Half-structured interviews with representatives of the scientific community	• 4 informants
Expert interviews	• 14 informants
Questionnaire	• 252 respondents

During the desk research, all platforms applying citizen science in Ukraine were taken into account, while among foreign practices, platforms hosting various citizen science projects were examined, as well as cases that directly or indirectly relate to wars, natural disasters, catastrophes, and other crises.

Audio records of the expert in-depth interviews were transcribed into written form and their content was analyzed afterwards.

The questionnaire included both closed and open-ended questions. The analysis of closed questions included counting the frequency of every proposed answer and creating graphs and charts. The analysis of open-ended questions included dividing answers into categories and then counting their frequency and results visualization in graphs and charts.

Our team conducted this research during a relatively short period, from July to September 2023, while circumstances and conditions may change dynamically and influence the results and conclusions made during the research.

Appendix 2. List of informants (experts)

1. *Pavlo Goldin*, Doctor of Sciences in Biology, the leading researcher of the NASU I. I. Schmalhausen Zoology Institute, Founder of the group "Dolphins of the Azov and Black Seas".
2. *Yurii Khalavka*, Doctor of Chemistry, associate professor at Chernivtsi National University, Founder of the initiative to help Ukrainian scientists UAScience.reload and Kunsht non-profit.
3. *Mykola Yunakov*, Ph.D. in Biology, science officer at Oslo University Zoology Museum.
4. *Tamara*, an activist from Crimea (the informant desires to stay anonymous).
5. *Mykyta Perehrym*, Ph.D. in Biology, senior lecturer of the Chair of Horticulture and Ecology of Taras Shevchenko Luhansk National University, guest researcher at the University of Oulu, Finland.
6. *Natalia Atamas*, research fellow at the Laboratory of Population Ecology of the Department of Monitoring and Protection of the Bird World at the NASU I. I. Schmalhausen Zoology Institute.
7. *Vadym Zhulenko*, ornithologist, postgraduate at the Chair of Zoology of the Lviv National University, employee of the Lviv National University Zoology Museum.
8. *Alina Frolova*, research fellow in the Department of Protein Synthesis Enzymology of the Systemic Biology Group of the NASU Molecular Biology and Genetics Institute.
9. *Oleksiy Vasyliuk*, junior scientific officer at the Department of Monitoring and Protection of the Animal World at the NASU Zoology Institute, CEO of Ukrainian Nature Conservation Group NGO.
10. *Lilia Kazantseva*, manager of the Astronomy Museum at the Taras Shevchenko University Astronomical Observatory.
11. *Natalia Matushkina*, Ph.D. in Biology, associate professor at the Chair of Ecology and Zoology of the Taras Shevchenko Kyiv National University Institute of Biology and Medicine.
12. *Azby Brown*, an expert on Japanese design, craftsmanship, and environmental sensibility, lead researcher for SAFECAST.
13. *Yevjen Synytsia*, associate professor at the Chair of Archaeology and Museology of the Taras Shevchenko Kyiv National University, CEO at the Ukrainian Association of Archaeologists NGO.
14. *Eddie von Wachenfeldt*, Ph.D. in Limnology, head of the aquatic assessment unit of Swedish Agriculture University (SLU), coordinator of the biological diversity within the SLU.

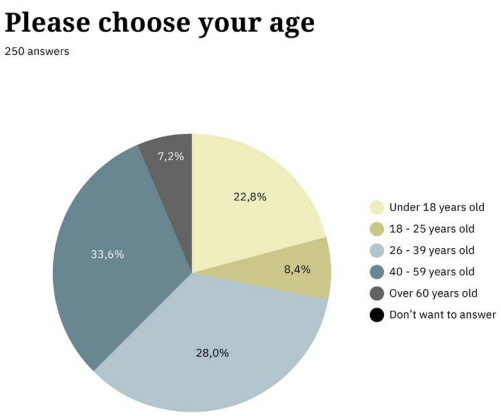
Appendix 3. questionnaire Results

The questionnaire was conducted from July 27 to September 19, 2023, using Google Forms.

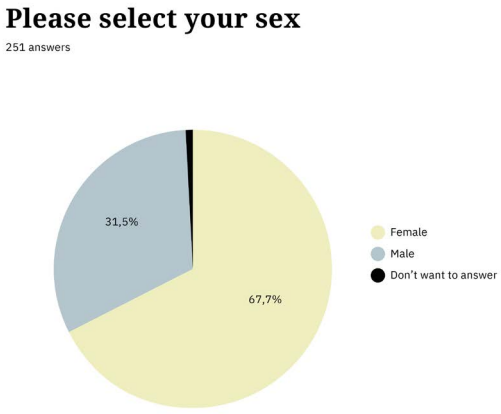
To spread information about the survey among potentially interested respondents, a *post* (36 shares) was created in theFacebook group *"Ukrainian Scientists Worldwide"* (31,8 thousand members). The questionnaire was also shared on these resources:

- *Flora of Ukraine*
- *Junior Academy of Sciences of Ukraine*
- *Ukrainian Ecological Club "Green Wave"*
- *Atheist*
- *Education for Sustainable Development in Ukraine*
- *News of Ukrainian Pseudoscience*
- *News of Higher Science*
- *Scientific Media Ukraine*

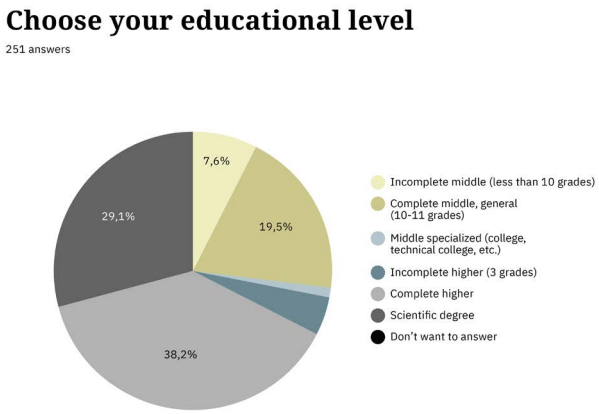
252 respondents of various age groups took part in our research. The largest group (33.6%) consists of middle-aged representatives — from 40 to 59 years old. The following big group is people from 26 to 39, which is 28% of the total. School-aged youth (up to 18 years old) were also well represented, 22.8% of the total. The lowest number of responses was from people over 60, only 7.2%. Particular attention should be paid to the group of 18 to 25, which was only 8.4% of total responses; unfortunately, this means that university students were poorly represented. Overall, the results demonstrate a wide range of the survey and that the topic we researched is of interest to various age groups.



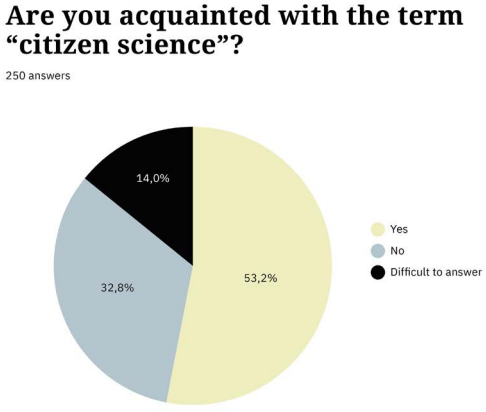
The survey results show a large representation of women in the research — 67.7% of the total number of respondents, compared to 31.5% of men. This high number of women in our research may be evidence that this group has a particular interest in the topic of our research, but it also may be the consequence of the war.



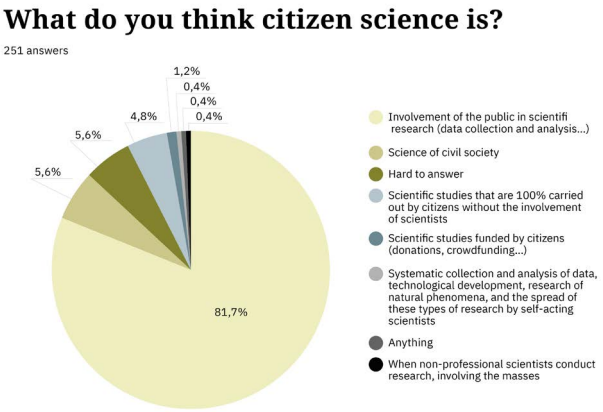
38.2% of the respondents graduated from university, and 29.1% even have a scientific degree. 19.5% graduated from school.



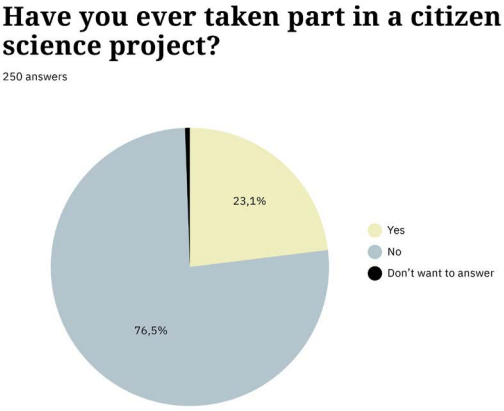
Slightly over half of the respondents claim that they know what citizen science is, while 32.8 are unfamiliar with the concept of citizen science, and 14% had struggled to answer.



However, when the respondents were offered to choose a definition of citizen science from a defined number of options, 81.7% gave the correct definition. Among other options, 5.6% honestly admitted that it was hard to answer for them, and another 5.6% chose the "science about civil society" option.



At the same time, 76.5 respondents claim they participated in citizen science projects.

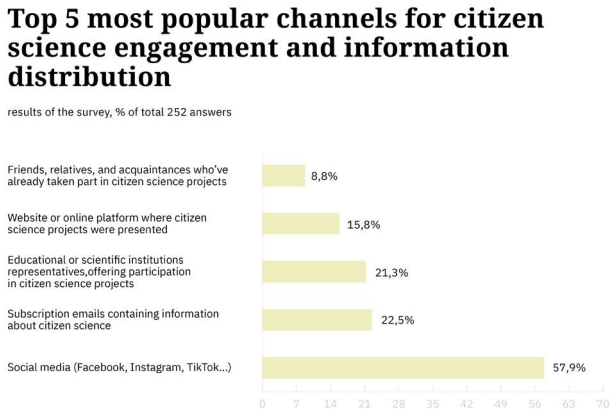


The survey results show that in Ukraine, citizen science is utilized most in the field of biological and environmental sciences (41.4% of answers, or 36 of 87). In particular, the most popular citizen science projects are UkrBIN (9 respondents) and iNaturalist (7 respondents). Citizen science in physical or technical sciences isn't well developed. For instance, only 8 of 87 (9.2%) respondents mentioned their participation in projects in this field, the most popular of which was participation in distributed computing projects (3 answers), when a user shares their computer power to compute large data arrays. 13 answers represent the field of social

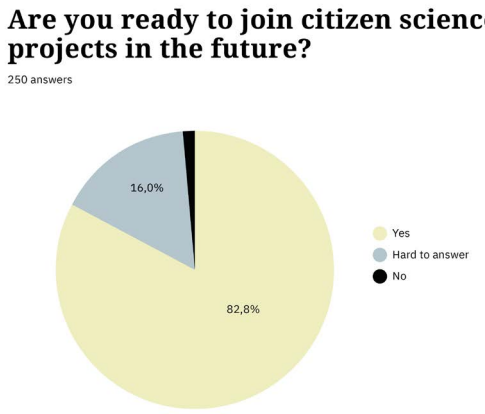
sciences and humanities (14.9%), in general, these are social surveys on different topics (9 answers) and participation in archaeological research (2 answers). It should be noted that 13 answers were classified as "Other" as we've found no further information on the content of the two mentioned projects (NordID, OnHhn), and the rest of the answers are rather evidence that respondents don't understand what citizen science is.

Scientific sphere	Mentioned instrument: number of answers
Biological and environmental sciences	UkrBIN: 9 iNaturalist: 7 Species documentation: 4 eBird: 3 Plant photos: 2 Collected soil specimens: 1 Accounting of storks: 1 Arrival and departure of certain bird species: 1 Water specimen collection in the local river: 1 Foldit: 1 Folding@home: 1 Zoology: 1 Volunteer trips to national parks: 1 Zooniverse: 1 Home weather stations network: 1 eteRNA: 1
Physical and technical sciences	Distributed computing: 3 Internet structure and stability research: 2 Collecting information about cloud and weather conditions in NASA app: 1 Astronomical data verification NASA: 1 Variable stars observation: 1
Social sciences and humanities	Social surveys: 9 Archaeological research: 2 Focus groups: 1 Sociology and journalism: 1
Other	NordID: 2 OnHhn: 1 Genius competition: 1 State and directions of science development: 1 Societal problems: 1 Science Day: 1 Summer school: 1 Packaging trash: 1 Promote this activity: 1 Management of scientific projects for children: 1 Teachers and children research Antarctic: 1 Educational programs at school: 1

In response to the question of how survey participants learned about citizen science, the majority (57.9%) replied "from social media", making this channel of engagement potentially the most effective in this field. A considerable number of respondents answered that they found out about citizen science from email newsletters (22.5%) and from employees of educational and scientific institutions (21.3%). 15.8% found out about citizen science via a website or an online platform, and only 8.8% — from friends, family, and acquaintances. Other communication channels, such as announcements, included less than 2% of the answers, thus being insignificant and inefficient for use.



It's important that the majority (82.6%) of respondents are willing to participate in citizen science projects in the future. At the same time, a significant part of the respondents (16%) are unsure whether they are ready to participate in citizen science. Several factors may influence this, but the most significant one is uncertainty in society, especially because of the war, constant stress, and inability to plan for the future.

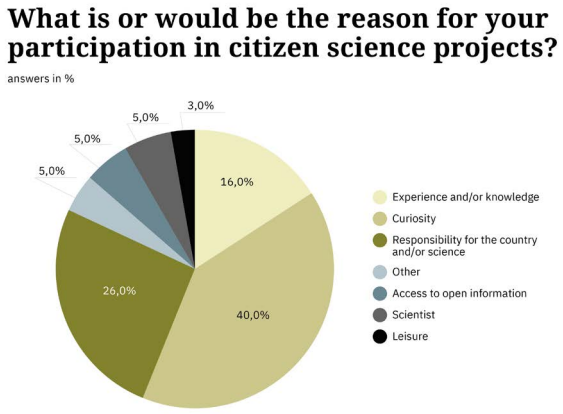


Responses to questions about reasons and motivation for participation in citizen science projects were grouped into following categories:

- Experience and/or knowledge
- Inquisitiveness and/or curiosity
- Responsibility for the country and/or science
- Openness of information
- Leisure
- Scientist
- Other

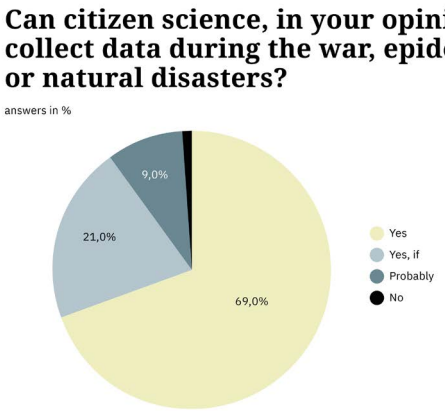
All responses from respondents were coded by these categories. It's important to note that every answer was attributed to only one category, though there were mixed answers.

The results showed that the majority of respondents are willing to participate in citizen science projects due to their curiosity and/or inquisitiveness (40%). At the same time, a significant part (26%) of the survey respondents mentioned that they feel responsible for the country, science, environment, and nature of the homeland and seek ways to contribute to the development of science or society in general. Experience and knowledge for professional and/or personal development are important arguments for participation in citizen science for 16% of the respondents. Ensuring openness of information and transparency serves as motivation for 5% of the respondents. It's worth noting that only 3% of the respondents consider citizen science a way to have quality leisure. This may indicate that the majority of the respondents treat participation in citizen science projects quite seriously.

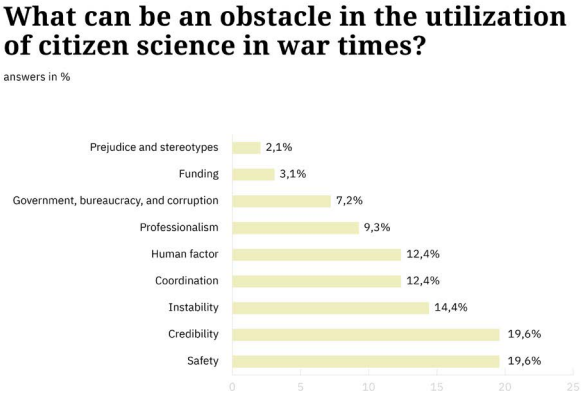


Citizen science can definitely help in collecting data during wars, epidemics, or natural disasters. This is the opinion of 69% of the respondents who have answered an open-ended question about it. Another 21% indicated that it can help, but only under certain conditions. In particular, the safety of the participants should be in the first place, and quality coordination and communication, clear

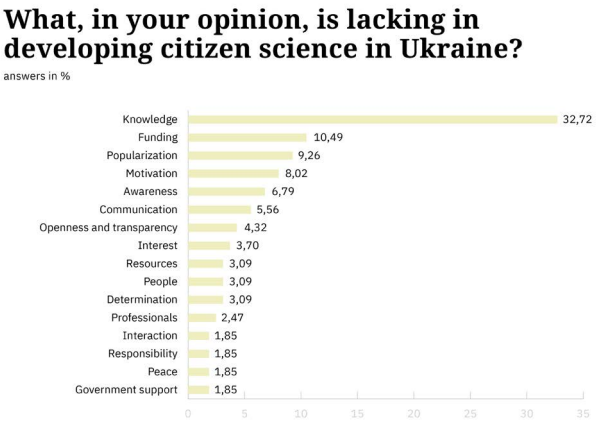
instructions, transparency, and openness are also needed. Only 1% of those who answered the question think that citizen science cannot be useful in any way during wars and crises.



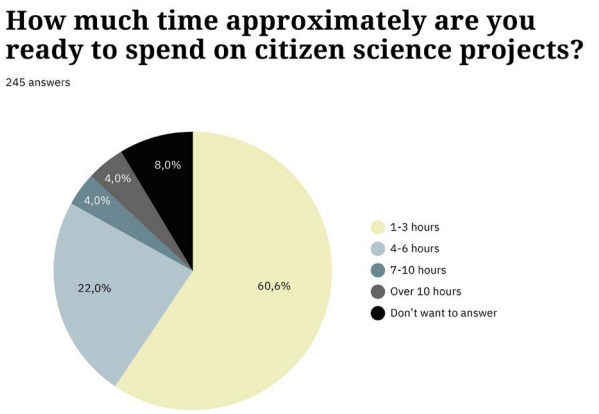
Among the obstacles to the use of citizen science during wars, safety was mentioned most frequently(19.6% answers), along with credibility and quality of the collected data (19.6%), as data quality strongly depends on the integrity of users, even under ordinary circumstances, and during the war, it may be more challenging to check and verify the received data. Instability during wars was mentioned as an obstacle to citizen science utilization by 14.4% of the respondents. In particular, obstacles like the absence of electricity, internet connection and connection in general, and a change in safety were among the answers. About 12.4% of respondents noted a lack of clear coordination and human factors like emotional burnout, change of priorities, volunteering in the humanitarian sphere, the need to find means of living, etc., can be significant obstacles in utilizing citizen science. The expertise of both scientists who start citizen science projects and the citizens who join them is important both for the development and the slowdown of citizen science. This was noted by 9.3% of the respondents. Another 7.2% respondents to our survey indicated that obstacles from the government, such as the absence of a legislative base,, bureaucratization, corruption, etc., can significantly slow down the use of citizen science in war conditions. Funding for utilizing citizen science in wartime was noted by only 3.1% of the respondents, and stereotypes and prejudice were noted by only 2.1%.



On the question of what is lacking in the development of citizen science, the majority of the respondents (32.7%) answered that it is awareness, as scientists know little about the possibilities of using citizen science and involving of citizens in it, and the citizens themselves are scarcely aware of opportunities of participation and importance of the development of citizen science for society. The second most common response (10,5%) was funding. Lack of popularization (9.3% answers), insufficient motivation (8%), and awareness among all the stakeholders and actors (6.8%) are also factors that slow down the development of citizen science in Ukraine, in the opinion of the respondents to the survey.



The majority of the respondents (60.6%) are ready to dedicate 1-3 hours per week on citizen science, and a considerable number (22%) are ready to spend even 4-6 hours.



Overall, the results show the positive attitude of the majority of respondents toward citizen science and their willingness to participate in it in the future, dedicating 1-6 hours per week on it. The main motivations for participation in citizen science are inquisitiveness, curiosity, the sense of responsibility, and the desire to contribute to the development of science, the country, and society in general. The majority of the respondents think that citizen science can be used in war times, but some critical challenges and obstacles, such as safety, data credibility, and instability, should be considered when implementing citizen science in crises. That's why strong coordination and spreading awareness are needed, and specialized training and protocol development may be necessary. Interestingly, most respondents learned about citizen science from social media. This indicates the potentially great power of this communication channel for citizen science promotion.

Appendix 4. Database of Ukrainian and foreign citizen science practices

1. Citizen Science Practices in Ukraine

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
1	*iNaturalist*	Mapping and sharing biodiversity observations around the world	iNaturalist is a social network for naturalists, citizen scientists, and biologists built around the concept of mapping and sharing biodiversity observations around the world. You can access it via the website or mobile application. It is an international platform that is very popular in Ukraine. Observations are made available to scientific databases, such as the Global Biodiversity Information Facility, to help scientists find and use the collected data. Illustrative use case is a photograph in the *Atlas of Grassland Habitats* (2022)).	Due to the quality of the photo, it may be difficult or impossible to identify the taxon of the species. In addition, sometimes users record species in the wild or captivity, but do not check the appropriate boxes. There may be cases when users add photos from the Internet rather than their own, and this raises the question of integrity. In some cases, connectivity issues may lead to inaccurate geolocation determined by the mobile device, and users, lacking experience, may not pay attention to this. All this causes the database to become clogged with low-quality data. But it is possible to ban unscrupulous users.	Users who were already using the app before the disaster can persist in recording findings during crises. Even in the first year of the war in Ukraine, the app *was used* at almost pre-war levels. There are cases when users go to the front or are under occupation and continue to use the app. iNaturalist has been used effectively during *pandemics to collect botanical data*.

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
2	*UkrBIN*	Collecting and sharing biodiversity data	It is the only crowdsourcing platform in Ukraine for collecting and sharing biodiversity data with a free access mode. With UkrBIN, everyone has a unique opportunity to contribute to the creation of a national biodiversity database, learn more about the distribution and number of plant and animal species in Ukraine, and help conserve biodiversity. Illustrative use case — photo in the *Atlas of Grassland Habitats* (2022).	Communication is facilitated through feedback forms on the website and a specially created *group on Facebook*. The terms of use are displayed on the website.	It can be used similarly to iNaturalist, but with some limitations due to the absence of a mobile application.
3	*Flora of Ukraine*	Collection of information on higher vascular plants of Ukraine	Contains information on plants that grow in nature and are cultivated in open ground in Ukraine. The group was created to popularize knowledge about the diversity of vascular plants in the country. This case serves as an interesting example of how social media can be used to collect data. Through the creation of albums, a *photo catalog of Ukrainian plants* was formed. Photos from the group are used in the *Atlas of Grassland Habitats* (2022)	Since this is a social media group, we can get constant support from the community.	Data collection can also continue in times of crisis, although to a lesser extent.
4	*Mushrooms of Ukraine*	Collecting information about mushrooms.	The first mycological community in Ukraine to collect data and disseminate information.	Since this is a social media group, we can get constant support from the community.	Data collection can persist during times of crisis, albeit to a lesser extent.

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
5	*Dolphins of the Black and Azov Seas*	Collecting data on dead dolphins.	Almost a thousand cases of dead dolphins have been recorded along the Black Sea coast in Ukraine, Bulgaria, and Turkey. Since scientists do not have access to a full-fledged study of the Black and Azov Seas in the context of the war, it is currently difficult to predict the number of animals affected. Citizens can help collect evidence to bring Russia to justice for killing dolphins. To do this, it is important to inform the scientists from the Ukrainian Scientific Center for Marine Ecology and the Schmalhausen Institute of Zoology of the National Academy of Sciences of Ukraine about the deaths of dolphins.	Communication is carried out via Facebook and messengers.	Announcements regarding data collection are disseminated on the pages of various organizations and within thematic groups on social media.
6	*SaveEcoBot*	Recording of crimes against nature for the purpose of filing lawsuits with the International Court of Justice for damages by the aggressor country.	All information provided by citizens is impersonal and confidential. You need to attach a photo of the environmental crime right in the chatbot.	It is possible to provide information via Viber and Telegram. The website has Terms of Use and Privacy and Personal Data Protection Policy.	It is used to document the impact of military actions by the Russian Federation on Ukrainian environment in order to bring the aggressor country to justice.
7	*EcoThreat*	Collecting data on environmental threats caused by russian occupiers and developing a plan for their further elimination.	The website and app allow anonymous reporting of environmental threats, including war crimes against the environment.	The site has a Privacy Policy section.	It is used to collect data on environmental threats in times of war.

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
8	*Polycam/ Backup Ukraine*	Digitalization of cultural heritage.	Backup Ukraine allows anyone to become an archivist by enabling the scanning of buildings and monuments into full 3D models using just a smartphone. These models are then stored in an open and secure online archive, ensuring their preservation beyond the reach of potential threats like bombs.	The website includes information on copyright. There are warnings about safe work during martial law. Very often users scan things and activities beyond cultural heritage (cars, bars...). However, to participate, users are required to register on the site.	The project is aimed at preserving cultural heritage in times of war.
9	*DNA collection in the subway*	A one-time event to collect DNA samples as part of an international project.	Volunteers ran around the subway on a certain day and collected DNA.		
10	*Individual ornithological initiatives*	Collecting data on the distribution, number, migration, and phenology of individual bird species.	Individual researchers (e.g., Hanna Kuzio, Natalia Atamas, Valerii Dupak, Vitalii Hryshchenko) collect data on the distribution, number, migration, and phenology of individual birds (e.g., rooks, storks, fisherwomen, and the gray crane). They use tools like Google Forms or request information via email. Announcements about these initiatives are shared through specialized websites and social media posts to disseminate information effectively.	This is an example of using citizen science without special websites or applications, which shows that citizen science is accessible to everyone. At the same time, when using this approach, there may be certain limitations in data collection, processing, and storage. In this case, the collection and subsequent analysis of data, as well as the dissemination of results, depends on one researcher or group of researchers.	Data collection can persist during times of crisis, albeit to a lesser extent.

2. Global and international practices of using citizen science

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
1	*SciStarter*	Mapping and sharing biodiversity observations around the world	iNaturalist is a social network for naturalists, citizen scientists, and biologists built around the concept of mapping and sharing biodiversity observations around the world. You can access it via the website or mobile application. It is an international platform that is very popular in Ukraine. Observations are made available to scientific databases, such as the Global Biodiversity Information Facility, to help scientists find and use the collected data. Illustrative use case is a photograph in the *Atlas of Grassland Habitats* (2022)).	Due to the quality of the photo, it may be difficult or impossible to identify the taxon of the species. In addition, sometimes users record species in the wild or captivity, but do not check the appropriate boxes. There may be cases when users add photos from the Internet rather than their own, and this raises the question of integrity. In some cases, connectivity issues may lead to inaccurate geolocation determined by the mobile device, and users, lacking experience, may not pay attention to this. All this causes the database to become clogged with low-quality data. But it is possible to ban unscrupulous users.	Users who were already using the app before the disaster can persist in recording findings during crises. Even in the first year of the war in Ukraine, the app *was used* at almost pre-war levels. There are cases when users go to the front or are under occupation and continue to use the app. iNaturalist has been used effectively during *pandemics to collect botanical data*.
2	*CitSci*	Platform supporting citizen science, community-based research to address community needs around the world.	The platform contains tools to support the entire research process, from project creation to participant management; creating customized data tables; data collection; data sharing and analysis; and feedback collection.	There is a section on *personal data* protection.	There are projects on different topics. For example, about *disaster recovery.*

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
3	*Zooniverse*	The goal is to make impossible research possible.	It is the world's largest and most popular platform for getting people involved in research. It brings together more than a million people around the world who come together to help professional researchers. The platform contains information about research projects from various fields where researchers can create a project, and interested volunteers can choose and join.	The rules are set out in the *Zooniverse User Agreement and Privacy Policy.*	
4	*Experiment*	The mission is to democratize science.	An online platform for funding, searching, and sharing research. You can create a project on the platform or support an existing one depending on your interest. There are projects in almost every field of science. If you create a project on the site to find funding, the platform will deduct a *percentage*.		
5	*Anecdata*	Used by hundreds of individuals and organizations to collect and access community scientific observations, it provides a platform for easily collecting, managing, and sharing scientific data.	Anecdata is a free online community and citizen science platform developed by the Community Lab at MDI Biological Laboratory in Bar Harbor, Maine, USA. Projects are created on the platform by creating data tables that participants fill out to share their observations. Participants join projects and use the Anecdata website or mobile app to share their observations. Project data is now available for anyone to view and download!	There is a section *"Terms of use"*	There are projects on climate change and flood risks.

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
6	Geo-Wiki	Provides an opportunity to participate in monitoring the earth's surface by classifying satellite and other remote images. Data can be entered using a computer or mobile device, and campaigns and games are used to encourage data entry.	It is also used to successfully integrate citizen-generated data sources with expert and authoritative data to address pressing policy issues (e.g., European Environmental Policy, SDG indicators, etc.).		
7	*CitizenScience.gov*	Accelerate the use of crowdsourcing and citizen science in the United States.	This is an official government website designed to accelerate the use of crowdsourcing and citizen science in the United States. The site includes a catalog of citizen science projects, a set of tools to help federal agencies, and a community of hundreds of citizen science specialists, practitioners, and coordinators.	Users have the ability to sort and find projects based on various parameters. Additionally, they can add new projects to the platform.	The catalog contains tools and practices from a wide variety of areas, including natural disasters.
8	*EU-Citizen.Science*	The mission is to establish itself as a key reference point for citizen science, fostering networked knowledge exchange among participants, practitioners, researchers, policymakers, and society across Europe.	An online platform for sharing knowledge, tools, trainings, and resources for citizen science.		

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
9	*European Citizen Science Association*	Accelerate the utilization of crowdsourcing and citizen science in the United States.	ECSA is a membership organization established in 2014. Its main goals are to strengthen the democratization of science, encourage the development of citizen science in Europe and support the participation of the general public in research processes — in all fields — natural sciences, social sciences, humanities and arts.	The website includes principles, guidelines and policies in the *Documents* section.	There are projects related to inclusion, equality, climate change adaptation, democratic governance, etc. There is an interdisciplinary project on the r*emediation of contaminated ecosystems.*
10	*Citizen Science Portal (Canada)*		A catalog of citizen science projects in Canada.		
11	*iNaturalist*	Mapping and sharing biodiversity observations around the world.	It is a social network of naturalists, citizen scientists, and biologists built on the concept of mapping and sharing biodiversity observations around the world. It is accessible via the website or mobile application. Observations are made available to scientific databases such as the Global Biodiversity Information Facility.	The rules of use are defined. It is an international instrument that is also used in Ukraine.	

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
12	*Water Monitoring in Colombian Vulnerable Communities in a Post- Conflict Scenario*	Assessment of water quality in areas of the Colombian Amazon affected by gold mining (mercury contamination of water and the environment).	In remote, poor areas of Colombia, impoverished rural communities use water directly from the river, exposing them to health risks associated with mercury, a heavy metal. The government does not assess water quality, so Dr. Mirella Di Lorenzo (Department of Chemical Engineering, University of Bath) developed cheap and easy-to-use sensors to monitor water quality. The system also has a mobile app and an interactive map that shows real-time changes in heavy metal levels in water bodies across the Colombian Amazon.	The map appears to be accessible globally, but the project name did not include the primary website or a link to download the application.	The device, app, and interactive map were created specifically to address the emergency situation of heavy metal contamination of water and food.
13	*Palestinian Action Network for the Planet*	Involve the population (mainly young people) in improving the environment in the occupied territories of Palestine. This is necessary to achieve sustainable communities close to nature.	They work with universities, schools, local governments, and create networks at the global and local levels to inform the Palestinian population about the maximum support for indigenous traditions. It is the locals who use a more efficient and environmentally friendly approach to housekeeping (they hardly use plastic and polyethylene, save water, and eat less meat).	The project is focused on raising awareness rather than science.	There is a threat of occupation, violence, and poverty in the occupied territories. However, by emphasizing that nature is a national heritage, scientists manage to mobilize the indigenous people of the occupied territories.

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
14	*Cities at Night*	The goal is to create a nighttime Earth map, akin to Google maps, using color images with a resolution ten times higher than what has been publicly available previously.	The database, comprising almost half a million images, is undergoing organization, cataloging, georeferencing, and calibration for scientific research purposes. Currently, nighttime satellite images are a powerful source of information in various fields of research: Light pollution, Environment and Ecology, Human Health, Economics...		Indirectly, it can be used to assess the impact of war on light pollution, assess the destruction of infrastructure.
15	*Globe At Night*	An international citizen science campaign aimed at raising public awareness of the light pollution impact by engaging citizens in measuring the brightness of the night sky using a computer or smartphone.	Light pollution threatens not only our "right to see the light of the stars" but can also impact energy consumption, wildlife, and health. Over the past 14 years, people from 180 countries have taken over 200,000 measurements, making Globe at Night the most successful light pollution awareness campaign to date!		
16	*CanAirIO*	Public air quality monitoring network.	A project that uses mobile and static sensors to measure air quality using mobile phones and low-cost technology.		

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
17	*LastQuake*	An earthquake detection and notification system developed by EMSC.	The system consists of a Twitter bot, a desktop and mobile website, and a free mobile app. LastQuake highlights earthquakes experienced by the population by collecting data through crowdsourcing and providing information to the public. The system's uniqueness lies in its innovative, automatic and multi- channel method of earthquake detection and information. When a tremor is felt, citizens seek information and rush to EMSC detection platforms: desktop and mobile websites, Twitter feed, and the LastQuake mobile app.		
18	*Citizen Weather Observer Program*	The Citizen Weather Observers Program (CWOP) is a public- private partnership with three goals: 1) to collect citizen- submitted weather data; 2) to make the data available to weather services and homeland security; and 3) to provide feedback to those who contribute data so that they have the tools to verify and improve the quality of their data.	You can send weather data (mainly from your home weather stations) through the form on the website.		

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
19	*Public Lab*	Achieving environmental justice through citizen science and open technologies. Satisfying the basic right to knowledge. A place to find and share knowledge, equipment, and become part of a community of like-minded people.	The PublicLab raises awareness of health impacts, improves scientific activities, creates new scientific and technological skills, and mitigates certain impacts. When people can easily and reliably track local impacts related to environmental injustice — increased flooding, poor air quality, pollution, and wetland destruction — they can make more informed decisions and take action.		Public Lab was founded in the aftermath of the BP oil disaster in 2010, when a media blackout left residents and the world uninformed. In response, a group of concerned locals, environmentalists, designers, and sociologists deployed “citizen satellites” (made of balloons, kites, and digital cameras) over the spill to collect real-time data on its impact. Through an open-source platform, participants compiled more than 100,000 aerial images into coastal maps before, during and after the oil spill. These high-resolution maps have been featured by the BBC and the New York Times, among others, allowing residents to tell the truth about what is happening on the Gulf Coast. The success of the mass mapping prompted the group to found the Public Lab as a new research and social space to develop low-cost tools and practical methods for community-based environmental monitoring and assessment.

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
20	*Safecast*	An international volunteer nonprofit organization dedicated to creating useful, accessible and detailed environmental data. All Safecast data is freely published in the public domain under the CC0 designation.	Following the devastating earthquake and tsunami that struck eastern Japan on March 11, 2011, and the subsequent accident at the Fukushima Daiichi nuclear power plant, accurate and reliable radiation information was not available to the public. In response, Safecast was created and quickly began monitoring, collecting and openly sharing environmental radiation information — rapidly growing in size, scope and geographic coverage. Subsequently, the air quality data was incorporated. The mission is to give citizens around the world the tools to stay informed by collecting accurate environmental data and sharing it in an open and collaborative way.	Data protection is in compliance with CC0 1.0 Universal (CC0 1.0) Public Domain Dedication No Copyright	It was created as a response to the need for accessible and open information after the Fukushima disaster.
21	*CitiSen*	The purpose of the study is to create a database of existing options for civic and political engagement and to identify what is missing.	CitiSEn — Refugee Citizen Science Engagement is a research project funded by the Austrian Science Foundation (FWF) as part of the Top Citizen Science initiative. CitiSEn seeks to learn more about the situation of Ukrainian refugees and temporarily displaced persons in Austria. And how they feel in the new society.		During disasters, the presence of refugees is common, and this practice can serve as an exemplary model for assessing the needs of refugees and implementing effective rehabilitation through engagement.

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22	*Citizen Science for Disaster Risk Reduction (CSDRR)*	The goal is to understand how citizen science is currently being used for disaster risk reduction and how it can be more effectively applied in the future in developing countries.	The website is essentially a catalog of cases. There is a map of projects. The resource is more focused on developing recommendations for improving mechanisms for monitoring, forecasting, and warning of diverse and multiple hazards; expanding dialogue and communication around hazards; and improving the application of resilience measures (preparedness, action, and loss prevention).	There is no way to join.	Catalog of disaster risk reduction projects.
23	*OpenStreetMap*	Created by a community of mappers who enter and maintain data on roads, trails, coffee shops, train stations, and more around the world.	OpenStreetMap adds a visual dimension to local data. Mapmakers use aerial imagery, GPS devices, and simple ground truth schemes to verify the accuracy and relevance of OSM data.	There is a "Copyright" section	They help create maps for areas affected by natural disasters, and many others. In times of war, it can bring both benefits and additional risks.
24	*WaterInsights*	Fresh water monitoring.	WaterInsights is a public science project for monitoring fresh water. You can buy a water quality test kit from them, and then add the results to the website.		This approach can be used during wars, crises, and natural disasters.
25	*BirdNET*	Identifying birds by singing using artificial intelligence, including collecting information on the distribution of birds.	Currently, BirdNET can identify about 3000 of the world's most common species. BirdNET is a public science platform as well as software for analyzing extremely large audio collections. BirdNET is committed to providing innovative tools for conservationists, biologists and ornithologists.	Sound detection may be false, as birds copy the sounds of the environment; birdwatching tool, international network. The terms of use are specified in the Play Market.	Mapping bird nesting and migratory patterns can help determine ecocide and the impact of disasters on bird numbers and biodiversity.

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26	*Merlin Bird ID*	Identify birds from photos and sounds. The program is based on the BirdNET database.	Merlin features the best community- collected photos and sounds, tips from experts around the world to help identify the birds you see, as well as habitat maps from Birds of the World — all based on billions of observations.	It is mostly popular in Canada and the United States, and to a lesser extent in Europe and Asia. There is no need to provide the exact location of the birds.	Mapping bird nesting and migratory patterns can help determine ecocide and the impact of disasters on bird numbers and biodiversity.
27	*Animal Tracker*	The Animal Tracker app for smartphones allows you to track the routes of wild animals around the world in real time.	Animal Tracker allows you to join the Movebank research database, which directly publishes information used by hundreds of researchers to analyze, share, manage, and archive data on wildlife movements and behavioral features during photo recording.	The app is mostly interesting for professionals. The terms of use are specified in the Play Market.	The information is useful for identifying local and global environmental changes that affect animal movements and behavior, for analyzing and assessing impacts, but requires some skills in animal identification

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
28	*Foldit*	An online puzzle game about protein folding in molecular biology. Players are given a sequence of amino acids or a partially folded protein and must find the conformation with the lowest free energy. The best user solutions are analyzed by scientists who can use them to find solutions to real-world scientific problems related to vaccine discovery and biological innovation.	The goal of the puzzle is to find the three-dimensional structure of a certain protein with the lowest free energy. Each task is published on the site for a certain period of time, during which users compete with each other. There is also a set of constantly available puzzles designed to familiarize new users with Foldit's features. During the game, players interactively manipulate the molecule by changing the shape of the main backbone and the position of the side groups, they can also rotate α- helices around their axes, change the chain connections in α- structures, impose weak constraints in certain areas ("rubber bands") or "freeze" them	A non-profit game that gives scientists access to new protein designs. The goal of protein design is to create completely new proteins that perform new functions. Proteins that can block viruses like the flu, break down plastic, or self-assemble into new materials.	In 2011, players helped to decipher the crystal structure of the retroviral protease of the Mason-Pfizer monkey virus (M- PMV), which causes AIDS in monkeys. During the COVID-19 pandemic, the platform was used to help decode a small part of the SARS-CoV-2 spike protein and create a protein that binds to the spike.

№	Tool/ Practice	Objective	Brief description	Efficiency, problems, shortcomings, communication, data policy, etc.	Peculiarities of the use of the Internet during wars and crises
29	*Berkeley Open Infrastructure for Network Computing*	BOINC's goal is to provide researchers with the opportunity to use the processing resources of personal computers and other devices around the world.	BOINC is a software that can utilize unused CPU and GPU cycles of computer hardware to perform scientific computations. BOINC has become the platform for many other applications in fields as diverse as medicine, molecular biology, mathematics, linguistics, climatology, environmental science, and astrophysics, among others.	BOINC is used by many groups and individuals. Some BOINC projects are based at universities and research labs, while others are independent areas of research or interest. In exchange, participants are offered the cryptocurrency Gridcoin to incentivize the public to donate their CPU power and time to scientific research. This is free software released under the terms of the GNU Lesser General Public License.	It is used in research such as improving climate forecasting models, searching for pulsars using radio signals and gravitational wave data, creating cognitive models of the human mind, predicting protein structure for disease research, developing pharmaceuticals, and analyzing genetic linkages to find disease-resistant genes.
30	*BugGuide.net*	Identification of insects and spiders.	It is a website and online community of naturalists, both amateurs and professionals, who share observations of arthropods such as insects, spiders, and other related creatures. The website consists of information guide pages and many thousands of photos of arthropods used for identification and research. As of December 2020, there are more than 1.3 million described species, as well as many undescribed species.	As of October 2020, it has 5,600 members. It is more commonly used in the United States and Canada.	The photos have contributed to or resulted from several scientific publications. Most of the images presented in the atlas of vespid wasps are by BugGuide authors.

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31	*Eyewire*	Mapping of retinal neurons.	This is a civic science game from the lab of Sebastian Seung at Princeton University. It is a computational game based on players mapping retinal neurons. Eyewire's gameplay is used for neuroscience research, enabling the reconstruction of neuronal morphological data, which helps researchers model information processing patterns.	Eyewire is employed to advance the use of artificial intelligence in neuronal reconstruction. The project is also being used to study how mammals see directional motion.	BugGuide photos have revealed new state records for invasive ants and pest beetles.
32	*Pl@ntNet*	Plant identification.	This is a public research project for automatic plant identification using photos based on machine learning.	As of 2019, it has been downloaded more than 10 million times in more than 180 countries. The issues of data use are *prescribed*.	Development of connectomics.
33	*Brain Explorer*	Researching the peculiarities of brain functioning through gamification.	The Brain Explorer app uses the latest in neuroscience research to explore brain function in fun and entertaining games for children and adults. By playing these games, people can learn about their brain functions and at the same time help researchers better understand how brain functions are related to mental health problems.	Many mental disorders, such as obsessive-compulsive disorder (OCD), are common in the population but often hidden from public perception. Although the app will not diagnose or give feedback on the user's mental health, it will allow researchers to study the mechanisms between brain changes and the development of mental disorders. The terms of use are set out in the Play Market.	

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