White Paper

Citizen Science Strategy 2030 for Germany

IMPRINT

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Acknowledgements

This White Paper was compiled with the participation of 219 people from 136 organisations (-> list on pg. 120 et seq.) from scientific institutions, museums and archives, libraries, science shops, civil society organisations, professional associations, foundations and private individuals who contributed to the White Paper Working Group process through the dialogue forums and meetings, writing workshops and the extensive Citizen Science 2020 online survey. Citizens and social stakeholders contributed an in-depth review thanks to the public online consultation from August to October 2021 with a total of 1,343 contributions (contributions, text annotations and votes) and 119 comments and the position papers from 31 organisations and institutions.

This White Paper was made possible by the great commitment of all authors and contributors to the White Paper working group, the public dialogue forums, the strategy workshops and public consultation.

The process was partially financed by a 50% position by the Helmholtz Centre for Environmental Research – UFZ and by in-kind collaborations with the Leibniz Association and Helmholtz Association offices and the "Bürger schaffen Wissen" (citizens create knowledge) team at the Museum of Natural History and Wissenschaft im Dialog.

We are very grateful to the German Federal Environmental Foundation (Deutsche Bundesstiftung Umwelt DBU) for extensive funding that enabled broad public citizen participation, including the public online consultation, the online evening talks, the production of an accompanying film, and the publication and public launch of this White Paper. Furthermore, the Federal Ministry of Education and Research (BMBF, Division 115 – Strategic Foresight/Participation and Citizen Research) funded the second dialogue forum and the Helmholtz Association funded the editing and layout of this White Paper. The Leibniz Institute for Social Sciences (GESIS) provided technical support for the development of the Citizen Science 2020 survey.

We would like to thank all contributors, participants, reviewers and supporters involved in the creation process of this White Paper!

Disclaimer

The views and opinions expressed in this White Paper do not necessarily reflect those of the participants or their organisations.

The German National Library lists this publication in the German National Bibliography; detailed bibliographic data is available online at www.dnb.de/EN/Home.

Composition and layout: Olaf Herling, Warstein/Berlin

Editorial office: Wissenschaftslektorat Zimmermann, https://lektorat-zimmermann.de

Printing: FRITSCH Druck GmbH, Leipzig

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CONTENT

KEY MESSAGES

The White Paper *Citizen Science Strategy 2030* presents a strategy with action recommendations for Germany to strengthen Citizen Science by 2030 in order to unleash its innovative potential for science, society and politics. This strategy can support the federal government in implementing the demands of the coalition agreement, which establishes Citizen Science as a strategic element of modern research,

"We will integrate Citizen Science and perspectives from civil society more strongly into research."

SPD coalition agreement, Bündnis 90/Die Grünen and FDP 2021 [26, pg. 24]

Citizen science describes the participation of people in scientific processes who are not institutionally bound in that field of science [1]. Participation can mean anything from short-term data collection to intensive use of free time and a high level of expertise. This White Paper identifies 15 key action areas for Citizen Science. Each action area names concrete goals and central starting points for how Citizen Science contributes to important goals in politics, society and science in Germany, and how these can be incorporated more intensively by 2030 (→ Fig. 1).

Determine ecological change using your smartphone thanks to the Flora Incognita app.
Photo: Jana Wäldchen/MPI-BGC

The contents of the White Paper were developed by the White Paper working group, a consortium of the Helmholtz Association, Leibniz Association and Fraunhofer Society along with university and non-academic partners based on the Green Paper "Citizen Science Strategy 2020 for Germany". 219 people participated in developing the paper, from 136 organisations, scientific institutions, professional societies, associations, foundations and individuals. The White Paper working group, with experts from around 40 organisations, and the Steering Committee, with members from five organisations, accompanied the White Paper development process with over 50 meetings, two public dialogue forums and four writing workshops from April 2020 to October 2021 (→ Fig. 13 "Development process of the White Paper"). In addition to the digital events, many people supported the White Paper development process. For example, the White Paper was supplemented by a nationwide public online consultation from August to October 2021 with a total of 1,343 submitted contributions (contributions, text annotations and votes) and 119 comments, as well as suggestions from five online panel discussions in September 2021 (→ Figs. 7, 10, 11, 12, 15) and by 31 position papers.

The process was supported by the commitment of the many authors and participants from various organisations without third-party

funding from May 2020 to October 2021. Funding for the online consultation, panel discussions, printing of the White Paper, production of the accompanying film and launch event was provided by the German Federal Environmental Foundation (DBU). The Federal Ministry of Education and Research (BMBF) funded the implementation of a dialogue forum. The Helmholtz Centre for Environmental Research – UFZ also supported the process by funding a part-time scientific coordination position and the Helmholtz Association funded the editing and layout of this White Paper.

Figure 1: The 15 action areas in the white paper

Key statements and mission statements for each action area

For each action area, a key statement summarises the most important findings and identifies strengths, needs, opportunities and challenges. A mission statement for each action area outlines the visions for 2030.

Networking and exchange

We are observing an increasing network of Citizen Science stakeholders and an intensifying exchange within the Citizen Science community. The exchange among Citizen Science actors and stakeholders within and between organisations is essential for knowledge transfer and experience with Citizen Science.

Mission statement: In 2030, Citizen Science lives through networking and exchange between science and society. Networking and regular exchange will be further promoted. Special attention will be paid to the exchange between Citizen Science actors, as well as to the synthesis and transfer of their expertise on initiating, coordinating and implementing Citizen Science projects and the associated experience and knowledge.

Funding instruments

The recognition of Citizen Science as a component in research and funding and the range of Citizen Science funding instruments has increased, but does not yet meet the demand. Funding needs for Citizen Science projects are great and are not even close to being met (e.g. the BMBF's temporary funding guideline for citizen research, with currently 15 funded projects, is only a start). An important role is also played by low-threshold funding, which is rarely offered, as well as specific offers such as start-up and final funding and offers in capacity building (coaching, training, and continued education). Structural support for coordination centres in civil society associations, public authorities and at universities and non-university research organisations is also important in order to transfer knowledge gained from experience in a qualified and open manner and to offer interested social stakeholders continuous points of contact.

Mission statement: In 2030, Citizen Science is supported by stakeholders in science, society, public authorities and practice through structural and financial measures (e.g. federal and state ministries and subordinate authorities and administrations, research and funding organisations, foundations, associations, networks, educational institutions). Funding organisations integrate Citizen Science into their funding portfolio for various corporate and research stakeholders. The prerequisite for funding Citizen Science projects should be quality-assured procedures and standards based on the rules of good scientific practice through regular evaluations. This facilitates greater social participation in science and increases its acceptance and relevance.

Citizen Science needs successful organisation and coordination for successfully engaging citizens. Citizen Science projects need sufficient personnel and financial capacities for volunteer management to inspire, guide and provide feedback. This volunteer management can be conducted by citizens, NGOs or research institutions participating in the project or in collaboration with established volunteer associations and initiatives.

Mission statement: In 2030, Citizen Science projects are characterised by professional volunteer management. Participants from all areas of society will be enabled to participate successfully and sustainably. Thus personnel resources and finances will be made available for the projects, along with connections to established volunteer structures. Local and regional stakeholders, associations and foundations in the field of volunteer management as well as local and regional media will work together specifically in volunteer recruitment and management. Together, they will carry out as needed and targeted training and continued education in Citizen Science projects.

Volunteer management

Citizen Science is a research approach, not just a science communication format in the sense of additional public relations. Strategic and evidence-based science communication plays a crucial role in the success of a Citizen Science project by promoting and bringing awareness to the participatory potential of collaboration between researchers and citizens. Good communication can help to recruit participants for a project, for example, or to create common ground for the stakeholders involved and to communicate the results of the project internally and externally.

Mission statement: In 2030, strategic and evidence-based science communication is an integral and fundamental part of Citizen Science projects to enable a dialogue between society and science. A position paper on Citizen Science values and guidelines involving different stakeholders (e.g. practitioners, civil society and science) can strengthen the implementation of science communication. Established interfaces in science communication at the institutions, additional project funding and continued education support Citizen Science actors in achieving the desired communication and impact goals.

Synergies with scientific communication

Recognition culture in and for Citizen Science

Recognition in and for Citizen Science is essential for the success and maintenance of participation in Citizen Science projects. In order to establish and expand recognition, respectful collaboration must be developed and applied in a targeted manner at the individual, political and formal levels. Already established and effective instruments of recognition must be continuously enhanced, both for citizen scientists and for project coordinators in the academic system (e.g. continuous communication and feedback culture). In addition, new instruments of recognition should be established, such as an expansion of the scientific reputation system to include a social impact indicator.

Mission statement: In 2030, targeted instruments of recognition in and for Citizen Science are applied in Citizen Science practice and evaluated with regard to their effectiveness. The previous instruments of individual recognition such as network meetings, continued education and an established, respectful feedback culture have been extended to the professional and social spheres of those involved, e.g. by testing pension points for Citizen Science. New structures and measures have been established, such as support units for Citizen Science activities at universities, training institutions and government agencies. Additionally, a review for the effectiveness of recognition tools and the introduction of a Citizen Science seal have also been instituted. This makes recognition a quality feature of Citizen Science and thus possible on an institutional and political level. The scientific reputation system integrates Citizen Science activities as valuable contributions to research.

Data quality and data management

Citizen Science data hold enormous potential for science and society. In order to fully exploit this potential, the accessibility, quality and reusability of Citizen Science data must be guaranteed for science and society alike. Sufficient resources should be available to implement quality assurance measures and data management and for research on these topics.

Mission statement: In 2030, reusable, flexible methods and tools exist to collect Citizen Science data, perform quality assurance and controls and analyse, archive and publish the data. Citizen Science data is sustainable, complies with FAIR principles and is described by generally accepted metadata standards.

Successful and fair collaboration in Citizen Science projects requires clear ethical and legal principles and guidelines. A common basic understanding of potential conflicts affords access and participation to all interested parties from science and civil society alike.

Mission statement: In 2030, Citizen Science projects follow clear legislative and ethical guidelines. These principles and framework legislation are, as in other disciplines, jointly agreed upon and adhered to from planning and implementing all the way to documenting Citizen Science projects. The ethics advisory boards have included Citizen Science as a component of research and are developing guidelines for topics such as data protection and personal rights, copyright and intellectual property, and insurance issues.

Legislation and ethics

Citizen Science enriches and holds great innovation potential for science and scientific culture, among other things through the integration of diverse knowledge domains, different perspectives of citizens and the development of new and large-scale data sets in space and time. Currently, engagement with Citizen Science is not a common practice in the scientific reputation system and corresponding strategies. Therefore it is often not exploited as an innovative research method.

Mission statement: In 2030, Citizen Science in all its facets is an expression of a modern scientific process that enables social participation in research through various formats. Citizen Science enriches scientific culture by helping to collectively identify and research social, ecological and economic challenges. The integration of Citizen Science in scientific processes sustainably and structurally strengthened through explicit incorporation into strategies of research orgaisations and designated staff positions. Good scientific practice is achieved by making targeted expansions of interdisciplinary training and continued education programmes in Citizen Science an integral part of university teaching.

Integration into scientific processes

Citizen Science introduces another format for educational concepts to develop competences regarding science in authentic learning contexts. The educational potential of Citizen Science can be achieved by adapting educational concepts to the interests and motivations of learners. Citizen Science should be integrated into curricula based on research for effective learning support. It should be embedded in guidelines and curricula through political support, and then be continuously evaluated. Collaboration between schools, extracurricular learning centres, universities and other research institutions should be promoted extensively and over the long term. This can help harness the potential of Citizen Science for the education sector.

Integration into educational processes

Mission statement: In 2030, implementing Citizen Science projects at educational institutions will be made possible through funding instruments that promote close cooperation with schools, university education and extracurricular learning centres. Teachers are important multipliers of Citizen Science. They have access to advanced training opportunities on integrating Citizen Science in educational concepts, along with teaching and learning materials for practical implementation. Activities are based on current research and are aligned with curricula and other frameworks.

Integration into decision-making processes

Citizen Science demonstrates its social added value as an often practical research approach to the full extent when relevant results are consistently considered in political and social decisions. This requires a common understanding among policymakers, administrators and the Citizen Science community on how Citizen Science can contribute to decision-making processes. Structural and procedural frameworks are also needed, e.g. Citizen Science strategies in government authorities and agencies, workflows for integrating quality-assured Citizen Science data into policy-making, management and monitoring. Furthermore, specific capacity-building offers should be provided, e.g. Citizen Science coordination centres in government authorities and agencies at local and state levels with practical advisory services for Citizen Science projects.

Mission statement: In 2030, Citizen Science provides practical knowledge on socially relevant issues and thus support political and social decision-making processes. Citizen Science contributes to evidence-based policy and management decisions through the collaboration of civil society, governmental, political and academic partners.

Medical and health research

Actively involving patients as citizen researchers in all stages of the research process has the potential to increase the relevance and usefulness of the results for healthcare. It also expands and strengthens the role of the patients.

Mission statement: In 2030, patients are frequently involved in all phases of medical and health research as citizen researchers. In medicine, the experience and expertise of patients and their families is recognised as significant. Their involvement in research through Citizen Science increases the relevance and usefulness of research results, facilitates their practical implementation and improves the situation of the patients. New frameworks and structures have emerged that enable joint research, the mutual respect of all participants, responsibly handling the health data of the contributors, adequate funding and recognition in science and medicine.

Sensor technology and artificial intelligence

The use of sensor technology and artificial intelligence (AI) in the context of Citizen Science improves the scope as well as the local and temporal availability of data sources. The use of AI allows the quality management of extensive Citizen Science datasets to be assessed, improved and made more efficient, and opens up new possibilities in data analysis.

Mission statement: In 2030, sensor technology and artificial intelligence are established tools for Citizen Science activities. In the projects, citizen scientists can take on different roles, operating the sensors, programming or analysing data. Cost-intensive tools are also provided by scientific institutions. Algorithms are an open and transparent foundation for decision-making processes.

Archives, libraries, museums and science shops

Archives, libraries, museums and science shops have a long tradition as links between research and civil society and therefore offer long-term physical and conceptual spaces for Citizen Science with great proximity to citizens. As an interface between science and society, they thus create innovative spaces and opportunities for shared experimentation and learning.

Mission statement: In 2030, archives, libraries, museums and science shops, along with other institutions at the interface of science and the public, identify as knowledge spaces and educational institutions tasked with institutional mediation, and thus as memory and transfer organisations. Citizen Science as a research and transfer approach is an integral part of the mission statements and image of the institutions at the interface of science and the public for active collaboration with citizens. They work as established contact points for professional societies and civic engagement to link science and society.

European perspective (D-A-CH)

The cooperation of the DACH countries (D-Germany, A-Austria, CH-Switzerland) in the field of Citizen Science is multifaceted and has developed into an important component of European integration for Citizen Science in Europe in recent years. Building capacity in certain countries, e.g. knowledge about and infrastructure for Citizen Science, supports the development of the national networks in cooperation with the European Citizen Science Association (ECSA) and other international partners. The closer collaboration and shared learning experiences of Citizen Science stakeholders at the scientific, organisational and political levels offer opportunities and possibilities for the targeted advancement of Citizen Science.

Mission statement: The DACH network is an established stakeholder in the European Citizen Science Network on a political and professional level. International measures and initiatives such as jointly developed capacities for the community, e.g. continued education and networking offers, as well as joint evaluations of various funding guidelines make Citizen Science an integral part of research and a central task of various organisations. The diverse cooperation at the political, scientific and network levels serves as best practice examples for European collaboration. This strengthens and promotes the national structures in Germany, Austria and Switzerland.

Accompanying Citizen Science research

The findings from the accompanying research enable increased professionalism based empirical data and advance the practical application of Citizen Science. Targeted funding of accompanying research should become an integral part of the funding strategy of Citizen Science projects.

Mission statement: In 2030, accompanying research is an integral part of Citizen Science projects and will already be considered at the project planning stage and supported by appropriate financial resources. Accompanying research is carried out by interdisciplinary teams and is oriented towards the scientific standards of empirical social research and evaluation research. Citizens are involved in order to clarify central points and questions.

Action recommendations

For the 15 action areas in this White Paper, there are a total of 94 political action recommendations with regard to promoting Citizen Science in Germany. The following stakeholders and responsible parties are target groups as addressees (→ Fig. 2):

- Practitioners in the Citizen Science community (volunteer citizen scientists, project coordinators)
- Civil society organisations (non-governmental organisations, associations, initiatives, networks)
- Science organisations (universities and colleges, non-university research organisations, German Rectors' Conference)
- Educational organisations (formal and non-formal education institutions)
- Policymakers (ministries, authorities, administration)
- Funding bodies (research funding agencies, foundations, selection committees)

Figure 2: Action recommendations in the white paper and their target groups

This White Paper addresses scientific policy with research organisations and funding agencies, educational institutions and the broader Citizen Science community with associations and private individuals. The transformative social and technical innovation potential of Citizen Science enables collaboration across sectors. Various federal and state ministries and local authorities can profitably promote the transformation potential of Citizen Science and civic engagement and incorporate them into their strategies and programmes (→ Introduction, → Box 2).

INTRODUCTION

What is Citizen Science?

Citizen Science describes the active participation of people in scientific processes who are not institutionally bound in that field of science [1] (→ Box 1).

This collaboration between researchers from the public and academia offers many innovation potentials for science: Citizen Science can help to generate innovative large-scale data sets that can often only be collected with the commitment of citizen scientists. Additionally, it promotes developing new scientific questions and helps public knowledge and impulses flow into research [2, 3, 4]. Citizen Science and citizen expectations regarding the research can trigger a stronger social orientation in science [5]. Moreover, Citizen Science plays a key role in enriching concepts such as open science, responsible research and innovation (RRI) and transformative science [6]. Citizen Science also offers many benefits to society. Citizens can expand their knowledge or contribute specific skills by actively participating. Through their own research, participants can also become better acquainted with scientific methods and ways of working, and understand the possibilities and limitations of them [7]. A strengthened understanding of science can then also promote public trust in science and a more positive attitude towards science [8, 9, 10]. Active participation in Citizen Science projects offers stakeholders the opportunity to develop relevant solutions to their own questions and enables them to use the skills they have acquired in other contexts [11, 12].

In the CS project PflanzeKlimaKultur!, citizen scientists observe and record the developmental stages of 11 selected herbaceous plants in their own gardens or in model beds in order to research the influence of climate change on the growth phases of plants. Photo: Pflanze-KlimaKultur/BO Berlin

Citizen Science today

The first of six goals of the vision of the Green Paper "Citizen Science Strategy 2020 for Germany" published in 2016 stated that by 2020 Citizen Science would be "an integral part of societal and scientific debates as well as an approach with multiple benefits for science, politics and society" [1, pg. 6]. This vision has not yet been fully realised.

The current Fridays for Future movement, the climate protection debates and the discussions on the Covid 19 pandemic demonstrate the social and political awareness of how important scientific findings and a general understanding of scientific processes are in dealing with the current challenges facing society as a whole. These events also show that effective solutions to urgent social questions require closer contact between science and the public, as well as the participation of civil society stakeholders and their different knowledge expertise. We know from the annual surveys of the German science barometer that

BOX 1 – The term ‘Citizen Science’

The term 'Citizen Science' arose in different contexts. For one, as concrete collaboration in environmental monitoring projects [8] and additionally, under the aspect of enabling people to participate in shaping science, as a contribution to a democratic society [13, 14]. Both ideas are reflected in the perception of Citizen Science today. There is a great diversity in CS with an already very long tradition in different disciplines as well as rapid developments in new areas and new possibilities through digitalisation, mobile technologies and social media. The following is a definition from the Green Paper “Citizen Science Strategy 2020 for Germany” [1]:

Citizen Science describes the engagement of people in scientific processes who are not tied to institutions in that field of science. Participation can range from the short-term collection of data to the intensive use of leisure time in order to delve deeper into a research topic with scientists and/or other volunteers. Although many volunteer scientists do have a university degree, this is not a prerequisite for participating in research projects. However, it is important that scientific standards are adhered to. This pertains especially to transparency with regard to the data collection methodology and the open discussion of the results.

The European Citizen Science Association (ECSA) has developed the “Ten Principles of Citizen Science” [15], which define the prerequisite for good practice in Citizen Science and a common self-concept. The range of Citizen Science activities is large and diverse and can include participatory projects as well as co-creative projects [16]. The concept of Citizen Science is a dynamic development process with a variety of stakeholders. Overall, Citizen Science means gaining new knowledge through concrete collaboration and by merging different perspectives in scientific projects, while at the same time releasing innovation potential on an individual and societal level.

30 to 50 per cent of all citizens are interested in science and research, and this figure went as high as 60 per cent during the first year of the Covid 19 pandemic [17, 18, 19, 20, 21]. One in two (49%) would also like to personally participate in a science project [19].

Citizen Science is now experiencing a steady rise in interest in Germany as well as in Europe and around the world. There are currently a large number of Citizen Science projects in Germany, 180 of which are listed on the “Bürger schaffen Wissen” platform (November 2021). The response to the Citizen Science 2020 survey and the information provided by participants in the dialogue forums indicates that the total number may be considerably higher. Volunteer citizens are actively involved in research work primarily in the natural and environmental sciences. However, research activities by volunteers also have a long tradition in the humanities, arts and cultural sciences, and new fields of research are developing in the areas of artificial intelligence and health research (→ action areas 11). The goal of all Citizen Science projects is the joint creation of new knowledge.

Political framework in the international arena

The scope of Citizen Science has developed in many different ways at the international and national level in recent years. Citizen Science is seen in Europe as an integral part of the Open Science agenda and the European Open Science Cloud. The European Green Deal and the EU Biodiversity Strategy 2030 stress the importance of the roles of social stakeholders and Citizen Science for a knowledge society. A European Green Paper on Citizen Science [22] was first produced back in 2013. Based on this paper, the White Paper on Citizen Science in the EU [23] was published in 2016, highlighting the potential of Citizen Science. Numerous initiatives and working papers from the EU Commission, such as the EU Pollinator Initiative and the working paper on *Citizen Science Best Practices* in Environmental Monitoring [24], contain concrete recommendations to expand Citizen Science across Europe.

International networks such as the *Citizen Science Alliance* founded in 2015, the *European Citizen Science Association* (ECSA), the United States *Citizen Science Association* (CSA), the *Australian Citizen Science Association* (ACSA) and *CitizenScience.Asia* promote global exchange to advance Citizen Science. The EU actively supports Citizen Science. Its international platforms, EU-Citizen.Science, SciStarter and Zooniverse, bundle current projects, resources and training offers internationally. The first European Citizen Science Conference took place in Germany in 2016 as a collaboration between the GEWISS project and ECSA, which was then continued by Switzerland in 2018 and Italy in 2020.

An active community of Citizen Science assets from civil society organisations, universities and other research institutions, professional societies, museums, libraries and other educational institutions has emerged in recent years in Germany, Switzerland and Austria. Several active Citizen Science centres and various Citizen Science platforms and networks have been established. In all three countries, Citizen Science conferences are organised annually by different host organisations (→ action area 14). There are also many regional and subject-based conferences and workshops. Furthermore, the funding landscape is changing.

Calibration setup as part of the CS project SMARAGD (sensors for measuring aerosols and reactive gases and analysing their impact on health). Photo: Jülich Research Centre/Natalie Kille

In Germany, Switzerland and Austria, several new funding programmes for Citizen Science have emerged in the last five years through various ministries and other funding organisations. The *League of European Research Universities* (LERU) first presented an *Advice Paper* [25] for its members in 2016. This paper contains important recommendations to structurally incorporate it at universities and recognise Citizen Science in research funding and evaluation processes (→ action area 8).

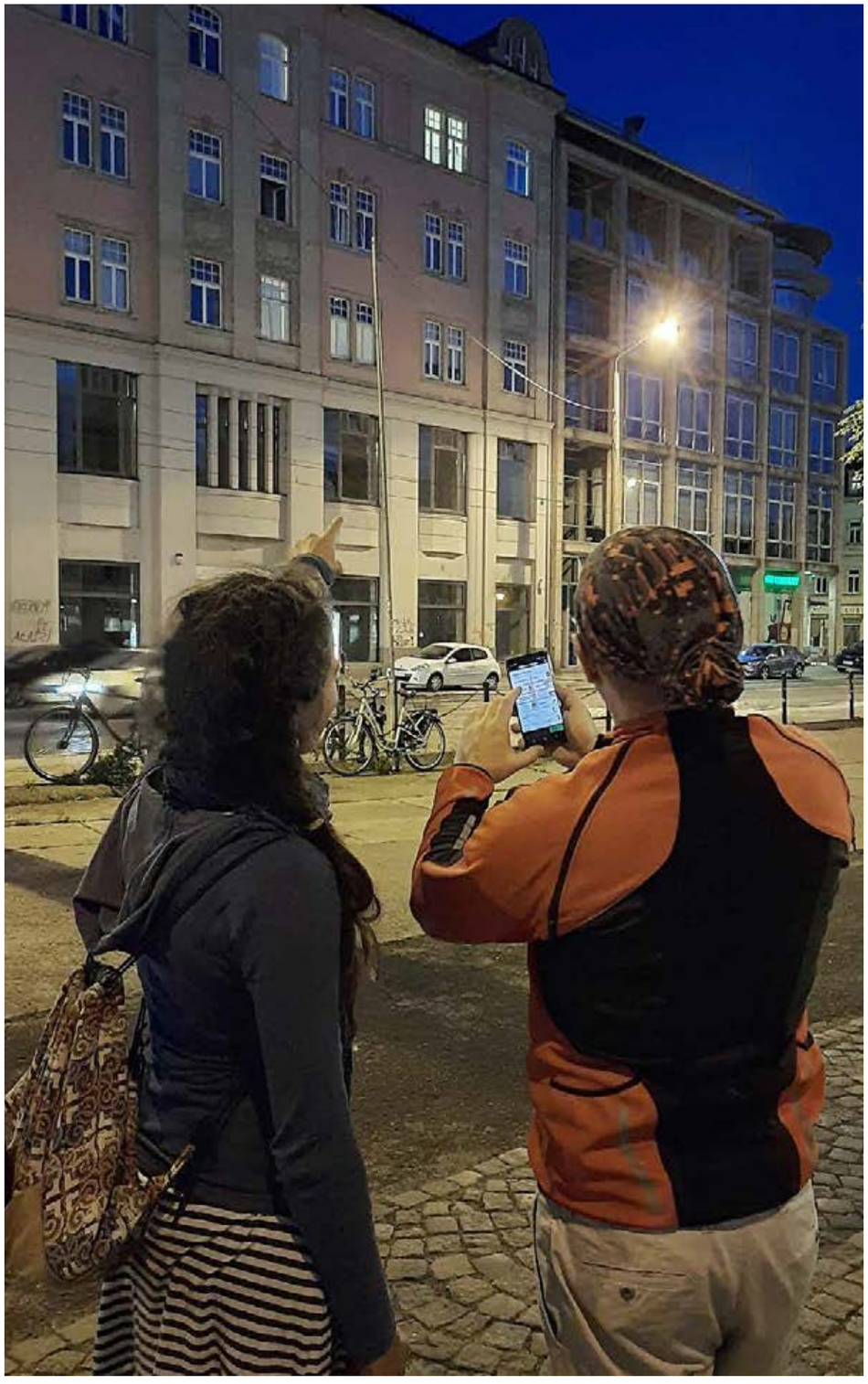
Many Citizen Science projects use a *bottom-up* structure and many are also not organised in networks. This is a very specific characteristic of Citizen Science, and local presence and individual formats are often important for success. Overall, Citizen Science thrives on the ideas and commitment of many, making it diverse and vibrant.

The development of the Citizen Science landscape in Germany

In Germany, Citizen Science is seen as an increasingly important instrument of participation and connects with the objectives and strategies of various ministries (→ Box 2). Citizen Science is prominently rooted in the coalition agreement of the German Federal Government as part of modern research to "more strongly incorporate perspectives from civil society into research" [26, pg 24].

After the publication of the Green Paper on the Citizen Science strategy, a new funding line from the Federal Ministry of Education and Research (BMBF) for Citizen Science was launched. Since 2021, 15 Citizen Science projects have now been funded in a second BMBF funding line, even though the current funding quota is still quite low. Citizen Science as a participatory format is mentioned several times as an important component in the BMBF's policy paper on scientific communication. Funding for Citizen Science also occurs in the biodiversity funding programme of the German Federal Ministry for the Environment and Nuclear Safety (BMU). The innovative potential of Citizen Science is also highlighted in the Federal Government's high-tech strategy ("new sources for new knowledge") [31]. In the Federal Government's data strategy, Citizen Science is ascribed an important role regarding data usability and promoting data literacy among citizens. Further links between individual departments and federal strategies can be found in Box 2.

Universities are positioning themselves with Citizen Science as active stakeholders in the region through the *Third Mission* and are in part developing their own funding lines and creating interfaces and instances to incorporate Citizen Science at the institutions. Among other things, the first Citizen Science professorship was established at the University of Jena and strategic networks or staff positions were set up at the universities of Düsseldorf, Münster and the Technical University of Berlin (→ Box 3 and → action area 8 for further examples of the implementation of strategic Citizen Science in scientific practice). A similar picture can be seen within the large non-university research organisations, which are developing internal funding lines and establishing networks for internal exchange and networking (e.g. CitizenScience@Helmholtz network with funding for the Citizen Science Programme 2019-2023, Leibniz Citizen Science Working Group and the Fraunhofer Citizen Science Network). A selection of important Citizen Science stakeholders is listed in Box 3 (→ action areas 1, 8, 9, 13).



Citizen scientists count and classify the artificial light sources on public streets and squares using the Nachtlicher app. Photo: Stefanie Partsch

Environmental associations and professional societies have also been performing Citizen Science projects, developing apps and organising networking events for decades, and are now increasingly using the possibilities of social media. Science shops, real labs and *FabLabs/Makerspaces* are also important contact points for Citizen Science. Other stakeholders include adult education centres and repair cafés, which are now involved in some projects.

Overall, Citizen Science is gaining in reputation and promoting and implementing Citizen Science as a research approach is becoming increasingly accepted. But at the same time, there is still a gap between the attributed potential at the strategic level and actual implementation at the concrete level. An example of this is BMBF's funding quota for Citizen Science projects (less than 5% of submitted project outlines in 2020), which is as a whole lower than comparable programmes, compared to Citizen Science project results actually being integrated into concrete political and social decision-making processes, which still hardly takes place.

BOX 2 – Citizen Science innovative potential – linked to the goals and strategies of various federal ministries

The examples listed below are only a sample and not an exhaustive list. There are various possible points of connection for several ministries.

Citizen Science enables …

- **Innovative research** with large-scale data sets in space and time. Generating and evaluating this much data is not possible in any other way (BMBF/DFG, Federal Government Data Strategy 2021 [27])
  Example: using the knowledge of many to monitor nature and the environment, climate or health on a large scale and over the long term

- **Participatory research, co-creation and integrating different knowledge domains** (BMBF/DFG)
  Example: research on topics of high relevance to society with active participation from the public and local stakeholders and their expertise (joint design, implementation and evaluation of research)

- **Scientific literacy, active lifelong learning and innovative communication in science** (BMBF/BMBF Science Communication Policy Paper 2019 [28])
  Example: research on topics in the domain of lifelong learning with the active participation of senior citizens.

- **Innovative potentials for digitisation** (Ministry of Transport, BMBF Digital Strategy 2019 [29], Federal Government Digitisation Strategy 2019 [30])
  Example: citizen researchers digitising archives

- **Technological development with new sensor technology and artificial intelligence** (Ministry of Transport, High-Tech Strategy 2025 of the Federal Government 2018 [31], BMWi Regulatory Sandbox Strategy 2019 [32])
  Example: citizen scientists using drones for earth exploration, using mobile sensors to measure air pollutants or performing automated image processing to identify plants

- **Environmental and biodiversity monitoring** (BMBF, BMU, BMEL and subordinate authorities and institutes)
  An example of how this can be applied is agricultural and forest monitoring by the Thünen Institute and Julius Kühn Institute or in the Biodiversity Monitoring Centre of the BfN and environmental monitoring by the UBA and research organisations

- **Social cohesion, social empowerment** (Ministry of Family Affairs, BMBF)
  Example: citizen researchers researching social cohesion by conducting their own interviews, storytelling or analysing documents

- **Health, life satisfaction and well-being** (Ministry of Health)
  Example: patient science to research diseases

BOX 3 – Citizen Science stakeholders in Germany, tools and capacities

The examples listed below represent a sample and do not claim to be exhaustive. For more detailed descriptions, see action areas 1, 8, 9, 13, among others.

- **Universities and research networks** (→ action areas 1, 8):
  Structural Citizen Science incorporation and networking examples
  - Citizen Science Chair at the Friedrich Schiller University Jena (**www.geographie.uni-jena.de/en/chairs**)
  - Citizens' University Office at Heinrich Heine University Düsseldorf (**www.buergeruni.hhu.de/en/citizens-university**)
  - Citizen Science Programme at TU Berlin/Berlin University Alliance (BUA) (**www.forschung.tu-berlin.de/servicebereich/menue/forschung_an_der_tu/citizen_science_projekte_2018**)
  - Citizen Science at the University of Münster (**www.uni-muenster.de/AFO/en/CS**)
  - Heidelberg University (z. B. **www.uni-heidelberg.de/en/research/research-profile/fields-of-focus/field-of-focus-iii/research-activities/cisar-citizen-science-in-archaeology**)
  - "Citizen Science" department at the Institute of Data Science at the German Aerospace Center (DLR) (DLR – Institut für Datenwissenschaften – Bürgerwissenschaften)

- **Non-university research organisations (→ action areas 1, 8):**
  - CitizenScience@Helmholtz Network (**www.helmholtz.de/en/transfer/citizen-science**)
  - Leibniz Citizen Science Working Group (**www.leibniz-gemeinschaft.de/en/forschung/citizen-science**)
  - Network of Fraunhofer Institutes using Citizen Science (u. a. Fraunhofer IMW, ISI, IRB, UMSICHT)

- **Science shops and houses** (→ action areas 1, 9, 13): Network of German-speaking science shops (**www.wissnet.de**), Science houses (such as in Braunschweig)

- **Associations** (→ action areas 1, 3): such as NABU, BUND, National Network for Civil Society (BBE), German Life Science Association (VBIO)

- **Professional societies** (→ action area 3): such asprofessional societies for natural history (e.g. DDA, GdO, AraGes, NetPhyd), history and genealogy (e.g. DGMPP, DGGN, GDUF), astronomy (AG)

- **Makerspaces/FabLabs/repair cafés/regulatory sandboxes** (→ action areas 8, 9): e.g. Netzwerk Reallabore (**www.reallabor-netzwerk.de**), Reallabor Schorndorf, Reallabor Potsdam-MaaS L.A.B.S, Erlebniswelt Mobilität Aachen, Reallabore Berlin (**https://stadtmanufaktur.info/en/living-labs**)

- **Museums, archives, libraries, botanical and zoological gardens** (→ action area 13): for example all major natural history museums such as the Natural History Museum Berlin (Citizen Science Competence Centre), Museum Koenig – Conference of Species, Senckenberg Nature Research Society (Museum in Frankfurt am Main/Museum in Görlitz), botanical gardens in Berlin and Leipzig, Saxon State and University Library Dresden, etc.

BOX 3 (continuing)

- **Citizen Science Online Platform** from MfN and WiD (→ action area 1): such as Bürger schaffen Wissen (www.buergerschaffenwissen.de/en)
- **Federal state academies** (→ action area 9): such as the Saxony State Foundation for Nature and the Environment/UmweltMobil
- **Adult education centres:** such as KVHS Anhalt-Bitterfeld, VHS Herford
- **Ministries & foundations with Citizen Science funding** (→ action area 2): BMBF, BMEL, BMU/BfN, DBU, Fritz Thyssen Foundation, Volkswagen Foundation, etc.
- **National authorities and downstream institutes, state offices and municipalities** (→ action area 13): such as the Federal Agency for Nature Conservation (BfN) (monitoring biodiversity), Thünen Institute Braunschweig (agricultural monitoring), the Deutscher Wetterdienst (DWD), the City of Leipzig Green Spaces Office
- **Diverse Citizen Science initiatives without Institutional affiliation**

Selected tools and capacities

- **Guides:** such as the Manual on legal questions in Citizen Science projects [33], Guide to good practices for co-creation projects [34], Guide to developing Citizen Science projects in protected areas [35]
- **Numerous networking events** from the different stakeholders: such as the Citizen Science Forum, Nature Observer Conference, Conference of Species, diverse events from Citizen Science projects and universities
- **Continued education & training:** such as training events by Citizen Science projects, "Bürger schaffen Wissen" training workshops, BfN seminars, iDiv/UFZ Citizen Science summer school
- **National online platforms for data collection, input or networking** (→ action areas 6, 12): such as www.naturgucker.de, DDA www.ornitho.de/index.php?m_id=1&langu=en, TU Ilmenau/MPI Jena www.floraincognita.com, Consortia from the National Research Data Infrastructure Germany www.nfdi.de/?lang=en

Green Paper "Citizen Science Strategy 2020 for Germany" (2016)

From 2014 to 2016, the consortium programme "BürGEr schaffen WISSen – Wissen schafft Bürger" (GEWISS) conducted a nationwide open dialogue with stakeholders from science, civil society and politics on the development of Citizen Science in Germany. The focus was on developing the Green Paper "Citizen Science Strategy 2020 for Germany" with visions for Citizen Science in Germany, promoting networking between stakeholders from science, civil society and politics, and providing practical resources to develop Citizen Science capacities. The joint project was coordinated and academically accompanied by institutions from the Helmholtz and Leibniz Associations with their university and non-university partners. More than 700 stakeholders from over 350 organisations and institutions contributed their perspectives regarding Citizen Science in Germany.

The Green Paper was published in March 2016. It presents the insight, requirements and potentials of Citizen Science in Germany, reflects on the added value that can emerge in the different areas of society and identifies untapped potential. Concrete proposals for courses of action and measures depicted how Citizen Science can be strengthened in Germany, which capacities are needed over the long term to successfully implement Citizen Science projects and also opportunities for connecting Citizen Science to political and social goals. The impact the GEWISS modular programme had by establishing Citizen Science in science, society and politics was manifold. The project initially enabled an open reciprocal approach between research, society and politics. It simultaneously provided a trigger for many of the stakeholders involved to develop and expand their involvement in Citizen Science. For example, by promoting Citizen Science projects in institutions or integrating Citizen Science into the strategy papers of individual institutions or universities. The development of a nationwide Citizen Science strategy received international attention.

Status and development of Citizen Science since the publication of the Green Paper

This White Paper is based on reviewing the implementation of the goals of the Green Paper "Citizen Science Strategy for Germany 2020" and the visions and courses of action for the Citizen Science community formulated therein. Which goals and options have been implemented? Which ones have been partially or not at all implemented? Which ones have not proved beneficial? And what new fields have been added in today's Citizen Science landscape?

An open "AG Weißbuch" (White Paper Working Group) with various public formats to engage interested stakeholders was conducted by the Citizen Science community based on these and other questions. It examined the courses of action from the Green Paper as well as the changes along the three core fields - strengthening, recreating and integrating Citizen Science in science, society and politics (→ Fig. 3).

Students prepare soil traps in the MikroSafari Citizen Science project. They are studying the composition of small animal communities along an urban heat gradient to understand how species communities are affected by environmental change and climate change. Photo: MikroSafari/UFZ/iDiv

What has changed since 2016?

When the Green Paper was published in 2016, Citizen Science was often seen as either an already long-established research approach or a completely new way of working. Citizen Science was also viewed with apprehension, especially from academic science [36]. This has changed considerably in the last five years (→ Box 2). There are now a large number of Citizen Science projects. Citizen Science is increasingly the subject of funding guidelines from various departments, research organisations, individual institutions and foundations. The amount of funding has increased and research funding programmes are slowly opening up to non-academic funding recipients such as associations and professional societies. Users are increasingly identifying with the format at the project level. This can be seen in the increasing number of projects also arising from other "related" participatory research areas (e.g. transdisciplinary research, action research) and in increased use of Citizen Science data for urgent research questions (e.g. for the global sustainability goals SDGs). In the last five years, a large number of resources have also emerged in Germany and abroad that provide very specific assistance for implementing projects in a practical way (guides, workshops, networking formats) and formulate measures for implementing and strengthening individual disciplines at the strategic level (e.g. Thünen Institute working paper on Citizen Science [37], UFZ position paper on action areas in environmental education and environmental communication [38]).

Citizens design the Tracing Jewish Life in Münsterland exhibition along with scientists and craftsmen from the University of Münster. Photo: WWU Münster/Bauhus

What are new developments since 2016?

Several new developments have been identified since the publication of the green paper (→ Box 2, → Fig. 3). The project landscape is expanding and increasingly more projects are being launched from a wide range of disciplines. New domains for Citizen Science are cropping up – with new questions and challenges – especially in the fields of social Citizen Science, artificial intelligence and sensor technology, as well as in medicine and health sciences. Libraries and archives are also emerging as new participants, especially in the social sciences and humanities. Universities are integrating Citizen Science at the strategic level into outreach activities in their local regions. Points of contact are being established at the various organisations for targeted dialogue and knowledge exchange. It has become apparent that there is considerable potential for sustainable structures, especially in establishing and expanding local networks and points of contact at larger organisations and in regional networks.

Meanwhile, technical infrastructure for data management with various data platforms are also increasingly evolving, but they are often fragmented. They do not tend to be standardised or sustainably incorporated or interoperable with other databases and still need to be significantly strengthened. Citizen Science is expanding further as a result of new mobile sensors and artificial intelligence techniques, as well as new projects in medicine and health sciences.

As a result of the GEWISS programme and the first European Citizen Science conference, the innovation potential of Citizen Science for open science, society and politics was presented in an anthology and various courses of action for stakeholders from politics, business, education and research organisations along with a research agenda were outlined [4]. Overall, the expansion of research through Citizen Science can be classified as part of an increasing professionalisation of the field. This is not only reflected in the emerging interfaces and structures, but also in corresponding offers for continued education and training on the subject of Citizen Science (e.g. web platforms, summer schools, training workshops and think camps).

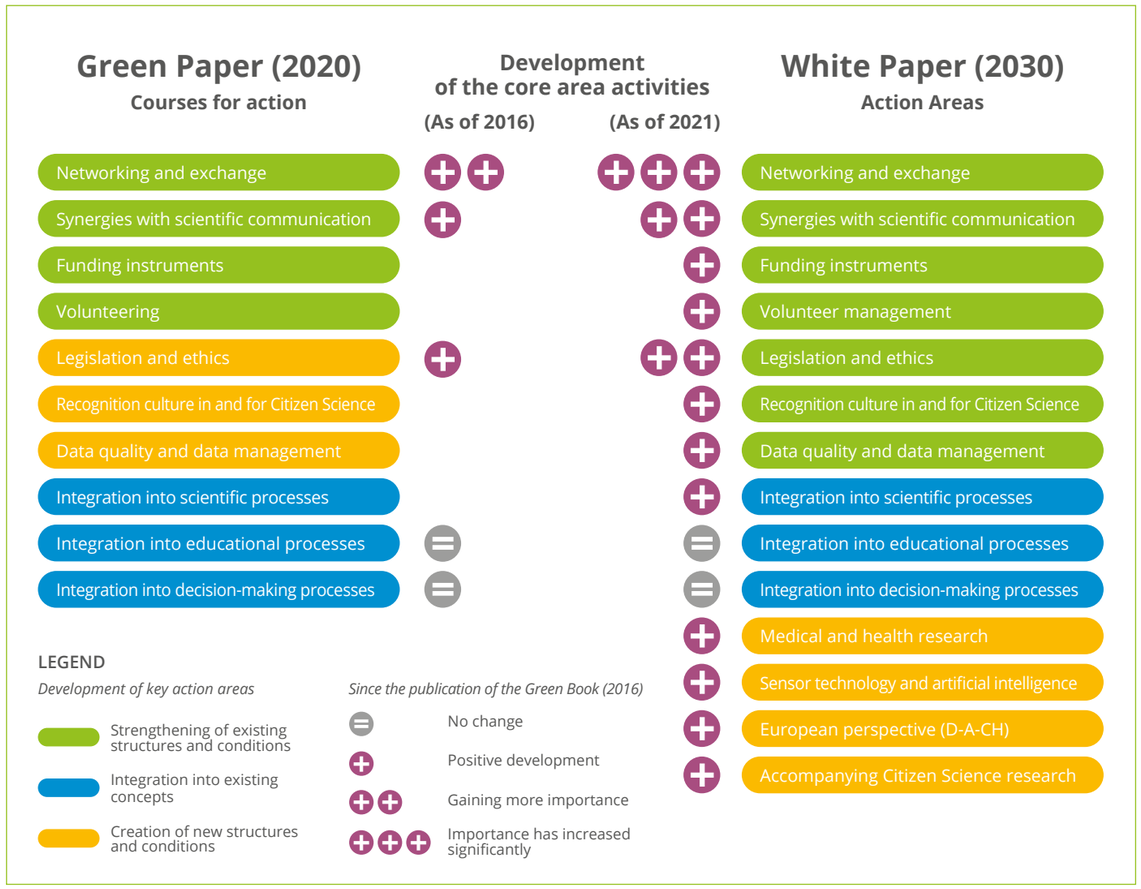


Figure 3: Development of the core area activities from the 2020 green paper to the 2030 white paper

What are remaining challenges?

Despite the diverse developments of Citizen Science in different subjects and spaces, there are still major challenges, potential for development and action areas. Citizen Science activities and the knowledge gained through Citizen Science still do not enjoy the same recognition as classical research processes. There are reservations regarding certain aspects such as data quality, although it has been proven in several scientific studies that Citizen Science produces valid data [36, 39]. Nevertheless, precisely this quality assurance is an important topic for the future, as is sustainable data management. The extent to which Citizen Science can promote trust in science and scientific understanding or scientific literacy on a broad scale must be analysed if the participants currently come primarily from the academically educated middle class with an affinity for science. This is where it is necessary to address social diversity, inclusivity and exclusionary factors (such as language and accessibility) as well as the fit accuracy and active involvement of desired target groups. Simultaneously, Citizen Science needs an even broader public in order to gain more recognition. It is also essential to increase acceptance among researchers in university and non-university research institutions as well as among institutions that provide funding.

In order to permanently and firmly ingrain Citizen Science in Germany, the visions, strategies and framework conditions of the green paper must be implemented (→ Box 2). This can facilitate a diverse community in the field of Citizen Science, working with distributed expertise, connecting with existing networks and initiatives and living through new things. Citizen Science can contribute as a component to the sustainable development of our democratic knowledge society.

Citizen scientists identify animals and plants using automatic image recognition in the Naturblick app and thus learn more about nature in their neighbourhood. The app can also record bird calls and recognise which bird is singing through automatic sound recognition. Photo: Sophie Bengelsdorf

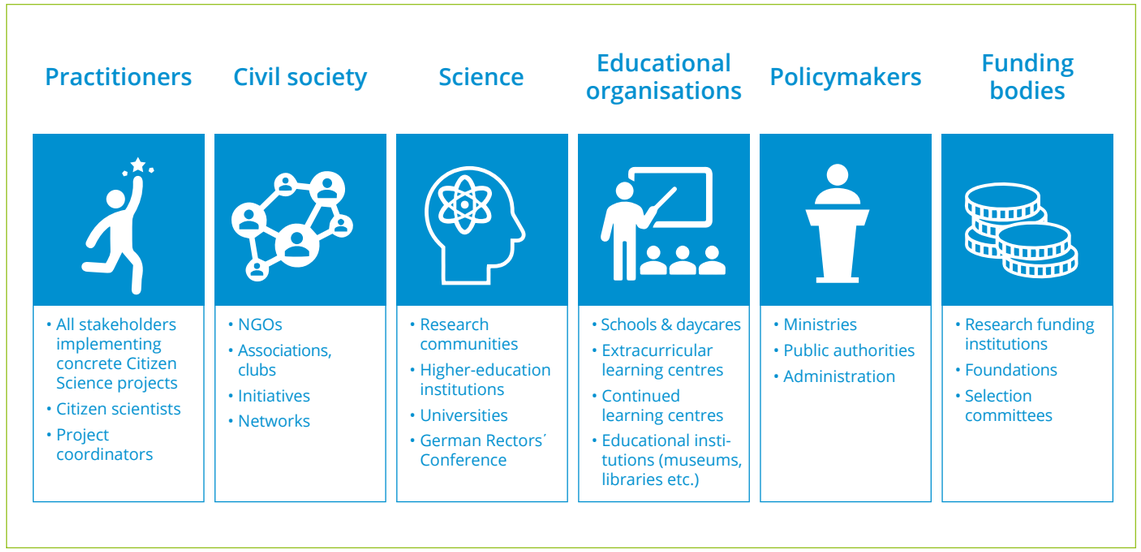


Figure 4: Target groups for the recommended actions

The White Paper Citizen Science Strategy 2030 for Germany

The *White Paper Citizen Science Strategy 2030* builds on the Green Paper and addresses the most important challenges, requirements and potentials of Citizen Science over the next ten years. The recommended actions show what needs to be done in the future to strengthen and better secure Citizen Science in Germany. The process of developing the White Paper is described in the chapter "Development process of the White Paper".

The White Paper aims to strengthen Citizen Science in society and science in order to be able to expand its innovative potential and clarifies the central tasks we are facing. How can we improve conditions in the German research landscape to allow more people outside institutional science to participate in research? How do we make Citizen Science engagement part of the scientific discourse? How can we support existing initiatives, projects and associations in their work? What needs to be considered in terms of data quality, data management and legal and ethical aspects? These and other possibilities and challenges were discussed in the white paper process in digital strategy workshops and dialogue forums with stakeholders from academia and the public.

In order to analyse the current status of Citizen Science in the 15 action areas of the White Paper, the White Paper working group conducted an online survey of the German-speaking Citizen Science community in September/October 2020 (hereinafter referred to as: CS Survey 2020). Quantitative and qualitative indicators were thus derived from the recommended actions in the Citizen Science Green Paper and an online questionnaire was developed based on them (available at: https://doi.org/10.5281/zenodo.5776150). The results of this survey are integrated into the individual White Paper chapters and cited with the reference "CS Survey 2020". The White Paper designates specific recommendations for 15 action areas on how Citizen Science can contribute to important goals from politics, society and science and how these can be anchored more in-depth. Six groups of addressees were selected to implement the recommended actions and are illustrated with symbols (→ Fig. 4). The White Paper also summarises each action area in a key message. A mission statement has been formulated to define a vision for the role of Citizen Science in the respective action areas in 2030, complementing the recommended actions (→ key messages).

Citizen Science provides new insights into science and scientific processes. Photo: Ralf Rebmann/Science in dialogue

Forecast

The White Paper illustrates ways to continually advance and anchor the Citizen Science landscape in Germany. In order to implement the strategy, the target groups from science, society and politics must realise the following measures:

- Establishing and implementing concrete action plans for the individual recommended actions from the white paper for the target groups to implement the required measures.
- Creating a more dynamic scientific process by breaking up outdated structures surrounding genuine open science and responsible research and innovation, enabling true participation as a scientific identity for innovation through transformative change in the scientific landscape.
- Expanding recommendations and solutions through an active, diverse Citizen Science community that is diversely anchored, permitting it to develop more of its own appropriate solutions.
- Active Citizen Science contributions in scientific journals and at professional conferences to further expand the scientific field.

German and international policymakers, the scientific community and society as a whole emphasise that the goals established in the Sustainable Development Goals (SDGs) – such as food security, health and well-being, securing clean energy supply, resource scarcity, climate and biodiversity protection, sustainable cities and communities – can be achieved most effectively through open communication and the involvement of stakeholders in science and civil society [40, line 1484 et seq., 41, 42].

This is where Citizen Science comes in to achieve the Millennium Development Goals. Our common intention and the targeted promotion and support from all stakeholders – citizens, associations and professional societies, research and educational institutions, museums, public authorities, the media and the corporate world – are important to enable profitable collaboration and to sustainably anchor Citizen Science in society and science in Germany.

CITIZEN SCIENCE – ACTION AREAS

In full gear: participants in the campaign prepare to test the river for microplastics. To ensure that the data collected is comparable, the standardised special net is provided by the campaign. Photo: BMBF/Gesine Born

Christine Ahrend
Head of the department of "Integrated Transport Planning"
at Technische Universität Berlin

Photo: David Ausserhofer

"I support the Citizen Science Strategy 2030 for Germany because we can only address societal challenges in a sustainable way through consistent collaboration between society and science."

Mission statement 1:

In 2030, Citizen Science will live through networking and exchange between science and society.

Networking and regular exchange will be further promoted. Special attention will be paid to the exchange between Citizen Science assets, as well as the synthesis and transfer of their expertise on initiating, coordinating and implementing Citizen Science projects and the associated empirical knowledge.

1 Citizen Science – networking and exchange

1.1 Situation analysis: Where do we stand since the Green Paper?

We have observed increased networking and more in-depth exchange within the Citizen Science community. By networking, we mean creating and maintaining connections with people or institutions involved in Citizen Science. Those interested in this reach out to Citizen Science points of contact or Citizen Science projects. We see networking both within the scientific community and with civil society. Networks at all levels facilitate exchange and collaboration between researchers and citizen scientists, and even among researchers themselves.

The fact that more and more platforms/networks/working groups/projects have been initiated, expanded and extended at various levels indicates increased networking within the past five years. The CS Survey 2020 shows that personal interaction with colleagues at their own organisations and other organisations, as well as local and regional networks (in whatever form - formal, informal, organised or loose, → Fig. 5) are important for half of all respondents to stimulate exchange and thus establish and expand Citizen Science competences. These include such competences as knowledge of project processes, communication, citizen researcher involvement, data collection, quality assurance, dissemination of results and organisational and administrative tasks, among others. 41% of the respondents are already members of a network, 9% are definitely planning to do so.

The existing **contact and coordination centres** organise exchange and networking within the scientific community (→ Box 4). They serve as a networking centre and workplace for all types of Citizen Science activities. Advisory and coordination centres help to find suitable partners, write successful funding applications, teach Citizen Science skills, ensure high-quality Citizen Science projects and recruit citizens for projects.

To build their own competence in Citizen Science and networking, most respondents in the CS Survey 2020 advocate for a support network of competent people from different organisations and points of contact in their own organisation. Just under a quarter to one-fifth of the respondents (24%) would like to see regional advisory centres or a central, cross-institutional advisory centre (22%) (→ Fig. 5).

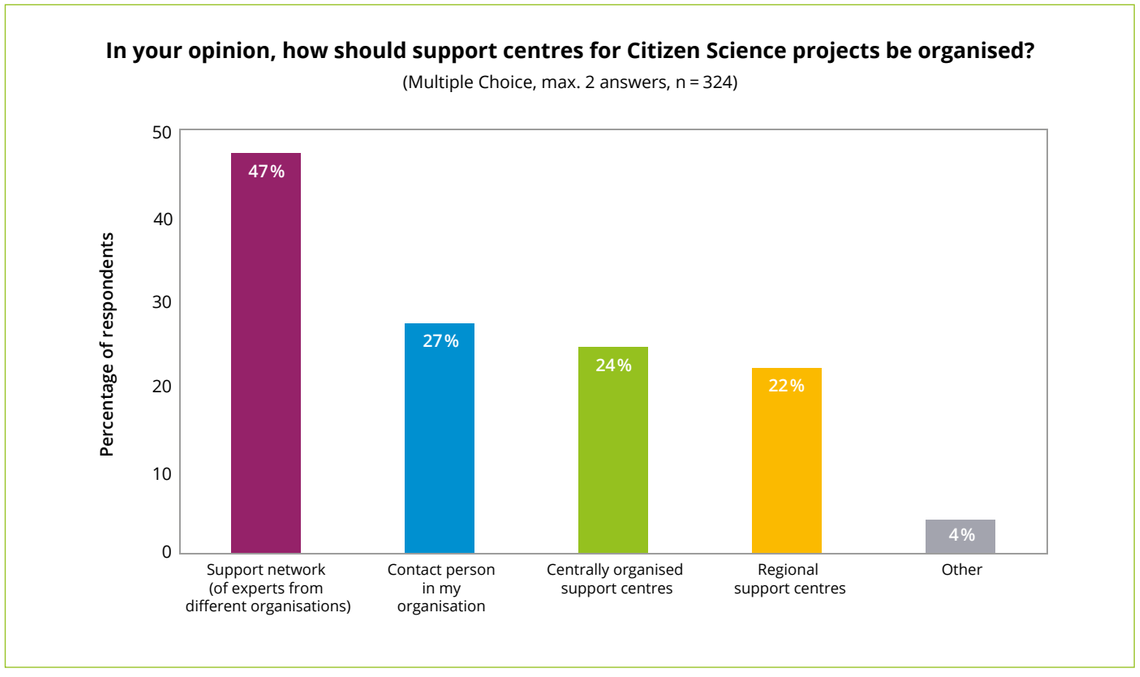


Figure 5: Participant assessment of the design of advisory centres (Citizen Science Survey 2020)

The various web-based platforms on which projects are listed and presented serve as important points of contact and information networks. There are various national platforms in German-speaking countries (→ action area 14 – European perspective). In Germany, the platform "Bürger schaffen Wissen" (BsW) (**www.buergerschaffenwissen.de/en**) has brought many Citizen Science projects together since 2013. The platforms in Austria, "Österreich forscht" (**www.Citizen-Science.at/en**, since 2014), and in Switzerland, "Schweiz forscht" (**www.schweiz-forscht.ch/de**, since 2015), represent network hubs in the countries mentioned. They present, connect and support Citizen Science projects and promote exchange within the community, especially through numerous offers such as annual Citizen Science conferences, training courses, workshops, etc. They are an important point of contact for scientists, citizen researchers, media representatives, political representatives and interested citizens. The project databases can be used to find Citizen Science projects and contact scientists for joint research projects. The number of projects listed on the BsW platform has increased from ten in 2014 to over 180, including completed projects in 2021. 60 projects are listed on the Austrian platform as of 2021. "Schweiz forscht" currently lists 63 projects as of 2021. Increased exchange and networking within the community gives rise to increased identification with the Citizen Science research approach and an increased number of Citizen Science projects. The slow but steady growth also leads to greater visibility and acceptance of Citizen Science within and outside of the scientific community. However, the Citizen Science Survey 2020 also showed that many citizen researchers network in their own forums or in other ways.

In addition to the national platforms, various **working groups** (WGs) on specific topics and Citizen Science **networks** have been founded in the past five years, for example at the Helmholtz Association, the Leibniz Association, the Fraunhofer Society and universities. These are also a sign of a growing community whose concerns and challenges are increasing and require sustainable solutions. Working groups on certain topics and many regional networks are signs of the diverse and decentralised commitment to Citizen Science. Networks make the diversity of Citizen Science visible to researchers and the public. They have the potential to make existing knowledge more efficiently usable for the community and to take regional and subject-related specificities into account. New ideas are also developed together and duplication of work can be avoided, e.g. in the compilation of materials and resources. Networks identify and develop new content and contribute significantly to establishing and steadily expanding the Citizen Science community. In addition to research institutions, technical schools and universities are the first points of contact for questions about Citizen Science. They contribute in many ways and thus strengthen the research approach. Some universities have institutionalised science shops or promote and support regional science shops or regulatory sandboxes, for example.

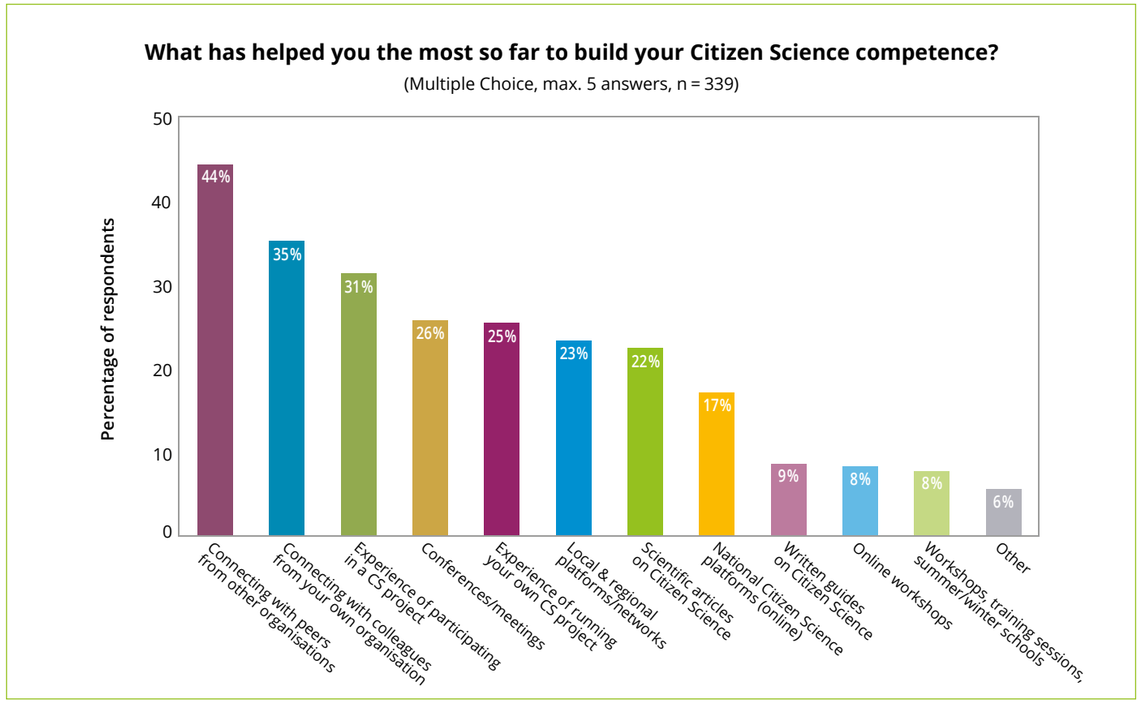


Figure 6: Participant assessment of Citizen Science capacity building (CS Survey 2020)

There are also active networks and platforms that do not have Citizen Science in their title but are committed to the idea of Citizen Science (→ action area 13 and → Box 4).

The visibility of projects contributes to the Citizen Science approach being perceived more strongly overall and being valued as "real" science. This fundamental gain in reputation within the scientific community (→ action areas 5 and 8) is the foundation for an exchange between researchers who are already active in the field of Citizen Science. New Citizen Science research designs are developed in open exchange between the participants. The results of the CS Survey 2020 (→ Fig. 6) show that exchange greatly contribute to building competences. For example, 44% of the respondents said that direct exchange with colleagues from other organisations had helped them build their Citizen Science competences. The second most important option for 35% of the respondents was exchange with colleagues from their own organisation. According to the CS Survey 2020, direct exchange with colleagues within an organisation and from other organisations contributes most to competence building. 30% of respondents (n = 324) would also like more advice on planning, implementing and running Citizen Science projects.

BOX 4 – Networking & exchange

The listed examples are only a selection. We are aware that there are many more currently active participants than those mentioned.

Points of contact/coordination centres

- Citizen Science laboratory at the German Aerospace Center DLR Jena (www.dlr.de/dw/en/desktopdefault.aspx/tabid-12910/22556_read-52206)
- Citizen's University at the Heinrich Heine University Düsseldorf, including advisory and funding structures for Citizen Science (www.buergeruni.hhu.de/en)
- Institutionalised Citizen Science working group at the University of Münster (www.uni-muenster.de/AFO/en/CS)
- Senckenberg Natural Science Society (www.senckenberg.de/en/get-involved/citizen-science)
- Centre for Citizen Science Austria – focus on cooperation with schools (www.zentrumfuercitizenscience.at/en)
- Participatory Science Academy of ETH and University of Zurich (www.pwa.uzh.ch/en)

Networks

- Helmholtz Association competence network "CitizenScience@Helmholtz" (www.helmholtz.de/en/transfer/citizen-science) and associated funding programme
- Leibniz research network "Citizen Science" (www.leibniz-gemeinschaft.de/en/research/citizen-science)
- Network of wildlife researchers in Berlin (https://berlin.stadtwildtiere.de/projekt)

– **Continuation Box 4** –

Working groups

- AG D-A-CH (www.buergerschaffenwissen.de/netzwerk/ag-dach)
- AG Citizen Science Berliner Raum (www.buergerschaffenwissen.de/netzwerk/ag-berlin)
- AG Region West (www.buergerschaffenwissen.de/netzwerk/ag-netzwerk-region-west)
- AG Science of Citizen Science (www.buergerschaffenwissen.de/netzwerk/ag-scienceofcitizenscience)
- AG Citizen Science in Schools (www.buergerschaffenwissen.de/netzwerk/ag-citizen-science-in-schulen)
- AG Citizen Science & Law (www.buergerschaffenwissen.de/netzwerk/ag-cs-recht)

Active networks and platforms without Citizen Science in their name

- Network of German-speaking science shops – Wissnet (www.wissnet.de)
- Living knowledge (https://livingknowledge.org/lk9)
- Federal Working Group on University Continuing and Distance Education (https://dgwf.net/bag-wiwa.html)
- Science Shop Kubus Cooperation and Advisory Centre for Environmental Issues at TU Berlin (www.zewk.tu-berlin.de/v_menue/kubus_nachhaltigkeit_umwelt/parameter/en)
- Social Science Shop of the Catholic University NRW in Cologne and the Protestant University R-W-L in Bochum (www.sozial-wissenschaftsladen.net)
- UNIAKTIV at the University of Duisburg (www.uni-due.de/diversity/service_learning.php)
- Science Shop Vechta/Cloppenburg, Wissenschaftsladen der Universität Vechta (www.wissen-teilen.eu/en)
- Regulatory sandbox (space for joint and mutual learning between the sciences and civil society)
- Netzwerk Reallabore der Nachhaltigkeit (www.reallabor-netzwerk.de)
- Reallabor at TU Berlin (www.oekohydro.tu-berlin.de/menue/labor/reallabor_wassersensible_stadt)
- Reallabor at the University of Wuppertal (www.idpf.eu/das-partizipative-reallabor)
- Reallabor at KIT (www.itas.kit.edu/english)
- BUND – various Citizen Science projects (www.bund.net/mitmachen/mitmachseite)
- Nature and Biodiversity Conservation Union NABU (e.g. annual bird count) (https://en.nabu.de)
- naturgucker.de as a social network for nature observers (www.naturgucker.de)
- Pollichia – Association for Nature Research, Nature Conservation and Environmental Education (www.pollichia.de)
- Volunteer exchanges (www.bmi.bund.de/EN/topics/community-and-integration/socia-cohesion-volunteering/socia-cohesion-volunteering-node.html, with links to individual volunteer portals)
- Volunteer agencies (https://bagfa.de/english)
- Science houses (www.hausderwissenschaft.de/english, www.hausderwissenschaft.org)

1.2 What are the requirements, opportunities and challenges?

The exchange goes beyond the scientific community. Networking between scientists and citizens offers enormous potential. It can help to reduce mutual threshold fears, promote understanding of scientific processes and anchor science more firmly in society. However, more resources and the intensified strategic partnerships (e.g. with voluntary agencies, professional societies or professional networks in science) are needed to reach the public with Citizen Science issues beyond the usual information channels.

What are the barriers/challenges?

Approximately 50% of all respondents in the CS Survey 2020 had never participated in Citizen Science events. This result is certainly a sign of a strong, independent and diverse Citizen Science community that exists through many bottom-up initiatives and perhaps exchanges ideas in other communities, e.g. in professional societies, associations or science shops. These structures are valuable and need to be recognised, valued and further supported.

Some demographics have not been reached yet and therefore no exchange can take place. This is partly due to the fact that the number of local and regional or even organisation-specific Citizen Science coordination centres (and staff) is only slowly increasing and open laboratories for Citizen Science initiatives are still more of an abstract model than reality. These challenges can be mitigated by utilising opportunities and implementing recommended actions.

Communication is central to networking. Some communication channels are listed in action area 4 “Synergies with scientific communication”. Networking projects related by subject can represent high added value within the projects and project participants can exchange information about conditions for success, but also possible obstacles, and learn from each other. Willingness for joint exchange is a prerequisite.

Events enable easy and personal contact for exchange and are also an expression of recognition and appreciation (→ action area 5). When designing event formats, it is important to consider who they are aimed at in order to ensure that they are appropriate for the target group. Project-related solutions adapted to the relevant groups of participants are needed. Regular meetings during existing local or regional networks (in person or virtual) are also a good opportunity for personal exchange. Some stakeholders already offer a wide range of events, such as the Naturgucker Congress, the Selbstgewusst Conference, the Conference of Species or events organised by the BBE network or the science shops.

Fishing in the Panke in Schönhausen Palace Park as part of the WissensFluss participatory project, organised by the Museum für Naturkunde Berlin. Photo: Maryam Mumladze

Where are there new opportunities?

Digitalisation offers good opportunities for networking independent of location. The resulting possibilities not only facilitate communication and, for example, data collection by the participants in Citizen Science projects, but also address people/groups that have not been reached so far and motivate them to participate. For one thing, higher project participation figures can be achieved by reaching potential citizen scientists. And digital training workshops or summer/winter schools are offered to build capacity for interested project initiators and multipliers, e.g. by “Bürger schaffen Wissen”, UFZ/iDiv and the Participatory Science Academy Zurich. Conversely, scientists can also be made more aware of Citizen Science through customised online formats, as these formats are much more time-saving to implement than participating in conferences, for example. Modules on specific topics could be considered for this (natural sciences/humanities and social sciences).

Short modular contributions could be used not only at online conferences and workshops, but also at particular specialist conferences.

In addition to digital exchange possibilities, the importance of personal communication should not be underestimated. For example, mentoring programmes can be set up to bring scientists with Citizen Science experience together with those interested in Citizen Science. In the future, even more attention should be paid to low-threshold ways of reaching potentially interested citizens.

Science shops and other stakeholders (e.g. voluntary agencies, civic associations, initiatives and extracurricular learning centres) have many years of experience in this area, which should be shared more in the future. These institutions often have a network of committed citizens who can be won over to Citizen Science. Potential is also offered at universities through studies such as gerontology, which could be used even more in the future. Citizen Science projects are already being performed in “research-based learning”. This could be extended to other universities in the future. If platforms, working groups, networks and relevant offers are strengthened, this will result in more exchange, which is useful for the research approach.

There is still plenty of room in the jar with the “yes” balls – networking and exchange can help put Citizen Science on an even broader footing. Photo: Ralf Rebmann/Science in dialogue

1.3 Recommended actions for area networking and exchange

1.1
Networks and working groups should be strengthened. Financial and non-material support should be provided for networking in organisations and funding programmes, e.g. through **network meetings for funded projects within a programme** or with **regional networking workshops** for Citizen Science projects.

1.2
Exchange opportunities for project coordinators should be anchored within the structure of the projects, since new project coordinators learn most from experienced colleagues.

1.3
Funding bodies and institutions from science and society (such as science shops, science houses, museums, libraries, archives, etc.) should consolidate and guarantee the extensive range of **local, regional and national exchange platforms.** This requires not only willingness but also financial resources.

1.4
Universities and research organisations should set up their own Citizen Science **contact, advice and coordination centres** combined with science shops, science houses and regulatory sandboxes. Specific contacts (existing or new advisors) should identify participatory, transdisciplinary research projects within the university or research institution, connect the participants, intensify Citizen Science, raise awareness among researchers, make ongoing Citizen Science projects visible and provide advice (e.g. on research design, funding opportunities, volunteer management, communication, etc.).

1.5
Research institutions should anchor support and networking structures for Citizen Science into the structure of **strategies and personnel planning.**

1.6
Research institutions and cities/municipalities should collectively **establish** transdisciplinary **city labs and regulatory sandboxes** and/or **science houses.** These should be low-threshold offers to create exposure to science and could also be role models and hosts for Citizen Science networks.

1.7
Research institutions and the Citizen Science community should make better use of the potential that has thus far not been exploited of networking with gerontology, at technical schools, voluntary agencies, neighbourhood offices, city libraries, science shops, etc.

1.8
Civil society organisations, research institutions and funding agencies should establish networking methods and formats for exchange and networking, such as the annual National Citizen Science Conferences (with different sponsors/organisers, e.g. through associations, science shops, volunteer agencies, etc.).

1.9
The Citizen Science community should draw up a map of networks, points of contact and coordination centres relevant to Citizen Science as well as physical spaces for knowledge transfer and dialogue with civil society (such as science houses, regulatory sandboxes, science shops, etc.). Municipalities and local multipliers should be seen and used as interfaces to accomplish this.

Addressees

Practitioners · Civil society · Science · Educational organisations · Policymakers · Funding bodies

Katrin Böhning-Gaese
Director of the Senckenberg Biodiversity and Climate Research Centre and Vice President of the Leibniz Association, Professor at Johann Wolfgang Goethe University Frankfurt am Main

Photo: private

"Citizen Science in Germany has added value for the society as a whole – and it is more relevant than ever for achieving an understanding of nature and a sustainable approach to it. And Citizen Science is indeed the cornerstone of the Senckenberg Society, founded in 1817 by citizens interested in nature."

Mission statement 2:

In 2030, Citizen Science will be supported by stakeholders in science, society, public authorities and practice through structural and financial measures (e.g. federal and state ministries and subordinate authorities and administrations, research and funding organisations, foundations, associations, networks, educational institutions).

Funding organisations integrate Citizen Science into their funding portfolio for various corporate and research stakeholders. The prerequisite for funding Citizen Science projects should be quality-assured procedures and standards based on the rules of good scientific practice through regular evaluations. This creates greater social participation in science and increases its acceptance and relevance.

2 Citizen Science – funding instruments

2.1 Situation analysis: Where do we stand since the Green Paper?

Since 2016, there has been an **increase in funding opportunities** for Citizen Science projects in German-speaking countries. In Germany, this is primarily reflected in specific Citizen Science calls for proposals. This can be seen particularly in state research funding from various federal ministries (especially BMBF calls for proposals in 2016 and 2019), as well as in the integration of Citizen Science into existing funding programmes (e.g. BMU - Federal Programme on Biological Diversity) and funding offers by foundations (e.g. DBU), universities and non-university research institutions. According to the BMBF, the two calls for proposals in 2016 and 2019 alone comprise a funding volume of around €13.5 million. The call for proposals for Citizen Science projects by the federal ministries is now part of an overall strategy to bring science and society more closely into dialogue and to increase participation and transparency of science (e.g. the Federal Government's High-Tech Strategy 2025 [31, 43]). Project funding from private funding organisations and by the research organisations themselves are becoming increasingly important. The German Research Foundation (DFG) funds Citizen Science formats mainly only for communication measures, events or European partnerships (e.g. BiodivERsA), but not through a specific funding programme.

Citizen Science is seen as an **integral part of open science** in the European context [44]. The EU promotes Citizen Science using the EU Research Framework Programme (e.g. networking activities, knowledge platforms through the "Science with and for Society" programme). In Austria, the Austrian Science Fund (FWF) launched the "Top Citizen Science" (TCS) [45] funding initiative for the fifth time in 2020. And the Austrian Ministry of Research (BMBWF) has been promoting cooperation between research and schools for over ten years with the "Sparkling Science Programme" [46]. From 2007 to 2009, a total of 299 research projects were funded through this programme with a total amount of approx. 35 million euros. The renewed call for proposals for "Sparkling Science 2.0" started in September 2021 and goes beyond collaboration between research and schools. In Switzerland, Citizen Science projects are funded by the Agora Programme from the Swiss National Science Foundation as part of science communication [47].

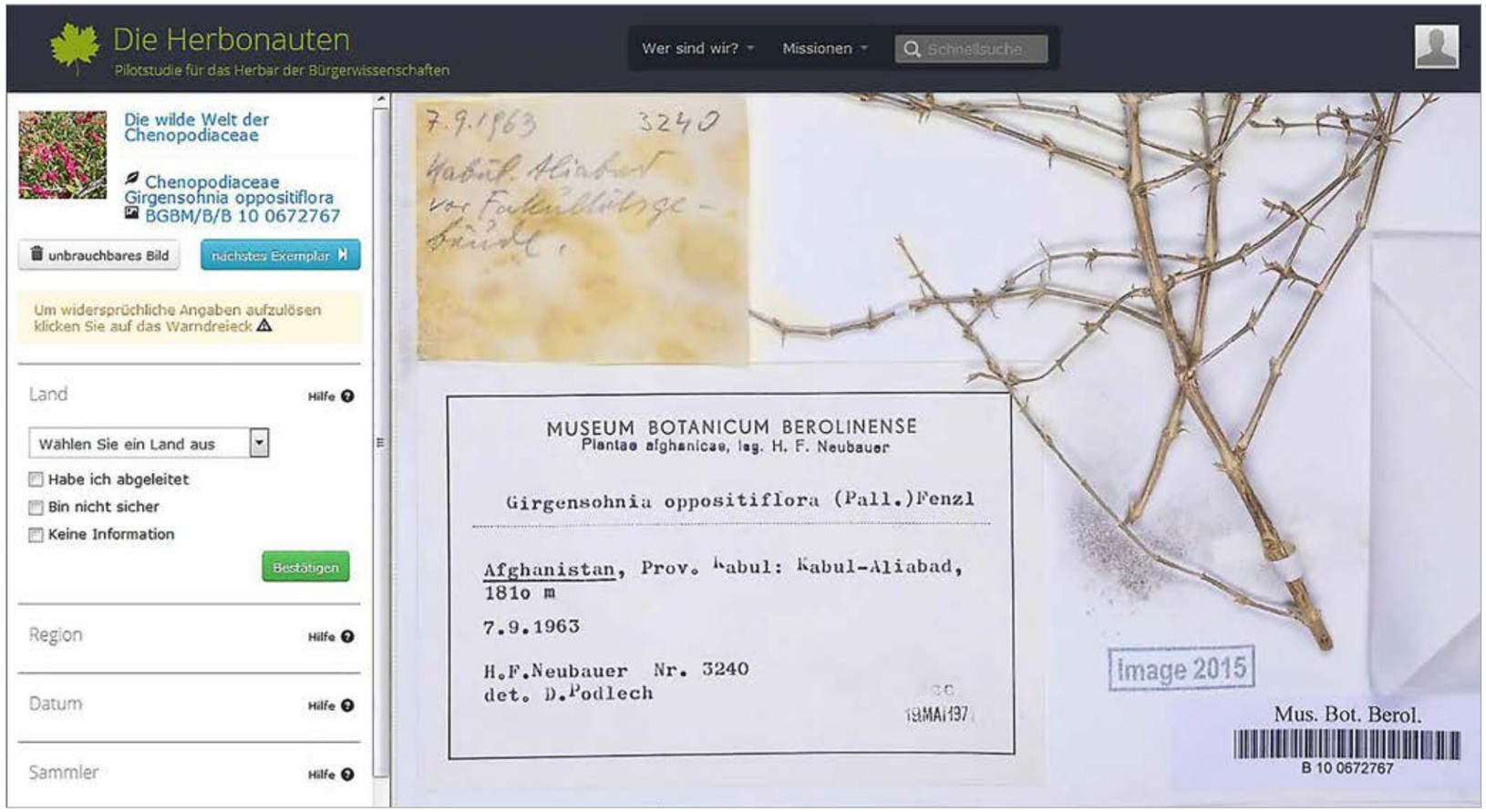
However, beyond project funding and funding as a pure communication measure, Citizen Science funding instruments are still the exception and grant recipients are predominantly scientific institutions. Moreover, the range of funding for Citizen Science projects outside traditionally strong natural history research is still quite limited.

The CS Survey 2020 pointed out that only a subset of Citizen Science projects receive research funding and many initiatives do not receive funding. This great diversity is a characteristic feature of the Citizen Science landscape.

2.2 What are the requirements, opportunities and challenges?

The results of the CS Survey 2020 generally show a high level of expectation from the Citizen Science community towards research funding organisations for **more funding opportunities in the field of Citizen Science:** Almost 70% (n = 287) state that the opening of existing funding programmes to Citizen Science projects has increased. However overall, only around 4% believe that sufficient instruments are currently available to fund Citizen Science projects. The discrepancy between demand and funding quota is evident, for example, in the BMBF call for proposals in 2019. According to the BMBF, around 450 project outlines were submitted during the first stage of the process. From this amount, only 15 projects received a funding recommendation [48]. This corresponds to a funding rate of less than 5%, which is significantly below the funding average of other funding guidelines. However, this was an open call for proposals with no restrictions regarding subject or discipline. Action must be taken particularly in the following subareas:

- Notably, 19 of the 78 coordinators (n = 78) do not currently receive project funding for **coordination services.**
- In addition to expanding project-related funding, **structural measures** should be implemented to **build capacity** over the long term (e.g. by funding permanent positions for coordination, education and continuing education, training, communication, volunteer management, counselling).
- **Low-threshold funding offers** such as "seed money" projects play an important role. The results of the CS Survey 2020 show that the majority of funding volumes for Citizen Science projects are in the five-digit range according to the funders. And according to the results of the survey, the median is just under €200,000. In exceptional cases, Citizen Science projects are also funded with six-figure amounts. Only a very small proportion of respondents (< 6 %) state that there are sufficient opportunities for such low-threshold funding (**microfinancing**). Such offers enable **start-up and supplementary funding**, which can close funding gaps in the context of the specific research process of Citizen Science projects (keyword: co-design, co-production). These are often accompanied by extended project phases [11]. This includes such things are measures and activities to recruit and train citizen researchers or measures to communicate the results in a way that is appropriate for the target group. Examples of this are various contributions in kind for event organisers, websites and the use of social media, information brochures and handouts for training, flyers and various equipment.
- Project-related funding should also extend to the area of **evaluation, accompanying research and research on the impact of Citizen Science** on the various stakeholder groups (→ action area 15).



Can you name the country this specimen comes from? Then the Herbonauts is the right place for you. The Herbonauts project: deciphering herbarium labels in the Botanical Garden Berlin with citizen support. Screenshot: Herbarium record in the Herbonauts portal.

With regard to the development of **information platforms for pooling, advising and networking**, the "Bürger schaffen Wissen" project (funded by the BMBF since 2013) and various other European platforms (e.g. EU-CITIZEN.SCIENCE) have made a significant contribution to making the existing knowledge on ongoing activities and projects available. Since 2019, a long-term perspective has been created at the University of Vienna with the Österreich forscht platform. In Switzerland, a comparable approach exists with the Schweiz forscht platform (→ action area 1).

The results of the CS Survey 2020 illustrate that almost 70% (n = 273) of the respondents are not aware of any advisory services for submitting applications and only about 30% would like more advice on planning, implementing and/or evaluating their Citizen Science project. The survey also highlighted the need to promote offers, especially in the field of data management (→ action area 6) and to create additional regional counselling services (→ action area 1). When asked about the potential organisation of counselling centres, respondents predominantly wanted a support network of competent personnel from different organisations. The second most important source of advice and support was points of contact in their own organisations. 20–25% of the respondents wanted regionally or nationally organised counselling centres or networks. This highlights the character of diversity and distributed knowledge in different organisations and the desire for strong local or intra-organisational consultation as well as expert contacts in different organisations. Geographical proximity and strengthening networks of different organisations seem to play significant roles.

The AgriSens project in cooperation with farmers – here the use of the FieldMApp software in the field. Photo: Christian Thiel

With regard to project funding by the federal government (especially the BMBF), the **administrative and funding-related challenges** for applicants (in the case of the BMBF three-stage call for proposals in 2019) are cited as barriers, especially among citizen researchers and NGOs. The complicated award guidelines and the electronic application portals as well as the extensive project management sometimes pose greater challenges for the funding recipients. Finally, the **long review phase** (sometimes more than a year) makes the funding format less attractive, especially for participants who do not receive institutional funding but finance themselves primarily through third-party funds, donations or membership fees.

2.3 Recommended actions for area funding instruments

2.1
Funding institutions and other stakeholders should expand specific **funding instruments for projects** and further open up existing funding programmes to Citizen Science as a research and communication method. In addition to international and national funding, the federal states and municipalities should also feel involved. The amount of **low-threshold funding (microfinancing)** should be expanded. Funding for **accompanying research and research on the impact of Citizen Science** should be supported (e.g. as part of project funding). In addition to expanding project-related funding, **structural measures** (e.g. new staff positions) should be implemented to **build long-term capacity**.

2.2
Funders and participants should support the **expansion of advisory services** for different target groups at the national and regional level.

2.3
Funders should remove administrative and technical barriers to funding so that in particular civil society groups can participate more easily in funding programmes. **Long evaluation phases** should be avoided and **flexible offers** should be created.

2.4
Business, administration and educational institutions (e.g. continuing education centres) should also exploit opportunities to specifically promote Citizen Science projects.

2.5
Scientific institutions, organisations, administrations, educational institutions, associations and professional societies should support Citizen Science **coordinators and communicators** through third-party funding or permanent positions.

2.6
Create "**tech pools**" for citizen scientists: Citizen Science projects often require a basic supply of relevant literature and technical equipment, especially in natural history, archaeology and astronomy. One example is the recording programmes of the Dachverband Deutscher Avifaunisten (Federation of German Avifaunists, DDA) for breeding birds and waterbirds or the reporting of chance observations on the reporting portal ornitho.de. A prerequisite for taking part is – in addition to specialist knowledge – a whole range of identification literature and optical equipment (binoculars, spotting scope with quiver and tripod, sometimes tablets or smartphones for digital recording, etc.). The cost of procuring all this is very high for volunteers (depending on the brand, between 500 to over 1500 euros) and is an obstacle not only for young people who are interested in joining in. Therefore, it would help significantly if the project funding would also cover the price of purchasing the necessary basic equipment, e.g. rental equipment. Borrowing could be organised through the coordinators or through libraries over the long term (for specialist literature) and continuing education centres (→ action area 13).

2.7
Participants from civil society should be given greater consideration when selecting members for various selection committees and selection processes for Citizen Science funding. They bring an important perspective to the selection and review processes for Citizen Science projects (e.g. relevance, degree of feasibility, applicability, innovative potential). In addition to selection committees, this could be extended to awarding prizes, implementing strategy processes and evaluations.

Addressees

Practitioners · Civil society · Science · Educational organisations · Policymakers · Funding bodies

Alexander Bonde
Secretary-General of the German Federal Environmental Foundation – DBU

Photo: DBU

"Citizen Science is a particularly effective format because it facilitates concrete collaboration between science and society. The goal: evidence-based solutions for key challenges of sustainable development. For the German Federal Environmental Foundation (DBU), Citizen Science is a particular interesting method because it can play a role in a variety of our applied funding topics."

Mission statement 3:

In 2030, Citizen Science projects will be characterised by professional volunteer management.

Participants from all areas of society will be enabled to participate successfully and sustainably. Thus personnel resources and finances will be made available for the projects, along with connections to established volunteer structures. Local and regional stakeholders, associations and foundations in the field of volunteer management as well as local and regional media will work together specifically in volunteer recruitment and management. Together, they will carry out as needed and targeted training and continued education in Citizen Science projects.

3 Citizen Science – volunteer management

3.1 Situation analysis: Where do we stand since the Green Paper?

According to the Enquete Commission, the central characteristics of civic involvement are *voluntary action, an orientation towards the common good and acting in the public sphere*. According to the fourth German Survey on Volunteering by the Federal Government [49], an important motive for citizens to volunteer is *to shape society on a small scale*.

In the context of Citizen Science, the aspect of involvement as a learning opportunity is particularly relevant. Interest in certain topics or research areas motivates volunteers to acquire expert knowledge. In addition to planning, organising and coordinating Citizen Science projects, volunteer management also includes the training and continued education of volunteers [1].

Citizens often commit to a Citizen Science research project for a certain period of time. The commitment is characterised by the specific project commitment and the recruitment based on the topic. The collaboration between scientists and volunteers strives for a high level of self-efficacy and active participation in different phases of the research process.

Since the publication of the 2016 Citizen Science green paper, policymakers have become increasingly interested in the involvement of civil society in scientific processes, especially in the field of environmental protection [50]. Furthermore, the range of educational and continuing education opportunities for both coordinators and researchers in volunteer management has expanded (→ Box 5, → action area 4 on scientific communication). Training and advanced training for volunteers on different aspects of participating in Citizen Science projects have been established and differentiated according to subject (e.g. wildlife monitoring, water monitoring, butterfly monitoring, → Box 5).

The CS Survey 2020 shows that the green paper courses of action in Citizen Science volunteer management have been partially implemented since 2016, but that there are also still many requirements and action gaps. Many experienced Citizen Science practitioners are able to successfully cope with the complex demands of everyday project work by combining knowledge and skills and to generate approaches to solutions for situational problems.

For almost half (approx. 45%) of the respondents, personal exchange with external and internal colleagues with Citizen Science experience is an essential factor for building this Citizen Science competence (n = 339). Building competence in the domain of Citizen Science is also promoted through exchange in workshops and conferences and through local and regional platforms and networks. However, only less than 10% of respondents mention structured workshops & training

as an important aspect of their Citizen Science training and education (→ action area 1). Overall, only one third of the respondents (35 %) would like more advice on planning, implementing and evaluating their Citizen Science projects (n = 324). Of those who would like more advice, two-thirds of the respondents (69 %, n = 87) mention volunteer management as advisory or event content – in addition to advice on data management.

The majority of the volunteers that participated in the CS Survey 2020 were male, on average over 50 years old and mostly from an academic background (48% university degree, 21% PhD). Other studies also show that the diversity of volunteers in environment-related Citizen Science projects is not yet balanced in terms of age, gender and level of education [51, 52]. Accordingly, the surveyed Citizen Science community would like to see a significant increase in volunteer diversity. Only 18% of the respondents agree that current Citizen Science activities are already succeeding in getting people from different backgrounds to participate in research.

The volunteers rate the impact of their Citizen Science activities on their personal development very positively (→ Fig. 7, → action area 9): Most notably, the aspects of collective and individual effectiveness through Citizen Science are frequently mentioned ("I feel I can make a difference as a group or individually", 91% and 83% of respondents respectively), the acquisition of knowledge about the project content (92%) and the motivation for long-term commitment to the project (82%) (n = 113). Also, 81% of the volunteers state that they feel "part of a Citizen Science community" and 73% express that their contributions to the Citizen Science projects gain recognition (n = 113).

The perspective of the surveyed Citizen Science project coordinators clearly points to challenges and gaps in volunteer management. In the projects represented in the survey, little data is collected on the socio-demographic background of the volunteers. About 60% of the n = 79 coordinators stated that they do not collect any data at all on volunteers. This can be attributed to a lack of human resources for systematic project evaluation, but also to a lack of awareness of the importance of project evaluation in Citizen Science projects. Thus, there is a lack of knowledge about the motivation, needs and education level of the volunteers. However, this data is an important foundation for project design, application and communication tailored to target groups (→ action area 4) as well as for targeted implementation of educational interventions (→ action areas 8, 9) and recognition mechanisms (→ action area 5). Systematic evaluation of Citizen Science projects (→ action area 15 accompanying research), including volunteer management, still needs improvement (n = 79). Only about 36% of the projects surveyed are systematically evaluated internally (i.e. with the help of standardised questionnaires or structured interviews), and about 23% are systematically evaluated by external experts (→ action area 15). 29% of the surveyed Citizen Science coordinators (n = 79) state that their project is not evaluated at all.

Citizen researchers ecologically monitoring small watercourses and streams. Photo: FLOW/BUND/UFZ

BOX 5 – Guidelines and points of contact for volunteer management

The examples given are only a selection

- „What does volunteer management mean?" (from Stiftung Mitarbeit): **www.buergergesellschaft.de/praxishilfen/kampagnen-und-aktionen/engagement-in-aktion/wie-funktioniert-freiwilligenkoordination-und-management/was-bedeutet-freiwilligenmanagement**
- Reifenhäuser, O. & Reifenhäuser, C. (2013). *Praxishandbuch Freiwilligenmanagement* (Practical Handbook on Volunteer Management). Beltz
- Training course on strategic volunteer management: **www.ehrenamt.de/1599_Ausbildungsgang_Strategisches_Freiwilligenmanagement_2021_S1.htm#**
- Training course on volunteer management: **www.fes.de/akademie-management-und-politik/ausbildungsgaenge/freiwilligen-management**
- Federal Association of Volunteer Agencies with "Agency Atlas": **www.bagfa.de/english**
- Overview of continuing education institutions throughout Germany: **https://dgwf.net/mitglieder-107.html**
- English review on volunteer management: West, S. & Pateman, R. (2016). *Recruiting and retaining participants in Citizen Science: What can be learned from the volunteering literature?* **DOI: 10.5334/cstp.8**
- Examples of volunteer training:
  - Wildlife monitoring: **www.wald.sachsen.de/saechsisches-wildmonitoring-4513.html**
  - Water monitoring: **www.idiv.de/de/web/flow.html**
  - Specialist seminars on knowledge of species from state academies or e.g. **https://foertax.de/** and **www.artenkenntnis.de**
  - Butterfly monitoring: **www.ufz.de/tagfalter-monitoring** and **www.vielfaltergarten.de**

3.2 What are the requirements, opportunities and challenges?

Successful volunteer management is characterised by approaches tailored to specific target groups of citizens and based on their needs, attractive training opportunities that promote better understanding of scientific working methods and lead to the collection of high-quality data, in addition to relevant expertise. Continuous peer exchange and regular feedback on research activities and project progress motivate volunteers to commit to the project over the long term. Such volunteer management is socially transformative by mobilising interested people from different social strata and thus enabling broad social participation in science and decision-making processes. Many of these potentials in volunteer recruitment and volunteer training and education have not yet been exhausted.

What do we still need?

The basic prerequisites for successful volunteer management are the qualifications and time resources of the Citizen Science project coordinators and staff. Project coordinators are responsible for many other

tasks besides volunteer management. They are usually mainly responsible for project conception and development and mediate between the goals and demands of science and social conditions and requirements. They often organise (in cooperation with institutes and associations) the project application and public relations work as well as volunteer recruitment and support and are therefore the point of contact for volunteers, researchers, media, authorities and other stakeholders. Therefore, project coordinators should be supported in their work by establishing and promoting training formats for personal exchange with experienced colleagues and Citizen Science projects that have already been established (e.g. in-person workshops/mentoring, network exchange). This can generate unity and permit more resources to be invested in volunteer management, which typically takes up a lot of time, especially in the start-up phase and during the Citizen Science promotion periods (e.g. "field season"). In order to ensure that volunteers can be contacted on a continuous basis and to build a sustainable relationship of trust with volunteers and other stakeholders, volunteer coordinators in Citizen Science projects should be employed on a long-term basis and should receive adequately pay.

In the CS project MikroSafari, pupils carry out the Ant Picnic experiment: ants are attracted with bait on small cardboard discs, observed and captured in order to understand which ant communities exist and how ants search for food under different environmental conditions. Photo: MikroSafari/UFZ/iDiv

In order to strengthen the evaluation and thus systematically improve volunteer management, structured, indicator-based guidelines or frameworks for internal evaluation should be increasingly distributed to Citizen Science coordinators. The identification of Citizen Science experts could be facilitated by a "forum for external project evaluation", which would establish contacts for evaluators.

Successful Citizen Science projects show that recruiting new volunteers can be achieved by developing specific target group concepts, appropriate communication channels and "messages" for the respective project as well as by identifying key multipliers.

In order to diversify the traditional target groups for Citizen Science projects, it is important to broaden the spectrum of cooperation partners in Citizen Science projects and to involve socially established infrastructural institutions for engagement and participation. Examples of these include local associations and nature conservation groups, science shops and regional or national associations or NGOs, foundations, continuing education centres and volunteer agencies. Their main task is to advise people who want to get involved and then to refer them to suitable agencies. Voluntary agencies also support voluntary work by offering a wide range of training courses for citizens and project organisers (e.g. on "volunteer management"). In academia, institutions for continuing education can provide contacts for older individuals with a strong interest in education and meaningful voluntary involvement. In order to attract people from non-academic backgrounds, professionals or senior citizens to participate in Citizen Science projects, it is necessary to cooperate with competent, networked local institutions (e.g. neighbourhood shops, multi-generation houses, senior citizen centres, senior citizen study institutions).

The advantages and opportunities of participating in Citizen Science projects must be clearly communicated to potential target groups. Structural barriers to Citizen Science involvement, such as long working hours or lack of time due to childcare, could be reduced through incentives such as paid time off from work, expense allowances or integrating child-friendly offerings in Citizen Science projects.

In order to enable stable and continuous project implementation, volunteers who are temporarily active in the project should collaborate with volunteers who are committed on a long-term basis (e.g. through mentoring to transfer expertise, → recommended actions for the continuation of projects in action area 2 "funding instruments"). The responsible Citizen Science project promoters (science institutions and associations) need financial resources to implement innovative formats to engage volunteers in projects.

Both Citizen Science funding institutions and citizens want close cooperation between researchers and volunteers in the form of co-creative projects. Appropriate approaches for this are joint development of questions, Citizen Science agenda setting and the assessment of project applications (funding). Project goals, methods and implementation can better correspond to the concerns and motivations of the volunteers if citizens are actively involved in project planning and structuring from the beginning. Volunteers thus engage intensively with the scientific knowledge process and identify more strongly with "their" project over the long term.

Where are there new opportunities?

The possibilities presented by online volunteering are becoming more and more popular and, due to its flexible offers in terms of time and location (micro-volunteering), it is attractive for many participants, especially during the COVID-19 pandemic.

Online platforms and workshops provide diverse access to Citizen Science projects and training opportunities (see the webinars on various projects). Some projects offer networking platforms for volunteers, which are widely used for exchange and mutual support. Many volunteer agencies use online databases to inform citizens about opportunities for local involvement. Establishing interfaces with central volunteer agency databases is an example of how to increase exposure for engaged citizens in the Citizen Science landscape.

Creative solutions, such as project apps with playful offers (gamification) for volunteers, can make valuable contributions to the continued training or motivation of volunteers as well as to project evaluation. For example, increased knowledge among volunteers can be tested in a digital quiz format. Timely individual feedback to volunteers on their research activities (e.g. via digital data collection tools or project apps) has been shown to contribute to knowledge and skill acquisition [53, 54]). Citizen Science projects can also draw experience from applications of the citizens' councils model (outcome of the BBE Network Meeting 2020, [55]).

The corporate volunteering movement, in which companies organise and/or support their employees performing voluntary work, should be taken into account in order to motivate middle-aged individuals who spend a great deal of time in their professional lives to participate in Citizen Science projects. Competent intermediary structures already exist for this purpose at voluntary agencies and other institutions.

Training and continuing education for students and scientists in Citizen Science and volunteer management are not yet available (apart from exceptions such as the "Citizen Science" associate chair at FSU Jena). However, this is a very attractive option for study modules in the realms of teaching and scientific journalism, environmental education and sustainability management (→ action area 8).

As part of the Love & Kisses – Digital Letters CS project, love letters from and to citizens are collected, researched and archived in order to preserve this disappearing everyday culture for posterity. Photo: CC-BY-SA Stephanie Werner

Also, some voluntary agencies have already established cooperation with universities regarding service learning.

What are the barriers?

In many Citizen Science projects, the following factors have a limiting effect on the implementation and success of volunteer management.

1) Lack of capacity and inadequate training for project coordinators in volunteer management (→ Chapter 2 Funding instruments and the BBE's demand for full-time positions in civil society infrastructure institutions).
2) Lack of structured project evaluation to improve and advance volunteer management based on evidence and geared towards its target groups (or educational materials and communication channels/ products, → action areas 4, 9).
3) Limited networking of Citizen Science projects with established volunteer management institutions.
4) Lack of co-creative offers and institutionalised opportunities for citizens to have a say in funding decisions (result of the BBE network conference).
5) Lack of outreach among potentially interested volunteers due to one-sided advertising of projects and one-track volunteer recruitment.

3.3 Recommended actions for area volunteer management

3.1
Citizen Science networks, associations and experienced project coordinators should design and implement **specialised training courses and structured networking opportunities** for project coordinators on the topic of volunteer management. Cooperation with established civil society institutions of engagement management is a good way to do this: National Network for Civil Society (BBE), Federal Association of Volunteer Agencies (BAGFA), community foundations (CFs).
Citizen Science funding formats should include the training and continued education of project coordinators. Existing training materials should thus be revised, translated, made accessible and better distributed and promoted, ideally through collaboration with voluntary agencies. In-person training formats should be used more often. Tutorials and instructional videos can also buffer project coordinators from many questions and thus spare their limited time capacities.

3.2
Project coordinators and educational organisations should expand and advance **training, coaching and mentoring opportunities for volunteers** that are tailored to their **needs and target groups**, and plan **"train the trainer" multiplier workshops from the beginning of project development to pass on expertise** from experienced volunteers and coordinators as well as from established Citizen Science projects. Collaboration with established stakeholders such as socio-cultural centres, WiLAs and BBE/volunteer agencies is recommended to achieve this. A platform with training materials (e.g. standardised courses to acquire knowledge of species) and workshops for coordinators and researchers could be created. Funding applications should already include resources for personal exchange between Citizen Science experts and newcomers, or for one-to-one mentoring or shadowing in another Citizen Science project.

3.3
Project coordinators should **increase the diversity of participants and Citizen Science project initiators** in order to take the Citizen Science approach beyond academic circles into mainstream society. This can be done through targeted cooperation with associations and voluntary agencies, neighbourhood shops, senior citizen offices and continuing education institutions, through project communication geared towards certain target groups, best practice examples or champions.

3.4
Funding agencies and academia should design and implement internal and external tools to **systematically evaluate volunteer management** (e.g. through volunteer satisfaction surveys) in Citizen Science projects. This should be a prerequisite and part of funding mechanisms. A systematic evaluation of Citizen Science projects in terms of how, what, when, why and who is reached and motivated is a starting point on the way to integrating Citizen Science into mainstream society.

Addressees
Practitioners · Civil society · Science · Educational organisations · Policymakers · Funding bodies

Christiane Grefe
Journalist for *Die Zeit*, book author

Photo: Die ZEIT

"I support the Citizen Science Strategy 2030 for Germany because – as we have seen, for example, with the Krefeld insect study – citizens that actively engage in research bring additional, and also critical perspectives to scientific and political debates, thereby broadening tunnel vision (including their own), bringing communities together and, last but not least: because it can all be fun."

4 Synergies with science communication

4.1 Situation analysis: Where do we stand since the Green Paper?

The 2016 Green Paper already identified the first key development areas with regard to potential synergies between science communication and Citizen Science. In this context, the need to focus on building capacity and developing skills was particularly noted. We thus broke down courses of action referring to creating clear structures and responsibilities in project communication, conceptualising guidelines, expanding qualifications, supporting communication departments and media, and increasing the use of digital and traditional media.

Including Citizen Science in the repertoire of science communication goes hand in hand with the generally increased attention and importance attributed to it at the present moment [28]. Science communication informs, educates and raises awareness of scientific issues. It takes on a mediating role between science and the public and creates spaces to initiate and maintain a dialogue about questions, findings and methods of research. The development of science communication from the deficit model (more information = better understanding) to communicative and participatory formats runs almost parallel in time to the Citizen Science scene, which is growing primarily through digitisation[KB1]. Genuine participation and collaboration in research processes can fulfil many overarching goals of science communication, such as understanding methods and processes according to theory. This is why Citizen Science and other participatory formats are increasingly taking on an important role in the discourse of science communication (→ Strategy process #FactoryWisskomm on the future of science communication, organised by BMBF 2021 [56]). In practice however, communication still often needs to be professionalised. This is often assigned as an additional task to project coordination.

Based on current data from the CS Survey 2020, it can be seen that some of the courses of action addressed in the Green Paper have already been implemented in practice. However, improvements and specific proposals still need to be made in other areas. Many guides and manuals pertaining to science communication [57, 58] and Citizen Science [7, 59, 60] have been written in English as resources on individual topics or tools. However, a synthesising discussion on the connection between science communication and Citizen Science still needs to be strengthened.

The data from the CS Survey 2020 indicate a need for such definite and structured guidelines. This is because only less than half (43%) of the respondents state that they have a definite strategy for science communication for Citizen Science projects. Similarly, more training and guides for science communication are needed in Citizen Science projects. According to this survey, only 37% of the respondents have attended a workshop on "Citizen Science and science communication", while 68% of the respondents confirmed a need for such advisory support structures as well as workshops (→ CS Survey 2020).

Mission statement 4:

In 2030, strategic and evidence-based scientific communication will be an integral and fundamental part of Citizen Science projects to enable a dialogue between society and science.

A position paper on Citizen Science values and guidelines involving different stakeholders (e.g. practitioners, civil society and science) can strengthen the implementation of science communication. Established interfaces in scientific communication at the institutions, additional project funding and continued education support Citizen Science assets in achieving the desired communication and impact goals.

4.2 Citizen Science in the discourse of science communication

Citizen Science combines central criteria and goals of good practice in science communication [57, 28]. Communication in active cooperation on specific and socially relevant issues not only focuses on the results of research, but above all makes methods and processes comprehensible and new knowledge emerges through exchange. The connection between Citizen Science and science communication is accompanied by high expectations in the discourse. These relate primarily to promote scientific literacy – this means the acquisition of various competencies that support the classification and reflection of scientific findings, such as factual competence, learning competence, ethical and moral competence – as well as the social relevance of the topics addressed [61, 62]. At the institutional level, Citizen Science is often rooted in concepts such as transfer or the Third Mission of universities, which stand for promoting not only research and teaching (first and second mission) but also exchange with the region and transfer to society through science communication. In this context, Citizen Science can contribute most decisively to more participatory and inclusive science and science communication. However, Citizen Science must remain first and foremost a research approach (i.e. not used purely as a public relations tool). Citizen Science can thus have a democratising effect resulting in greater transparency, better accessibility and more participation, and establish a new culture of collaboration.

4.3 What are the requirements, opportunities and challenges?

Successful communication invites people to participate in research and motivates them to continue. It also informs about project goals, methods and processes. It opens up spaces for discussion, feedback, incentive and exchange, and shares project results and findings. Formats, channels and specific content are derived from the direction and purpose of communication and exchange (additional references to the topic of exchange and networking → action area 1). This requires strategic planning of communication and, depending on the format, also requires competences and capacities to be able to fill the roles that arise: as moderator, tutor, networker, facilitator, etc. Many projects also aim to raise the awareness of individuals and society as a whole on issues and processes to spark changes such as changes in behaviour, for example.

With the idea-mining format of the AFO of the WWU, citizens in Burgsteinfurt develop concepts for the use of former Jewish buildings. Photo: WWU Münster/Bauhus

In this context, the still relatively emerging fields of the science of science communication and the science of Citizen Science play a special role. In each field, evidence-based knowledge is created and theoretical classification of and critical reflection on the subject area are implemented. The focus is on what impacts the science communication or Citizen Science formats

have on which dimension and with which instruments (→ action area 15). Stronger dovetailing of the research fields and transferring them into the respective communication practice is therefore expedient. This perspective is still not embraced enough when evaluating science communication in Citizen Science projects. For example, only one third of the respondents state that the dialogue between citizens, researchers and decision-makers is systematically evaluated (→ CS Survey 2020).

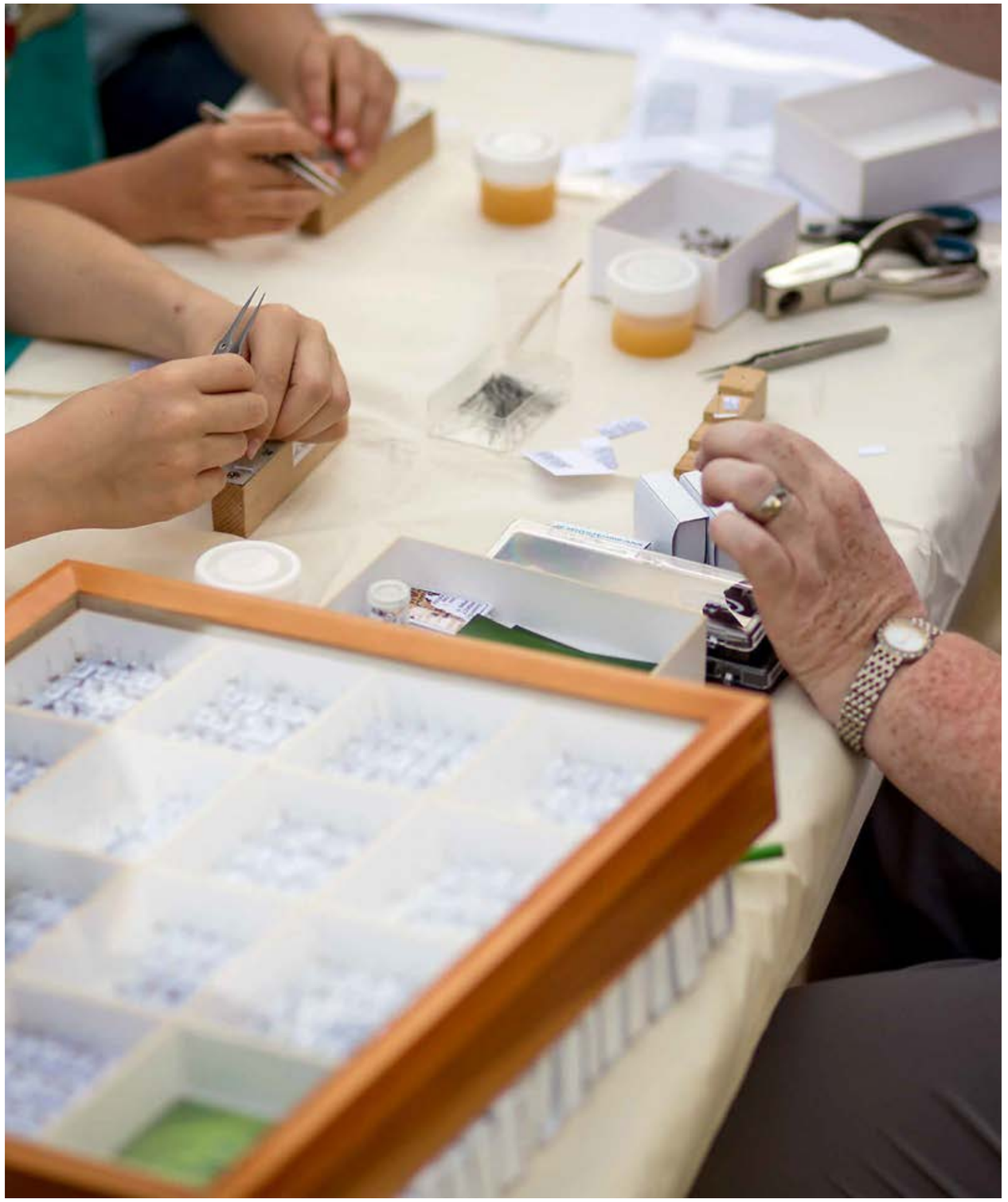
Since the project landscape in Citizen Science is very diverse in terms of the type and duration of projects, topics, disciplines and levels/types of participation, a general recommendation for successful communication strategies does not seem to make sense. However, the following points are helpful as a starting point for fundamental discussions and to develop corresponding positions:

1. First, it is advisable to define values to provide guidance and to play a part in or accompany communication. For example, transparency, openness, flexibility in the process and recognition have proven to be helpful and fundamentally important. This can draw from the knowledge, experience and resources in the areas of participation or citizen participation as well as from participatory research projects [15, 63].

2. Building on a discussion of values, it is crucial to develop a guideline for science communication in Citizen Science projects that brings together these findings of the discussion of values and, above all, also breaks down the different levels of communication and the respective goals. The Framework on Citizen Science Interaction and Communication [64] could be used as a basis for this, supplemented by tangible advice on possible formats, tools and methods of implementation.

3. For this, it is necessary to incorporate communication in the projects through people, structures and competences as well as collaboration with corresponding partners. It is only in this way that the achievements of Citizen Science projects can be made visible and receive recognition and a stable communication culture can be established (→ action area 5 “Recognition culture”).

4. All of these requirements also need the implementation of continuous training and exchange opportunities so that the people involved can exchange information on the research status and best practices. Project coordinators should have meta-competencies, e.g. in the basics of strategic communication or participation. They should be in a position to acquire any lacking expertise, such as web design, writing skills or press relations, by involving third parties (→ action area 3).



Sharp instincts are needed here – identifying mosquitoes for the mosquito atlas at the Citizen Science Festival in the Park at Gleisdreieck 2016. Photo: Karo Krämer/ Science in Dialogue

4.4 Recommended actions

The paths taken in the Green Paper to utilise synergies between science communication and Citizen Science as well as the proposals explained in this white paper are to be implemented in practice by 2030 if possible. To do so, existing structures must be strengthened and expanded and new forms must be developed (see the following list). The ultimate goal is to integrate these proposals into the processes in science, politics and practical application. The implementation proposals are presented in the following and specified by assigning the measures to target groups and describing the specific timelines.

4.4 Recommended actions for area synergies with science communication

4.1
Science communication should be included as an elementary and mandatory component in Citizen Science project proposals, taking into account the necessary competence and human resources.
Involvement of the project participants in training/education measures should be made possible.
Formulation, implementation and review of specific communication and impact objectives (self-evaluation and accompanying research) should be ensured, taking into account the current state of research and the guideline still to be developed (→ action area 15 “Accompanying research”).

4.2
Financial resources and structures are needed to expand and promote exchange between project participants and training opportunities for project participants. The same applies to transferring findings from the research field into practice, which should be strengthened.
There should be a substantive discussion on which values are essential for science communication in Citizen Science projects. Building on this discussion on values, the community should strive to generate guidelines and produce guides for science communication in Citizen Science projects.

4.3
University and programme leaders should embrace society’s shift towards greater focus on science and enable the opportunity for change towards greater participation of the community in science.
Students, graduate students and young scientists should already be familiarised with the potential of Citizen Science and be able to establish the link to science communication. Science communication seminars should be included when training young academics.

4.4
As a central element in Citizen Science projects, science communication should be appropriately equipped with material and human resources.
The existing offers for relevant qualifications should be expanded. To do so, the persons that are responsible for projects must be able to include the budget and time for training when applying for Citizen Science projects.
The funding organisations should be correspondingly open and flexible in their design; criteria catalogues and calls for proposals should be designed accordingly.

4.5
Institutions should create structures (qualified permanent points of contact) for networking communication from individual projects with institutional communication, focusing on methods and processes as well as openness for exchange with civil society.
Existing structures (press office, transfer officers, etc.) should offer more support for Citizen Science project initiators. If necessary, additional competencies should be strengthened for this purpose.

Addressees

Practitioners | Civil society | Science | Educational organisations | Policymakers | Funding bodies

Jana Holz
Board member and spokesperson netzwerk n

Photo: Alexa Gothe

“We support the Citizen Science Strategy 2030 for Germany because science does not belong in the ivory tower! A sustainable and good life for all needs many voices and a joint outlook made up of research, transformation and a willingness to change – that's why Citizen Science offers just an excellent approach.”

5 Recognition culture within and for Citizen Science

5.1 Situation analysis: Where do we stand since the Green Paper?

Participants in Citizen Science attach great importance to receiving recognition. Recognition is understood as an attitude towards an achievement that expresses appreciation through gestures and actions such as praise. Recognition also often motivates people to initiate and/or participate in a project, and is an important factor confirming the successful progress of a given Citizen Science project. In 2020, it was clear that those successfully practicing recognition within and for Citizen Science were offset by deficits at the political and formal levels (→ action area 8).

Recognition within and for Citizen Science projects is often already used on individual and community levels (→ Box 6). For example, activities in research as well as in communication, exchange and networking have been developed and implemented together on an equal footing (→ action area 4). Additionally, Citizen Science project results, such as the Red Lists for endangered species, are used in research and politics as a basis for decision-making. Networking and communication amongst each other and the structures and funding for Citizen Science have improved and contributed to recognitizing the Citizen Science approach (→ action area 1 and 2). Experiences of volunteer management (→ action area 3) are also used. Founding the Deutsche Stiftung für Engagement und Ehrenamt (German Foundation for Engagement and Volunteering, DSEE) in 2020 as a central nationwide contact point to promote volunteering is a clear sign of strengthening engagement in Germany.

Despite positive developments and trends in recognition for Citizen Science, (such as the Third Mission of universities, which aims to interlink science and society), a reputation system for Citizen Science is lacking in science and in recognition from politicians, e.g. through extensive funding (→ action area 2). Most citizen scientists and researchers point out inadequacies in the recognition instruments, such as naming participants in specialist publications or acknowledging projects in the media and in society (→ CS Survey 2020). Clearly, the choice of recognition instruments hardly take into account the different needs of citizen scientists and project coordinators.

5.2 What are the recognition needs within and for Citizen Science?

Strengthening existing mechanisms for recognition

The results of the CS Survey 2020 and evaluations of expert interviews show perceived appreciation for recognition instruments already applied, such as praise, network meetings, learning opportunities for citizen scientists and project coordinators, as well as an intensive feedback culture. Other such positive effects are participation in free qualification and training courses, sharing scientific use of data and information and jointly developing practical applications for project results with politicians. Small gestures of appreciation and gratitude also have a high level of acceptance. Recognition instruments already used successfully should be further strengthened and expanded.

Identifying needs of specific target groups

Choosing appropriate recognition requires identifying citizen scientists' and project coordinators' needs. For citizen scientists, these can include needing social contact or experiencing something new, exploring one's personal environment, or the desire to learn. Project coordinators must expand the scientific reputation system to implement Citizen Science activities, perhaps using a social impact indicator. Specific needs for recognition are best determined with help from the project participants. Furthermore, a distinction should be made between recognition for Citizen Science project participation and recognition for implementing Citizen Science on a formal level, as the needs of citizen scientists and project coordinators may differ. Also, recognition between participants may change during a project, requiring the instruments to be adapted. Recognition measures should then be based on the particular target group and formulated according to individual, community, political and formal requirements. The importance of recognition in Citi-

Mission statement 5:

In 2030, targeted instruments of recognition in and for Citizen Science will be applied in Citizen Science practice and evaluated with regard to their effectiveness.

The previous instruments of individual recognition such as network meetings, continued education and an established, respectful feedback culture have been extended to the professional and social spheres of those involved, e.g. by testing pension points for Citizen Science. New structures and measures have been established, such as support units for Citizen Science activities at universities, training institutions and government agencies. Additionally, a review for the effectiveness of recognition tools and the introduction of a Citizen Science seal have also been instituted. This makes recognition a quality feature of Citizen Science and thus possible on an institutional and political level. The scientific reputation system integrates Citizen Science activities as valuable contributions to research.

Identifying and herbarising aquatic plants at Haussee in Feldberg. CS project Diving for Nature Conservation. Photo: Silke Oldorff/NABU BFA Living Lakes

zen Science, using current as well as new instruments, should be scientifically investigated and supported (→ action area 15).

Determining the impact of recognition instruments
The effectiveness of recognition measures and forms established thus far should be recorded and evaluated by 2030 (→ action area 15). This requires developing indicators to measure the instruments' effectiveness. Based on the determined effectiveness of recognition instruments, we must also consider participants' motivations. Instruments must then be adapted or realigned accordingly.

Expanding infrastructure
The CS Survey 2020 currently shows high demand for citizen scientists to get involved early in research processes and to continue their involvement. This requires institutional structures (e.g. citizen universities) and human resources (e.g. Citizen Science advisors), which should be included when planning and implementing Citizen Science activities.

Strengthening visibility
To improve recognition for citizen scientists in Citizen Science projects, their participation should be recognised in reports, lectures and newsletters; contributors' names should also be mentioned in specialist publications as much as possible. The survey showed that these recognition instruments are appreciated by citizen scientists and should therefore be applied more widely. Recognition is likewise essential for Citizen Science project coordinators. This occurs by adding a social impact indicator to the scientific reputation system where Citizen Science activities are initiated, implemented and communicated by the research participants.

BOX 6 – Further information on recognition

Building on the extensive experience of recognition from the work of associations, such as the BUND and NABU environmental associations, numerous manuals and recommendations should be used for Citizen Science on the environment:

- www.bund.net/fileadmin/user_upload_bund/bundintern/KnowHow/Handbuecher/Handbuch_Freiwillige_gewinnen.pdf,
- https://sachsen.nabu.de/imperia/md/content/sachsen/150702-nabu-ehrenamt-zukunftschance-fuer-den-naturschutz.pdf.

A practical guide on recognition instruments going beyond environmental and nature conservation work is available from the Landesfreiwilligenagentur Berlin. The instruments presented here should be reviewed and applied to Citizen Science where appropriate:
https://landesfreiwilligenagentur.berlin/files/2015/10/InstrumenteAnerkennung_Katalog.pdf.

Recognition also depends on financial support. A diverse range of funding adapted to needs is presented in the policy paper "Vorschläge für die Förderung von Citizen Science in der Umweltbildung und Umweltkommunikation" (Proposals for funding Citizen Science in environmental education and environmental communication). These are pioneering methods for developing funding instruments and for recognition within and for Citizen Science (→ action area 2):
www.ufz.de/export/data/global/203484_DP_2018_2_Richteretal.pdf

5.3 Recommended actions for area recognition culture within and for CS

5.1
Citizen Science participants should **increase use of and apply** already established and successful **recognition instruments** (such as feedback culture, adapted language clear communication about the project and clear distribution of tasks) to achieve improved recognition of Citizen Science activities in society, politics and science. Resources for applying these instruments, such as time resources, must be considered accordingly in planning Citizen Science projects.

5.2
Project coordinators should define and apply **recognition tools** with citizen scientists, political stakeholders and NGOs when planning and implementing a Citizen Science project. They should **evaluate and develop tools regarding their impact when necessary**. Results of the **accompanying research** on recognition will be used to optimise Citizen Science processes.

5.3
Project coordinators or participants should make citizen scientist participation in research processes **more visible** in presentations, media reports and professional publications. Formal recognition can be implemented, for example, by introducing a **Citizen Science seal, logos, acknowledgements** or **publications** naming the data collectors.

5.4
Research institutions should establish a **social impact indicator** for research based on Citizen Science as a **reputation factor** similar to the publication indicator. The indicator should be based on existing proposals for social impact, e.g. that of the EU, which present and recognise collaborations between participants from the academic and non-academic worlds [65]. Thus, practical experience of project coordinators and participants should also be recognised for profile-building and criteria when deciding on chair positions.

5.5
Participants, research institutions and civil society should develop **guidelines and quality criteria** to be used for reference when applying recognition instruments in Citizen Science projects. Applying these tools is taught in continuing education and training courses and is designated by a **Citizen Science qualification certificate**.

5.6
University and non-university research institutions and authorities should **establish or expand formal and political structures, such as departments and strategies**, at institutional scientific and non-scientific levels for **services and advice regarding Citizen Science**. This can establish a recognition culture for Citizen Science.

5.7
Ministries, authorities, Citizen Science participants and research institutions should collaborate to create and test new recognition instruments. One could create a **"Citizen Science Day"**, for example, which might also involve **employers** within the professional environment and create **time quotas** for Citizen Science, or **introduce pension points for involvement in Citizen Science** or for researchers or policy makers involved in Citizen Science projects.

5.8
Research funding sponsors should provide permanent **financial and human resources** to implement recognition instruments and measures. This could take the form of **micro-financing for events, training and permanent staff** to implement recognition instruments. Furthermore, it is important to establish **opportunities for qualification for Citizen Science participants to establish a recognition culture**.

Addressees
Practitioners · Civil society · Science · Educational organisations · Policymakers · Funding bodies

Ansgar Klein
CEO of the Federal Network for Civic Engagement

Photo: Henrik Andree

"Citizen Science in Germany has added value for all people who take engagement seriously as a place of learning and who want to strengthen learning as well as research in shared local and regional educational landscapes of civil society."

Mission statement 6:

In 2030, reusable, flexible methods and tools will exist to collect Citizen Science data, perform quality assurance and controls and analyse, archive and publish the data.

Citizen Science data is sustainable, complies with FAIR principles and is described by generally accepted metadata standards.

6 Data quality and data management

6.1 Situation analysis: Where do we stand since the Green Paper?

Citizens contribute to scientific projects with extraordinary commitment and often enormous expertise. This contribution manifests itself particularly in the data that citizens collect during projects. Citizen Science data is therefore an especially valuable result of Citizen Science projects. Data being collected by engaged citizens offers opportunities with considerable potential, especially for science. This is clear from the CS Survey 2020. Around three-quarters of the researchers surveyed (n = 75) said that scientific data can be collected on a larger spatial and temporal scale through contributions from Citizen Science than would be possible in traditional scientific projects. About half of the researchers interviewed recognise that citizen participation saves on time and costs in data collection and analysis. About one-third of the researchers state that Citizen Science data help supplement scientific data. This is especially true when certain data cannot be collected without volunteer participation due to the scope and broad expertise required for collection. An example of this is data on the occurrence of animal and plant species essential for biodiversity research (e.g. the extensive data sets from the GBIF). Numerous scientific publications in recent years have proven the basic usability and usefulness of Citizen Science data as an additional source of data for scientific research in a wide range of disciplines, including ecology and medicine [66, 67, 68, 69, 70].

An essential prerequisite for the scientific usability of Citizen Science data is data quality. Comprehensive and transparent quality assurance and control concepts for Citizen Science data can also help to remove existing barriers and reservations regarding Citizen Science on the part of the scientific community. This is required in order to establish Citizen Science as a recognised research approach. Quality assurance and control measures are already very important in Citizen Science projects. Quality assurance measures are taken before, during and after data collection. These measures include developing guidelines on data quality, establishing standardised procedures for data collection, training and supporting participants, collecting evidence (e.g. through photos) and experts assessing the collected data. This was the finding of the CS Survey 2020. Numerous scientific papers also deal with questions of quality assurance and examine the cause-effect relationship between data quality and the quality of the scientific results derived from it [71, 72, 73, 74, 75].

6.2 What are the requirements, opportunities and challenges?

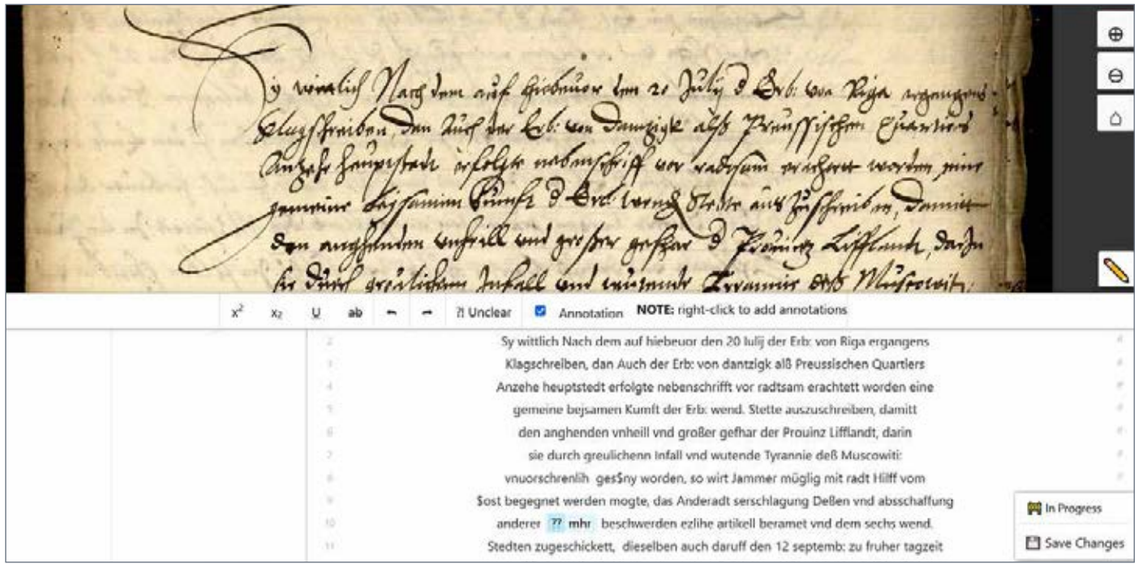
Ensuring data quality

Quality assurance and control is largely performed manually in Citizen Science projects. This requires a considerable amount of time and effort. Automatic quality assurance procedures have the potential to considerably reduce this effort (→ action area 12). This applies particularly to procedures for automatic plausibility and completeness checks right at data entry, machine learning procedures for image and text recognition, detection of conspicuous data points and statistical procedures to normalise data. However, these still need to be advanced in regards to their effectiveness and expanded into usable tools in order to be applicable in practice [76]. Less than 10% of the respondents in the CS Survey 2020 (n = 309) stated that automatic procedures are used for quality assurance in their Citizen Science project. Ultimately, both manual and automatic quality assurance procedures must be used in a complementary manner [76].

Sustainable usability of Citizen Science data

Citizen Science data should be sustainable and usable by large parts of science and society to ensure the long-term impact, visibility and acceptance of Citizen Science. The principles of findability, accessibility, interoperability and re-usability for research data formulated in the FAIR data principles [77] (**www.go-fair.org/fair-principles**) set the standard for sustainable usability. Descriptive data about the data (metadata) play an important role. They ensure that the data can later be interpreted and is interoperable. They also make the origin and process of creating the data as well as quality assurance and control measures taken transparent.

Open science ensures that scientific findings are transparent and accessible and enables them to be disseminated and developed further [78]. Citizen Science data and methods should therefore also be freely accessible and usable where justifiable from a moral, ethical and legal standpoint (→ action area 7). This goal has not yet been achieved. Only around 65% of the respondents to the CS Survey 2020 (n = 309) stated that the data collected in their projects had been published or would be published in the future. Data are mainly released on project websites (58%) and in specialist publications (44%). Data archiving is done on institute



In the Hanse.Quellen.Lesen! CS project, citizen scientists transcribe manuscripts from the Hanseatic period with the help of the Transkribus web interface. Here is an example of the web transcription of the recess of the assembly of Wendish towns from September 1575 (AHL – Hanseatica 174). Photo: Vivien Popken/Hanse.Quellen.Lesen

René Smolarski, former co-leader of the project, and Marcus Plaul, research assistant, sift through a small part of the holdings of the Research Centre for Historical Media (IFhM) at the University of Erfurt. Photo: Martin Schlobach

servers and in media that are relevant to citizen scientists. Scientific archives and repositories are hardly used. This is problematic, especially regarding data findability and sustainable access to the data. There are hardly any established publication channels for Citizen Science data [79] considering data access options for scientists, citizen scientists and the interested public.

The majority of the respondents in charge of data management in Citizen Science projects (n = 98) do not use metadata standards for the description of Citizen Science data or are completely unaware of them. This is problematic especially regarding data interoperability and re-usability, but also with regard to quality control. There have been some first initiatives to standardise and improve the interoperability of Citizen Science data, such as Working Group 5 from COST Action CA15212 Citizen Science and the Data and Metadata Working Group of the CSA, which is developing the metadata vocabulary PPSR (Public Participation in Scientific Research) Common Conceptual Model (**https://core.citizenscience.org**). There are a wide range of metadata standards specific to certain domains of research data. These standards can also be used for Citizen Science. Aspects specific to Citizen Science data and projects must be represented. This includes characterising project participants (e.g. with regard to their expertise and skills). It also pertains to the description of the data collection strategies typically used in Citizen Science projects, which in some cases differ fundamentally from those used in traditional scientific projects [80].

Citizen Science data management

Effective data management is the foundation for data sustainability and re-usability. The constant increase in data in science and research makes managing such data through all stages of the data life cycle a complex task. This poses particular challenges for scientists and citizen scientists. Data management is also becoming increasingly important in Citizen Science, although its significance has often times not yet been

reflected in calls for proposals and funding from third-party donors. This fact was also emphasised by the majority of the participants in the CS Survey 2020. The participants would also like to see suitable guidelines and tutorials as well as support in data archiving. More advice on the topics of data quality and archiving is greatly needed and less so on planning and implementing data collection. In addition to general advice from central offices, participants would like to see a strengthened exchange network with data science experts. Implementation measures should, where possible, build on existing structures and guidelines for research data management.

Respondents to the Citizen Science survey also expressed a need for freely available and user-friendly data collection tools. Research is currently being conducted on identifying important basic principles to develop such tools [81] as well as on developing basic methods for data collection by laypeople. Important points for these tools are user-friendliness and re-usability, so as to enable scientific laypeople to collect high-quality data and motivate them to participate [81]. It is crucial that methodological developments can be used directly in Citizen Science projects later on. This is generally not yet the case. Freely available tools can often only be used with the help of IT experts [82], commercial software is an alternative, but represents a major cost factor in Citizen Science projects and also prevents the advancement of tools by the Citizen Science community.

Citizen scientists are provided with the appropriate equipment for data collection, as here in the Berlin NO2 Atlas project – but often their own smartphone is enough. Photo: Ralf Rebmann/Science in dialogue

6.3 Recommended actions for area data quality and data management

6.1
Scientists and participants should work specifically on **advancing automatic methods and tools for quality assurance and control. Funding must be made available** for the necessary methodological research, implementation of the tools, maintenance and user support.

6.2
Funding institutions should **promote the sustainability of project results, including the data collected**. At the same time, it should be **mandatory to publish data generated in Citizen Science projects, as per the FAIR principles**.

6.3
Scientists and practitioners should create **standards for Citizen Science data documentation**. To do so, appropriate metadata standards for Citizen Science data must be developed. These should build on existing metadata standards for scientific data, such as domain-specific standards, and extend them to include aspects specific to Citizen Science if necessary. Scientists and practitioners should also develop guidelines and tools facilitating the selection of suitable metadata standards and the standardised description of Citizen Science data.

6.4
In order to achieve sustainable usability of Citizen Science data, sponsors, scientists and practitioners must **create structures for data archiving, data publication and access to Citizen Science data**.
This requires advancing methods, tools and guidelines to anonymise Citizen Science data with personal references as a prerequisite to publish the data. Scientific institutions should offer uniform possibilities for archiving Citizen Science data by opening existing or emerging structures (e.g. long-term scientific repositories such as the NFDIs) or by creating new structures. Access opportunities to Citizen Science data (e.g. data portals) must also be created or expanded for citizen scientists.

6.5
Scientists and practitioners should **advance methods and tools for citizen scientists to visualise and explore Citizen Science data**.

6.6
Scientists and participants should **establish effective Citizen Science data management** to ensure data quality. This can be achieved by opening established support and advisory structures for data archiving, data management and quality assurance, such as points of contact for research data management, to citizen science projects (including projects that are not linked to an institution). This can also be done by establishing and strengthening an exchange network on data-related issues in Citizen Science projects, and by creating guidelines and tutorials on data management and quality assurance for Citizen Science written in easily understandable language and suitable for the target group. Additionally, re-usable and configurable tools should be created to support the collection and provision of Citizen Science data.

6.7
Funding agencies should provide **financial resources for data management and quality assurance when funding Citizen Science projects**.

Addressees
Practitioners · Civil society · Science · Educational organisations · Policymakers · Funding bodies

Thekla Kluttig
Saxon State Archive, State Archive Leipzig

Photo: Saxon State Archive/Regine Bartholdt

"I support the Citizen Science Strategy 2030 for Germany because the infrastructure organisations of archives, libraries, museums and science shops can have an important function as interfaces to institutional science and free citizen research – if they accept the challenge!"

Mission statement 7:

In 2030, Citizen Science projects will follow clear legislative and ethical guidelines. These principles and framework legislation are, as in other disciplines, jointly agreed upon and adhered to from planning and implementing all the way to documenting Citizen Science projects.

The ethics advisory boards have included Citizen Science as a component of research and are developing guidelines for topics such as data protection and personal rights, copyright and intellectual property, and insurance issues.

7 Legislation and ethics

7.1 Situation analysis: Where do we stand since the Green Paper?

The Green Paper outlined two demands regarding law and ethics. In the case of legal conflicts, guidelines on "data openness", "intellectual property" and "data protection" should be developed for Citizen Science project initiators and participants [1, pg. 28]. With regard to ethical conflicts, ethical questions on and about Citizen Science need to be further clarified and reviewed. So far, there have been vastly different reactions to the demands, which is why we have to consider the current status of law and ethics separately.

7.1.1 Legislation

With regard to legal issues, two recommended actions from the Green Paper have already been implemented:

1) **Survey on legal conflicts, conflict identification and courses of action:** A survey was conducted in June 2020 among project leaders in the German Citizen Science community. It included questions regarding insurance protection, data protection and copyright, as well as advisory needs. The responses of the 69 participants revealed a great deal of uncertainty and very high consulting needs, especially with regard to image rights, licences and data handling in general [83]. A series of questions on legal issues was also included in the CS Survey 2020. An example of the high need for consulting are the answers about the official regulations for handling data (data management plan), which 38% answered affirmatively, 22% negatively and the majority (41%) answered with "I don't know".
2) **Developing a guideline, finalising the guideline: consultations, formulations, distribution, communication of its use:** The legal guideline was drawn up and deals intensively with the issues relevant to Citizen Science projects, namely insurance protection, data protection, personal rights and copyright [33].

7.1.2 Ethics

In contrast to the progress made on legal issues, a less positive result can be seen of the demands regarding ethics. In fact, virtually no progress can be identified. At least we see based on the CS Survey 2020 that there are also solutions for ethical conflicts when integrated into formalised rules. Thus 48% answered yes in response to the question about whether there are rules concerning intellectual property, 9% answered no and 43% said they did not know (n = 289). When asked about whether there are ethical guidelines for conflict in the project, only 6% answered yes, 41% answered no and the majority of 53% actually said they did not know (n = 287). Finally, there

were 16 responses to the open question about existing regulations to resolve ethical conflicts. The approaches mentioned in the responses can be compared to those from academia and other organisations. For example, the participants stated that they observe the following regulations in their projects, among others: Code of conduct, dispute resolution, structured measures, code according to the quality criteria from "Österreich forscht", regulations from ethics committee applications, online etiquette and association statutes.

7.2 What are the requirements, opportunities and challenges?

Firstly, the requirements, opportunities and challenges in the area of **law** are recognised as having a high need for consulting on legal issues. Furthermore, there is a great deal of uncertainty about how to deal with data (data protection), suitable licensing models (copyright) and image rights. This is demonstrated both by the survey on legal issues [83] and the CS Survey 2020. Citizen Science is also generally committed to open access, but there is a desire for concrete advice on feasibility.

The guideline [33] can show sample solutions based on the current legal situation and define the legal framework, but it cannot replace individual legal advice. Additionally, the legal situation is changing due to new court rulings and amendments to European law. This can be seen especially with copyright law, which was reformed in June 2021.

There is a great desire for exchange on these topics, which was addressed with the creation of the "Citizen Science & Recht" working group. More local workshops and advisory services represent an additional approach.

Requirements, opportunities and challenges regarding **ethics** can only be deduced from the CS Survey 2020. To do so, we have summarised the open question about experiences according to the conflicts contained therein into known ethical problems, even if they are not directly named. The questions were: "Which legal or ethical issues in Citizen Science have you already dealt with? What problems have you encountered in this area during your project so far? Please tell us about your experiences here." There were 108 responses, some of which we illustratively summarised into four challenges comprising ethical conflict:

Recording bat calls with a detector. Photo: Christof Häberle

- **Information problems:** This conflict results from the participants lacking knowledge on certain norms pertaining to joint research. This is shown in the following statements, "When do we have to file an ethics application?" or, "Is 'collection' of input from co-researchers considered data collection, meaning we need to submit an ethics application?". The same applies to the statement good "scientific practice", which may not be understood the same way by everyone. Ethical conflicts can result from lack of information about the rules followed by the joint research practice: "The researchers get the credit, not the citizens, right?". The following experience also illustrates this: "Associations and initiatives are not aware of their scientific potential and are not able to engage in a scientific work process."

- **Recognition:** A series of statements deal with the necessary recognition of non-academic project researchers. For example, the following question was expressed in the survey on law: "To what extent are participants who contribute soil samples considered 'co-inventors'?". This question asks if participants are recognised as equal researchers or if "Citizen Science is recognised within cutting-edge research". The problem of recognition also seems to be an important issue when publishing papers: "naming citizen scientists in publications". However, issues with recognition go beyond publications, as the following statement illustrates: "The question of wages or other means of recognition for volunteer service was a topic at one of our network meetings. [...] Respect for the participants is essential in all cases." The same statement can be observed in the following experience: "Citizen scientists participate in their free time. They often want both a small financial contribution for their work and, above all, professional and personal recognition for their performance and knowledge. [...] Disregarding this can lead to disgruntled volunteers and thus produce a negative impact on the project." A final point is the sustainable recognition of Citizen Science, which is an increasingly difficult problem due to its project-based organisational

form: “short-term project duration → building a community → after project end → leaving the community (ethically justifiable?)”. Even though tangible recognition should always be discussed individually in the context of the different project forms, it can be identified as a general action area.

- **Misconduct:** Probably the most dramatic area of ethical conflict is the danger of misusing Citizen Science. This refers to, for one, the voluntary nature of citizen scientists, as one of the participants identifies: “The need to reduce research costs (outsourcing data acquisition)”. The misuse of Citizen Science as low-cost alternatives to paid workers is also evident here: “‘Exploitation of participants”. However, current science policy to instrumentalise Citizen Science can also have an abusive character, as the following statement from the survey examines: “It may appear that ‘Citizen Science’ does not fulfil its original purpose of facilitating independent research. It seems that the doctrine from academic bureaucracy has spilled over into free voluntary research. This may ruin the run of research.”

- **Conventionalising new practices:** A fourth challenge is the necessary negotiation of new rules for Citizen Science, the successful establishment and subsequent professionalisation of which is urgently required. Central to this is the question of which rules to adopt and who formulates them. Ethical conflicts regarding this arise when certain groups assert themselves over others and basically hijack Citizen Science with their rules. An example of the sensitivity to this challenge is evident in the following: “The segregation of women was totally ignored because of local circumstances”. The participants also expressed a certain expectation towards this process and its possible problems: “Citizen Science and scientific integrity is an aspect that the academies and Science et Cité will probably take up”.

How high is the nitrogen dioxide concentration in my city? Visitors to the Mitforschen Festival in autumn 2020 will find out during a guided tour of the Berlin NO2 Atlas project. Photo: Ralf Rebmann/Science in dialogue

7.3 Recommended actions for area legislation and ethics

7.1
Sponsors should fund the development and operation of a legal advisory service through additional staff positions or projects to develop open training materials.

7.2
Research and educational institutions should offer local points of contact for legal consultation in the Citizen Science environment, including one-to-one consultations and workshops for interested parties. Furthermore, a national network for the exchange of legal use cases would help steadily increase knowledge.

7.3
Project participants and scientists should work together to draft standards and guidelines on what correct Citizen Science practice should look like and explain them in their environment and network (→ action area 9 “Educational concepts”, as the topics of ethics and law should also be part of further training). Editable and adaptable documents are helpful to involve the community in this.

7.4
Funding agencies should anchor Citizen Science in the “Guideline for Ensuring Good Scientific Practice” code.

7.5
The work of existing science ethics councils and committees should be expanded to include Citizen Science concerns and conflicts.

7.6
Initiators from politics, project teams and science should agree on common rules for Citizen Science projects that are accepted by all. All participants should be equally and fairly included when formulating these rules.

Addressees

Practitioners · Civil society · Science · Educational organisations · Policymakers · Funding bodies

Dirk Messner
President of the German Environment Agency

Photo: Susanne Kambor

"The environment, climate and sustainability are currently presenting us with major challenges, more than ever before. We can only find answers to these challenges with comprehensive research and broad social participation: environmental and climate protection concerns us all. Citizen Science is a very important part of this."

Mission statement 8:

In 2030, Citizen Science in all its facets will be an expression of a modern scientific process that enables social participation in research through various formats.

Citizen Science enriches scientific culture by helping to collectively identify and research social, ecological and economic challenges. The integration of Citizen Science in scientific processes is strengthened in a sustainable and structural way by explicitly incorporating research organisations' strategies and staff positions. Good scientific practice is achieved by making targeted expansions of interdisciplinary training and continued education programmes in Citizen Science an integral part of university teaching.

8 Integration into scientific processes

8.1 Situation analysis: Where do we stand since the Green Paper?

The action area "Citizen Science in scientific processes" represents a holistic view of the science system with branches leading into the topics of project funding (→ action area 2), data quality (→ action area 6) and recognition culture (→ action area 5). Citizen Science can be applied in different ways based on the phases of the research process – from formulating research questions and choosing methods, data collection design, data collection, analysis and interpretation to communicating research results. Shirk et al. [14] name the following levels of participation in a research project according to the degree of intensity of citizen interaction: "contract" (citizens commission scientists), "contribute" (participation in data collection), "collaborate" (participation in research design, data collection and analysis), "co-create" (joint work with scientists on a research problem) and "colleagues" (independent generation of new knowledge in a research field by citizens). The different forms of citizen participation along the research cycle are also confirmed in the CS Survey 2020 with 64% of the respondents (n = 79) as an added value in the visibility and social acceptance of research. Unfortunately, the contributory approach is insufficiently incorporated into the Citizen Science project landscape in numerous areas. An example of this is agricultural research; a first positive trend here is the contributory approach in monitoring the agricultural landscape [84]. The co-creative approach of citizen participation on topics relevant to society [85] is still under-represented [4]. The predominant form of citizen involvement in science is through generating comprehensive data sets (citizen observers, counters, data collectors). This is also confirmed by the CS Survey 2020: 54% of the researchers surveyed (n = 75) confirmed time savings and 58% (n = 75) confirmed cost savings when involving citizens in data collection.

It does not require considerable additional effort and working time to involve citizens in the research process. From the perspective of research, more recognition is needed from the scientific community for this commitment to increase motivation to apply Citizen Science as a methodology in science. This can be in the form of a social impact indicator as an extension of the current scientific reputation system (→ action area 5). There still needs to be an increase in the visibility of best practice approaches, as reflected in the sentiment from the CS Survey 2020 on rewarding and distributing Citizen Science activities in the areas of expertise of the participants (→ action area 5): 54% (n = 280) of the respondents state that researchers are not rewarded for their commitment to Citizen Science.

Another essential premise to successfully integrate Citizen Science activities into the research process is the acceptance of the data collected in Citizen Science projects. There is also scepticism about the

data quality from Citizen Science projects (→ action area 6). The CS Survey 2020 showed that data and results from Citizen Science projects are mainly published on project websites. Citizen Science project results thus do not go through the scientific peer review process and are also difficult to find and reuse. Earlier surveys showed that some Citizen Science projects did not even intend to produce scientific publications [86]. At this point, the Citizen Science community urgently needs to become more professional and gain scientific reputation by publishing Citizen Science research results in internationally recognised journals. The exponential increase in Citizen Science publications and Citizen Science Special Issues in renowned journals indicates a change in this (→ Box 7).

Accompanying research and evaluation research for Citizen Science projects are seen as central instruments that enable empirical findings on the impact of Citizen Science. They make the added value and potential of Citizen Science projects more tangible for the scientific community. For this reason, this topic was expanded into its own action area during the transition from the Green Paper to the White Paper (→ action area 15 "Accompanying research").

In the 2016 Green Paper, central prerequisites to apply Citizen Science in two courses for action were identified to be **further training and empowerment of scientists**. Initiatives have emerged directly in the Citizen Science communities since then, which compile training materials and measures on online platforms. The European Citizen Science Platform [87] offers an aggregated overview of worldwide training opportunities. In Germany, the German Centre for Integrative Biodiversity Research (iDiv) and the Helmholtz Centre for Environmental Research – UFZ organised a summer school, and the national Citizen Science

In the CS project FLOW, citizen scientists measure chemical water parameters, record the habitat structure of water bodies and identify aquatic invertebrates and insects. Photo: FLOW/BUND/UFZ

BOX 7 – Citizen Science in the scientific publication landscape

The examples given are only a selection. The authors are aware that there are many more examples than those listed.

Citizen Science Special Issues in Scientific Journals

- Citizen Science: Theory and Practice: an open-access, peer-reviewed Journal https://theoryandpractice.citizenscienceassociation.org
- https://journals.plos.org/plosone/browse/citizen_science
- www.mdpi.com/journal/ijgi/special_issues/Citizen_Science_Geospatial_Capacity_Building – ISPRS International Journal of Geo-Information (Special Issue „Citizen Science and Geospatial Capacity Building")
- www.mdpi.com/journal/sustainability/special_issues/citizen_sci_sus – Sustainability (Special Issue „Citizen Science and the Role in Sustainable Development")
- www.mdpi.com/journal/diversity/special_issues/citizen_science_diversity – Diversity (Special Issue „Citizen Science for Biodiversity Conservation: Harnessing the Power of the Public to Address Wicked Conservation Problems")
- https://jcom.sissa.it/archive/15/03 – Journal of Science Communication (Issue 03, Special Issue: Citizen Science, Part II, 2016)
- www.britishecologicalsociety.org/introducing-the-citizen-science-special-feature-and-hub – Special Feature in 6 Journals (Journal of Applied Ecology, Journal of Animal Ecology, Journal of Ecology, Methods in Ecology and Evolution, People and Nature, und Ecological Solutions and Evidence) from the British Ecological Society (February 2021)
- https://cdnsciencepub.com/toc/as/6/3 – Arctic Sciences Journal (Vol. 6, Issue 3, Special Issue: Knowledge Mobilization on Co-Management, Co-Production of Knowledge, and Community-Based Monitoring to Support Effective Wildlife Resource Decision Making and Inuit Self-Determination, September 2020)

Citizen Science reference books

- Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J. & Bonn, A (2018). Citizen Science: innovation in open science, society and policy. London: UCL Press. www.uclpress.co.uk/products/107613 (open access).
- Lepczyk, C. A., Boyle, O. D. & Vargo, T. L. (Eds.) (2020). Handbook of Citizen Science in Conservation and Ecology. Berkeley: University of California Press.
- Noss, R. F. (2020). Handbook of Citizen Science in ecology and conservation. Berkeley: University of California Press.
- Oswald, K. & Smolarski, R. (Eds.) (2016). Bürger Künste Wissenschaft: Citizen Science in Kultur und Geisteswissenschaften. Computus Druck Satz Verlag.
- Skarlatidou, A. & Haklay, M. (2021). Geographic Citizen Science Design: No one left behind. London UCL Press.
- Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., Samson, R. & Wagenknecht, K. (Eds.) (2021). The Science of Citizen Science. Springer. https://link.springer.com/book/10.1007/978-3-030-58278-4 (open access).
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platform “Bürger schaffen Wissen” has been offering training workshops [88] on the topic since 2020. The academic system is slowly but noticeably shifting to the new requirements. For example, the first Citizen Science chair was filled at the University of Jena in early 2020. Other universities and science organisations are also implementing Citizen Science at their institutions with funding programmes, such as the Helmholtz Innovation Fund, and in their strategies, such as the Berlin University Alliance of Berlin Universities and Charité, University of Potsdam - Gesellschaftscampus, University of Münster - WWU Citizen Science Competition 2020, University of Düsseldorf - Citizens’ University, Citizen Science@Helmholtz, Leibniz Working Group Citizen Science. Nevertheless, Citizen Science competencies are scarcely systematically integrating into university teaching. Around 60% (n = 75) of the researchers surveyed said that Citizen Science is not part of curricula/study plans. 69% (n = 75) of the researchers stated that there were no training courses on Citizen Science for researchers at their scientific institutions. Regarding this, the CS Survey 2020 results also show an urgent need for specific advisory services on Citizen Science at scientific institutions. The courses of action will therefore remain in place in 2020. An extension of the courses of action from the Green Paper would be to integrate Citizen Science methods not only into university teaching, but also to introduce children to them at an early age through schools and to integrate senior citizens through continuing education [89].

Since the preparation of the Green Paper, additional action areas have been identified for Citizen Science to be better integrated into scientific processes. **Citizen Science projects and their results need to become more visible in the German science system**. Extensive documentation of Citizen Science projects improves comprehension and transparency. The description of the applications of Citizen Science as a research method has the potential to attract participants in the established sciences who are not yet active or to inspire new research disciplines. However, the current focus remains on life and natural sciences [4]. But Citizen Science projects are also seen as an opportunity to address societal issues in the humanities and social sciences. These are summarised under the term ‘social Citizen Science’ or ‘interdisciplinary research’ [90, 91]. The different terminologies must be defined further.

As part of the VielFalterGarten CS project, citizens of the city of Leipzig observe and count butterflies and develop solutions for insect-friendly design of urban green spaces in collaborative work with BUND Leipzig, the city of Leipzig and scientists from the UFZ and iDiv. Photo: Peter Barczewski/3d-artstudio

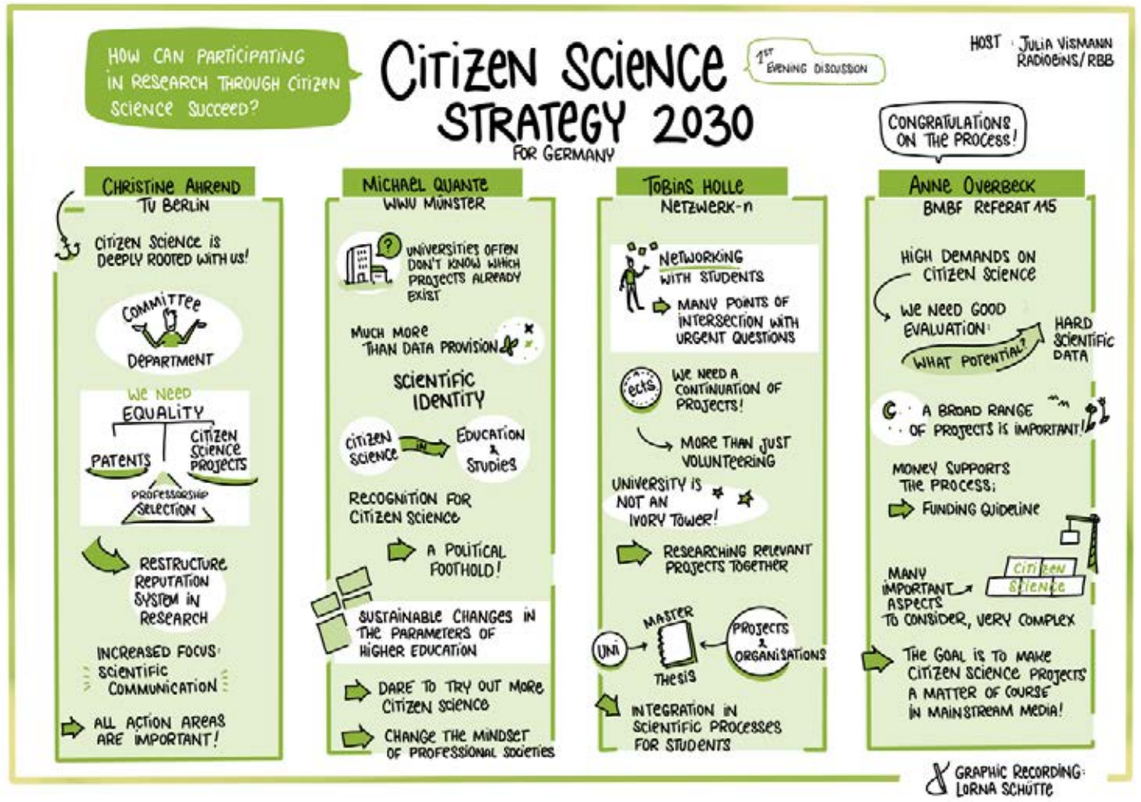


Figure 7: Results of the digital panel discussion “Citizen Science in Science and Research – Quo vadis?” on 8 September 2021

8.2 What are the requirements, opportunities and challenges?

Integrative collaborations between citizen researchers and science institutions are currently still not realised enough due to the scepticism from “classic” science towards citizen research that still exists in some disciplines despite the rise in interest in Citizen Science from established science since 2016 (→ Box 7). 24% of the n = 75 researchers surveyed in the German-speaking Citizen Science community stated that Citizen Science does not currently bring any added value to the individual research field. Increasing the number of these collaborations requires appropriate support, such as more visibility, more networking and exchange formats in museums, WILAs, libraries, recognition, etc., from specialist researchers, management and interested citizens (→ action area 13). There also needs to be constant communication between science, society and business in order to use existing competences and communicate research results. Furthermore, collaboration between citizens and scientists is important for both building trust in Citizen Science and for orienting research topics towards societal interests. Citizen Science should be considered part of good academic and scientific practice.

We have observed in recent years that Citizen Science projects are taking on very diverse questions and pursuing very different conceptual approaches and participation formats. New transformative research approaches such as those pursued by the LivingLabs, WILAs and the regulatory sandbox strategy (Wuppertal Institute, KIT, TU Berlin, Thünen Institute, etc.), in which solutions to societal problems are developed, tested and implemented in research processes, enable new-value design possibilities for citizen participation and new forms of collaboration between scientists and participants (→ action area 12 “Sensor

technology and artificial intelligence" as a new research area in Citizen Science). Equal inclusion of different forms of knowledge paves the way to a new knowledge economy.

The German Citizen Science community sees an urgent need to increase the intensity of citizen scientist participation in Citizen Science research projects. Involving citizen scientists at an early stage in determining research questions (scope phase or co-creation) is a particular challenge. Maintaining direct contact with citizen scientists is sometimes very time-consuming. As there are not enough financial resources available, it is currently not always possible to give sufficient space to the scope phase in Citizen Science projects. However, this is very important, especially in Citizen Science projects, for the early involvement of citizens and the progression of the project. The same applies to the follow-up for Citizen Science projects. The survey and the expert interviews underline an urgent need for explicit scheduling and more research funding instruments for Citizen Science activities in academic research projects. A large proportion (64%) of the researchers surveyed (n = 75) stated that there were no specific funding instruments for Citizen Science at scientific institutions (e.g. competitions). 38% of all respondents (n = 276) stated that there are currently not enough instruments for Citizen Science project start-up funding, and 43.5% of the respondents (n = 276) noted not enough instruments for Citizen Science project follow-up funding.

Attaching a wildlife camera for the WTimpact CS project. Photo: Christof Häberle

The scientific process must be extended to a greater extent to citizen researchers at applied universities, universities and research institutions. Opportunities to sensitise "non-citizen scientists" to Citizen Science methods can be created through highlighting citizen scientist participation with published acknowledgements in research reports or on project websites. This can also be done by listing citizen scientists as co-authors in scientific publications and their participation in scientific conferences (e.g. in online events increasingly organised as a result of the Covid pandemic) to report on their experiences (→ action areas 5 and 1).

The initiative to use Citizen Science as a method in research projects usually comes from individual scientists and is not always welcomed by department heads or institute directors. Therefore, we must continue to raise awareness of the use and recognition of Citizen Science as a research method at universities and science organisations. A first step towards making Citizen Science more visible would be to establish a central Citizen Science office as a point of contact for questions, such as an institutional Citizen Science contact person (e.g. University of Düsseldorf) (→ Fig. 7).

8.3 Recommended actions for area integration into scientific processes

8.1
Interaction with civil society must be within the scope of researchers. Research communities and universities should improve recognition of Citizen Science as a research method, e.g. by including Citizen Science experiences in the scientific evaluation system through a point system for Citizen Science engagement and by including Citizen Science as a criterion when performing a general evaluation of research projects. Citizen Science could be further strengthened by mutual exchange between Citizen Science projects in different research fields and the promotion of interdisciplinary Citizen Science projects.

8.2
Scientific institutions and funding agencies should incorporate Citizen Science participation more firmly in academic research **by systematically examining future research projects in relevant disciplines for effectiveness and influence of Citizen Science**, among other things.

8.3
Scientific educational institutions should produce training and further education materials, expand available training workshops and open educational resources in order to make Citizen Science a more well-known method in academic research. An example of how this can be achieved is by integrating Citizen Science skills, open science and participatory methods into university curricula. At the same time, open science training courses at universities (e.g. introductory courses in scientific work) should be developed and made accessible to citizen researchers.

8.4
Universities and scientific institutions should create advisory structures on Citizen Science that can be used by their own academic researchers and students. In support of institutional structures, we should promote developing a national network for the exchange of experience between Citizen Science advisory centres (→ action area 1, → course of action 1.10).

8.5
Research communities and universities should present the existence of their own Citizen Science activities more concisely on their websites and at the same time build digital platforms that present, network and support Citizen Science projects in order to increase visibility for Citizen Science as an innovative potential for science. Events and initiatives should be organised regularly at scientific institutions to promote rapport between science and citizens, such as "science night", "science shops", "book a scientist" or "open door day".

8.6
In Citizen Science projects, scientists should systematically highlight the citizen researcher participation, for example by publishing acknowledgements in research reports and on the project website or by listing citizen researchers as co-authors in scientific publications (→ action area 5).

8.7
Scientific publishers/journals should increasingly extend the scientific publication processes to Citizen Science.

8.8
Citizen researchers should be increasingly involved in scientific congresses and conferences, for example to report on their experiences and thus act as a trigger for "non-Citizen Science scientists" and the specialist community. Therefore, funding agencies should finance these activities in research projects and openly communicate this funding opportunity so that the Citizen Science community can actively perceive it.

8.9
Research funding institutions should plan a larger timeline and monetary volume for Citizen Science research project funding in order to make discovery processes with citizens more attractive and feasible for scientists. This can be made possible by providing sufficient funding for the initial phase of Citizen Science projects and for the follow-up of citizen participation in research projects, and by appointing citizen researchers as jury members for the distribution of research funds in selection procedures for Citizen Science research project funding (e.g. from federal ministries, foundations). Citizen Science should be a significant part of the portfolio of research funding organisations (e.g. DFG).

Addressees

Practitioners · Civil society · Science · Educational organisations · Policymakers · Funding bodies

Michael Quante
Vice Rector for International Affairs and Transfer at the University of Münster

Photo: WWU/Peter Wattendorf

"Citizen Science is at the core of any scientific strategy development to address major societal challenges."

Mission statement 9:

In 2030, implementing Citizen Science projects at educational institutions will be made possible through funding instruments that promote close cooperation with schools, university education and extracurricular learning centres.

Teachers are important multipliers of Citizen Science. They have access to advanced training opportunities on integrating Citizen Science in educational concepts, along with teaching and learning materials for practical implementation. Activities are based on current research and are aligned with curricula and other frameworks.

9 Integration into educational concepts

9.1 Situation analysis: Where do we stand since the Green Paper?

The courses of action on educational concepts and Citizen Science in the Green Paper can be sensibly divided into four areas: school, extracurricular learning centres, university teaching, lifelong learning.

9.1.1 School

The Green Paper outlined the following courses of action: 1) integrate Citizen Science as an approach in school curricula, 2) expand and adapt Citizen Science curricula, 3) get students involved.

There are some practical examples that prove successful involvement of pupils in Citizen Science activities. However, this is not based on institutionalised structures. No mention of Citizen Science could be found during an exemplary analysis of the gymnasium/gesamtschule (grammar school/comprehensive school) curricula for the subjects of biology and geography for NRW (2019) and for the subjects of natural science and technology, astronomy, computer science, human-natural technology, biology, chemistry, geography, social sciences, art, mathematics, music, physics, economics and law for Thuringia (2012-2018).

Very few teachers (n = 18, out of over 750,000 teachers in Germany in 2019/20) participated in the CS Survey 2020. 80% of the participating teachers were from a gymnasium (grammar school) and, according to their own information, only six had already participated in Citizen Science activities with learning groups, while eight said they were planning to do so. The learning groups with which Citizen Science projects have been performed or are planned are mainly learners in grades 10-12. The implementation is usually part of the subject lessons and rarely takes place outside of school.

9.1.2 Extracurricular learning centres

The Green Paper identified establishing and supporting Citizen Science structures by expanding Citizen Science as a learning opportunity in extracurricular learning centres (such as environmental education centres, museums or libraries) as a course of action.

Extracurricular learning centres are among the initiators of Citizen Science activities, some of which have been integrated into school education. Additionally, archives and science shops should also be mentioned as important extracurricular learning centres in Citizen Science. The results of the CS Survey 2020 (n = 53 coordinators) show that there are frequent collaborations with educational institutions (43%), with associations and NGOs (34%) and with museums (30%). Coordinators cooperate less frequently with school laboratories (19%), libraries and archives (15% each), botanical gardens (11%), cultural centres (9%) and zoos (8%). The main target group in this instance is

adults. Some extracurricular learning centres are involved in several Citizen Science projects.

9.1.3 University teaching

Integrating Citizen Science into scientific research in university teaching and into the curricula of study courses were indicated in the Green Paper as courses of action.

Citizen Science as a scientific method has hardly been addressed in teaching so far, despite selective measures such as summer/winter schools and training workshops being offered in isolated cases. Hardly any theses are written using Citizen Science methods. Despite its potential, Citizen Science has not yet been introduced in all subject areas. A number of positive examples show profitable collaboration between schools and universities based on Citizen Science. The same applies to collaboration between research institutions (where Citizen Science is researched) and academic educational institutions.

9.1.4 Lifelong learning

The Green Paper identified the following recommendation for action: Enabling lifelong learning through Citizen Science for all educational groups. This recommendation for action is divided into the aspects of learning effects and educational opportunities. The CS Survey 2020 suggests that the majority of Citizen Science has learning effects, for instance that knowledge has been acquired, when asked about the achievement of educational goals. Participants and project coordinators differ in their assessment of these effects (→ Fig. 8). Participants believe that Citizen Science has more of an effect on their knowledge ($n_{Knowledge}$ = 94) than on their interest ($n_{Interest}$ = 93), skills (n_{Skills} = 94) or attitudes ($n_{Attitudes}$ = 93). Project coordinators consistently rank the effects of Citizen Science on participants' knowledge ($n_{Knowledge}$ = 26), skills (n_{Skills} = 20), interest ($n_{Interest}$ = 18) and attitudes ($n_{Attitudes}$ = 16) more accurately than the participants themselves. However, the majority of project coordinators have not yet evaluated the impact on participants. Their assessment of the impact on participants is largely based on the experiences of the project coordinators. Funded Citizen Science projects more often use structured interviews and/or standardised questionnaires for evaluation.

Some learning opportunities are not included as often in the projects (e.g. systematic

In after-work expeditions, EMU brings regional research projects to life, as here on the Bever River. Photo: WWU Münster/Bauhus

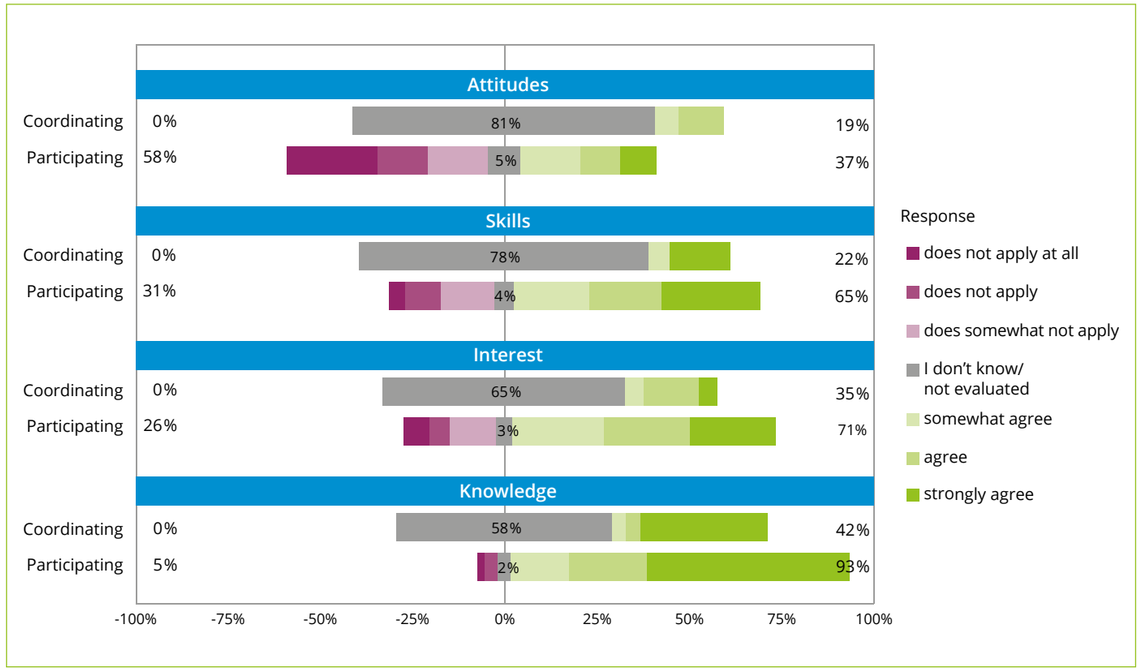


Figure 8: Comparison assessments from project coordinators and participants on the extent to which educational goals were achieved; from left to right, percentages refer to cumulative negative responses (brown colour scheme), undecided responses (grey colour scheme) and cumulative positive responses (green colour scheme)

feedback, expertise platform), although they are used at a similar frequency by participants. An example: While seven out of ten projects (n = 79 coordinators interviewed) offer information materials, only five out of ten participants (n = 113 participants interviewed) use these materials. Five out of ten participants also report using systematic feedback during the projects (→ Fig. 9a). Although systematic feedback to participants has a positive effect on the assessment of their knowledge and skills, only four out of ten projects provide it to participants. Participants who received systematic feedback on their activities in the project rate their knowledge and skills more positively than participants who did not receive feedback (knowledge: $n_{feedback}$ = 51, $n_{no\ feedback}$ = 59; skills: $n_{feedback}$ = 51, $n_{no\ feedback}$ = 56).

These differences in the assessment of the acquired knowledge and skills depending on the educational service of systematic feedback cannot be found for the educational service of information materials: Little difference can be discerned between participants that have used or not used information materials when self-assessing their knowledge and skills (→ Fig. 9b). Information materials seem to play a lesser role than systematic feedback for the knowledge and skills of the participants (knowledge: $n_{information\ material}$ = 54, $n_{no\ information\ material}$ = 56; skills: $n_{information\ material}$ = 53, $n_{no\ information\ material}$ = 54).

9.2 What are the requirements, opportunities and challenges?

9.2.1 School

Citizen Science was not mentioned in the curricula studied. However potential connections could be found, such as a requirement to cultivate competency acquisition in scientific thinking and working methods and to use questions from research practice as a context in lessons. These points of contact confirm the potential of inserting Citizen Science in curricula. However, a collaboration is required for actual implementation

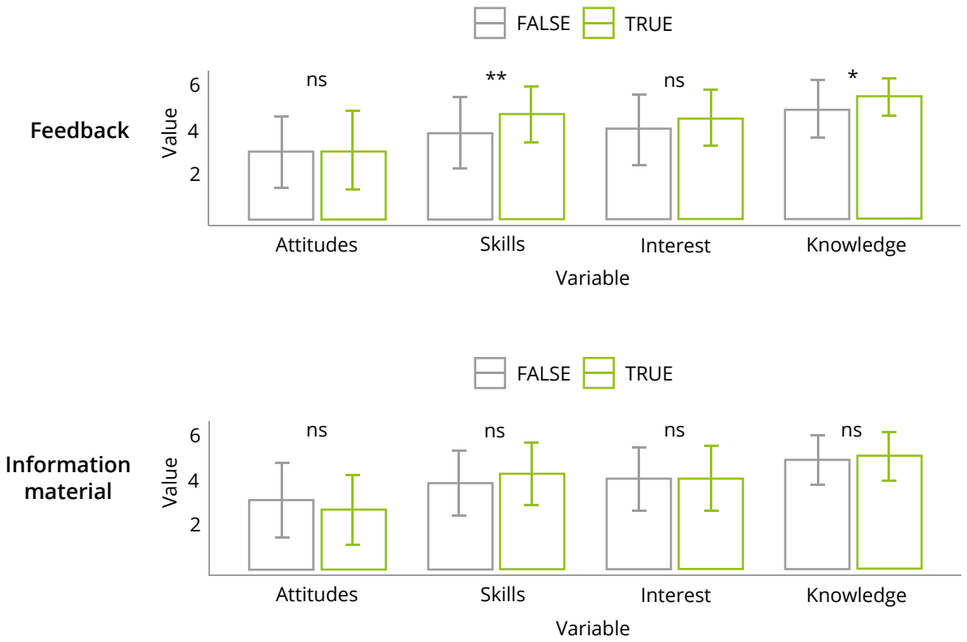


Figure 9a, b: Comparison between participants who (a) collect systematic feedback or not and (b) who have used information material or not (*p < .05; **p < .01; ns = not significant)

between the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany, responsible institutions in the individual federal states and the Citizen Science community. Additionally, it is necessary to integrate the topic of Citizen Science into teacher training and professional development.

The very low participation of teachers in the CS Survey 2020 is evidence of the lack of networking between teachers and Citizen Science so far. Teachers seem either to have not been reached or to have not considered the topic relevant.

9.2.2 Extracurricular learning centres

The repeated participation of extracurricular educational facilities might indicate that Citizen Science is becoming established as an approach in these institutions. However, school laboratories that are often directly linked to research institutions are rarely cooperating partners. It remains to be determined which factors favour the integration of Citizen Science into extracurricular educational programmes. Respondents to the CS Survey 2020 identified three areas as challenges for incorporating Citizen Science into their learning opportunities: little flexible organisational structures, lack of human and financial resources and lack of expertise and supporting materials such as guides. Thus, it seems that more structures and services are needed to stimulate and support extracurricular learning centres and Citizen Science coordinators.

9.2.3 University teaching

The CS Survey 2020 shows that the majority of students are not familiar with the concept of Citizen Science, according to the researchers. On the part of the researchers, the amount of those who are aware of Citizen Science predominates. However, only 33% of the researchers surveyed thought that the teachers at their institutions were open to this concept. There is also a lack of training opportunities on teaching Citizen Science methods. Consequently, there is a shortage of teaching staff with corresponding expertise. Furthermore, Citizen Science is not integrated into the curricula of the degree programmes. However, both are regarded as an essential aspect and requested by the EU [92]. The shortcomings of university teaching in teacher training regarding Citizen Science naturally continue in schools.

9.2.4 Lifelong learning

The positive assessments of the project coordinators on participant knowledge, interest, skills and attitudes indicate positive learning and development effects in Citizen Science projects. However, the reasons for the discrepancies between participant and project coordinator assessments should be investigated and explained (e.g. socially desirable answers, self-selection). However, it seems to be more important to support project evaluations through funding, as standardised questionnaires and structured interviews can be used to ensure comparable evaluations.

Educational opportunities created in many Citizen Science projects are not necessarily used by more participants. In many cases, educational opportunities that are in demand and successful (e.g. feedback on activities) should be developed further and shared as examples.

European Union programmes create co-creative formats. Here is a workshop with Latin American universities and initiatives in Panama City. Photo: LASIN, Glasgow

9.3 Recommended actions for area integration into educational concepts

9.1
Science and educational institutions should work **together to develop and make available practical recommendations for establishing Citizen Science in extracurricular learning centres**.

9.2
To create and attract learning opportunities, Citizen Science coordinators should **tailor educational opportunities to the interests and abilities of participants** by drawing on previous research on participant motivation.

9.3
Participants should build on research findings to develop **effective educational opportunities**, such as systematic feedback to participants on activities and expanding projects to promote learning.

9.4
The Standing Conference of the Ministers of Education and Cultural Affairs of the Länder and the Ministries of Education of the Länder **should initiate integrating Citizen Science into curricula and teacher training as a format for authentic, research-based learning** and promote this by developing teaching and learning materials.

9.5
Sponsors support Citizen Science coordinators, educational institutions and educational sciences by jointly d**eveloping teaching and learning materials (as open educational resources when possible)** based on the latest research to **integrate Citizen Science into teaching practices.**

9.6
Academic institutions should offer **measures to build capacity** for university lecturers on the topic of Citizen Science, as part of funded internal or external training programmes, to **integrate Citizen Science into the module plans and thus into university teaching** (→ action area 8).

9.7
Funding agencies and scientific institutions should **fund and assist the evaluation and research** (→ action area 15) of educational processes in Citizen Science by funding and promoting the evaluations, providing professional advice using evaluation guidelines and strengthening collaboration between Citizen Science projects and educational research.

9.8
Develop a **comprehensive and long-term Citizen Science funding programme** that integrates schools, extracurricular learning centres, universities and other research institutions. The extensive and long-term Sparkling Science funding programme in Austria is a successful best-practice model for the required recommendations for action to strengthen collaboration between education and science in the area of Citizen Science (2007 to 2019 with a volume of 34.9 million euros). The success of the funding approach, which integrates schools, extracurricular learning centres, universities and other research institutions, as evidenced by evaluations, should serve as a model for the development of innovative structures and activities in educational concepts and Citizen Science.

Addressees

Practitioners · Civil society · Science · Educational organisations · Policymakers · Funding bodies

Norbert Steinhaus
Bonn Science Shop

Photo: private

"I support the Citizen Science Strategy 2030 for Germany because of the need for responsible research and teaching that focuses on stakeholder involvement and participatory processes to incorporate values, needs and expectations."

10 Integration into decision-making processes

10.1 Situation analysis: Where do we stand since the Green Paper?

The status of Citizen Science has improved in recent years in German and European political strategies [16, 41]. Citizen Science is a component of the European Union's Open Science Strategy [93] and the German High-Tech Strategy 2025 [31], as well as the policy papers of the Federal Ministry of Education and Research on science communication [28] and participation [94], and the recommendations for action from #FactoryWisskomm, among other things (→ action area 4 on the combined effort between Citizen Science and scientific communication). While the potential to integrate Citizen Science results into decision-making processes at the strategic level has been repeatedly expressed, Citizen Science results have thus far rarely been incorporated into concrete political and societal decision-making processes, such as in the areas of transport and urban planning or review of environmental standards [95, 96, 97].

Selected areas of nature conservation are much further along. Data from Citizen Science projects in these areas already contribute to fulfilling national and international reporting obligations, such as the European Farmland Bird Indicator [98, 99] and the Grassland Butterfly Indicator (→ Box 8) [100]. The use of Citizen Science results in nature conservation is also expressed by how Citizen Science has been integrated into the structure of relevant authorities. Examples of this include the Citizen Science Special Interest Group of the European Environment Agency [61]) and the long-standing cooperation of the Federal Agency for Nature Conservation (BfN), the Red List Centre and the Biodiversity Monitoring Centre with volunteers, associations and professional societies, among others.

Other examples from the environmental field include a 70-year-old Citizen Science project by the Deutscher Wetterdienst (DWD), in which citizens collect regional phenological data that form the basis for DWD forecasts, especially for the weather for farmers in rural areas. Citizen initiatives use "senseBoxes" to measure fine dust and noise levels and share data with authorities. In the Netherlands and in Flanders/Belgium, the open environmental data from Sensor.Community is already being integrated into the data portals of public authorities.

Since Citizen Science is a cooperative and often application-oriented research method, it has great potential to contribute to political and societal decision-making processes [95, 96, 101] and to involve citizens in policymaking. Citizen Science projects can provide a foundation for evidence-based policymaking [102, 103], for example by answering questions relevant to local policy (e.g. small-scale exposure to air pollutants) or by providing data on large space-time scales (e.g. distribution of invasive animal and plant species). Citizen Science can contribute to different phases of policymaking, ranging from defining problems, preparing policymaking processes and implementing policies to monitoring policy decisions [104]. Citizen scientists can contribute to data collection, assist in interpreting data through their expert knowledge and contribute to the development of policy recommendations. Policies based on Citizen Science results have the potential to become more relevant to citizens, as policy solutions are more closely aligned with their realities. The research process is made transparent by citizen participation in key research steps, from the collection and analysis of Citizen Science data to the interpretation of research results. This can increase the legitimacy of the research results and the subsequent acceptance of political decisions made based on these data [105, 106]. Additionally, citizen researchers can develop a deeper understanding of democracy by gaining insights into the often difficult deliberation processes that accompany political decisions during their research activities.

Mission statement 10:

In 2030, Citizen Science will provide practical knowledge on socially relevant issues and thus support political and social decision-making processes.

Citizen Science contributes to evidence-based policy and management decisions through the collaboration of civil society, governmental, political and academic partners.

The data collected using the Night Lights app makes it possible to better analyse light emissions and draw conclusions on how we can reduce light pollution in the future. Photo: Christopher Kyba/GFZ

The potential attributed to Citizen Science in strategy papers [93] conflicts with the fact that the results from Citizen Science projects are often not actually taken into account in politics. This is reflected in the CS Survey 2020 results. Approximately 58% of the 281 participants saw added value from the results of Citizen Science projects for political and societal decision-making processes, as they can form the foundation for decisions together with other data sources. About 30% stated that Citizen Science data is an essential data basis for decision-making processes. Only 3% of the respondents considered Citizen Science data to be of no value for decision-making processes due to uncertain data quality.[1] For around 65% of the 75 participating researchers, Citizen Science provides added value by strengthening the social relevance of research through the collaborative development of research questions with citizens and other stakeholders. For 49% of the researchers, further added value comes from more effective implementation of research results. Practical implementation of research results from Citizen Science

1 Participants who indicated the option "Don't know" are not shown. The cumulative relative frequency is therefore below 100%.

BOX 8 – Involvement of Citizen Science initiatives in European biodiversity monitoring and reporting

Citizen Science plays a key role in biodiversity monitoring and reporting, both in the collaborative design of monitoring and data collection as well as in evaluation and communication. Many citizen scientists throughout Europe have been collecting data for several decades. These data are used in detailed species mapping and lists. The citizen scientists are sometimes organised in natural history associations and projects or work individually. This enables a level of coverage and accuracy of reporting that official monitoring alone could not achieve. Citizen Science initiatives thus provide important information for political decision-makers. Specific areas of application are:

- The Pan-European Common Bird Monitoring Scheme (PECBMS), where a network of citizen scientists submit bird observations. The resulting PECBMS Common Farmland Bird Index and the EU Common Bird Index are recognised indicators of biodiversity in Europe and have been incorporated into the
  - assessment of the rural development plans of the European Union Member States,
  - the assessment of the EU Biodiversity Strategy and progress towards the Sustainable Development Goals (SDGs), and
  - the monitoring and evaluation measures in the Common Agricultural Policy (CAP).
- Citizen scientists from 20 European countries are collecting comprehensive data on the distribution of butterfly species as part of the European Butterfly Monitoring Scheme (eBMS). The Grassland Butterfly Index is calculated based on this data and includes data on 17 butterfly species. The indicator is used to assess progress in the EU Biodiversity Strategy, to report to the Convention on Biological Diversity and to evaluate progress towards the SDGs. Monitoring is currently being extended to Southern and Eastern Europe as part of the Assessing Butterflies in Europe (ABLE) project funded by the European Union.
- The Red List of Threatened Species, established by the International Union for Conservation of Nature in 1964, has become the most comprehensive source of information on the extinction risk of animal, fungal and plant species (IUCN Red List). The IUCN Red List is thus an important indicator of global biodiversity and an effective instrument for implementing political measures to protect biological diversity. Endangered species are classified into categories on the Red List based on standard criteria. Data from Citizen Science repositories such as eBird, BirdTrack and xeno-canto are already being used for IUCN assessments on bird species. Citizen Science data on range, population size, habitat and ecology, as well as use and trade, help to inform necessary conservation measures.

More than 6,000 volunteers participate in the nationwide bird monitoring organised by the Dachverband Deutscher Avifaunisten. For two years now, mapping breeding birds has been possible with the help of the NaturaList app, which enables digital recording directly in the field. The digital service is now used by about half of the staff because it alleviates most desk work. More info at www.dda-web.de and www.ornitho.de. Photos: DDA

projects is addressed at various points in the CS Survey 2020. From 2016 to 2020, 20% of the 199 respondents attended Citizen Science events that addressed transferring research findings to policy and practice. When asked about important recognition factors for citizen scientists, 74% of the 200 respondents identified these as the joint development of practical measures based on Citizen Science results and 72% as the direct exchange with politicians. In contrast however, only 16% of the 276 respondents felt that Citizen Science is currently valued by policymakers as a valid tool for making decisions. Overall, the results from the Citizen Science survey suggest that Citizen Science has not yet fully realised its potential for integration into decision-making processes.

The clear commitment of German politics to Citizen Science with the Coalition Agreement 2021–2025 is therefore all the more welcome: "We will use Citizen Science to incorporate perspectives from civil society more strongly into research." [26, pg. 24] Good channels should now also be created so that the results from citizen research can also be used as an evidence base for political decisions.

10.2 What are the requirements, opportunities and challenges?

Developing a common understanding of how Citizen Science can contribute to decision-making processes
Citizen Science can fully develop its added value for society as a typically application-oriented research approach if relevant results are consistently taken into account in political and societal decisions [94]. Discrepancies between its reported potential to contribute to decision-making processes and the lack of participation can reduce the credibility of the affected decision-making processes and demotivate citizen scientists. To avoid this, it is important that all stakeholders involved collectively determine both whether Citizen Science can contribute to decision-making processes and how. The level of participation should be considered mandatory by all stakeholders and should be considered throughout the entire decision-making process. Whether and how Citizen Science can contribute to decision-making processes must there-

fore be determined at the beginning of a decision-making process. For this purpose, it often makes sense to communicate with representatives from public authorities and agencies early in the project, for example, to clarify possible expectations and demands regarding data quality. Public authorities and agencies can support involvement in decision-making processes by embedding collaboration with Citizen Science projects in their strategies, i.e. permanently integrating it into their official activities and also equipping their staff with the necessary competences and enabling them to act.

Respecting relevant quality standards so that Citizen Science project results can be incorporated into decision-making processes

Ensuring data quality is a key challenge for Citizen Science projects, since concerns are often raised about the quality and transparency of data collection, processing and analysis [106, 107]. Compliance with established quality standards must be ensured in all Citizen Science projects [106], much like projects outside of Citizen Science. In addition to general quality standards, Citizen Science data must also meet legally defined standards in many policy fields before they can be used in decision-making processes (e.g. Water Framework Directive WFD, Monitoring of Common Breeding Birds MhB, Pan-European Common Bird Monitoring Scheme PECBMS) [108, 109]. Currently, data from Citizen Science projects are not or only partially compatible with these standards. In order to rectify this situation, it is necessary to consider how the results are later used during the conception phase of projects [95]. The necessary standards and methods should be planned and documented from the beginning, since observing them at a later stage may only be possible to a limited extent. We must ensure close communication with

In the KnowledgeFlow: the Berlin Panke CS project, citizen scientists explore and discover the biodiversity and habitats of a local Berlin river – the Panke – as well as wetlands in the Berlin hinterland (Spreewald, Spandauer Forst and Karower Teiche) on river and wetland excursions. Photo: Maryam Mumladze

the users of the data that will be collected (e.g. local and national environmental agencies or nature conservation authorities) [95]. It may be useful to appoint specific contact persons with a corresponding mandate for all stakeholders involved in order to support early coordination processes. In some decision-making processes, consideration should also be given to how data from traditional research projects and results from Citizen Science projects can usefully complement each other [103].

Linking participatory processes with Citizen Science

The way that citizens participate in political and social decision-making processes has changed in recent years. In representative democracies, traditional participation through elections is increasingly supplemented by deliberative (participation-centred) procedures such as citizens' petitions or citizens' councils, which are particularly important at the level of municipalities and federal states [110]. Both deliberative procedures and Citizen Science are distinguished by a high level of citizen participation. With that in mind, there are promising starting points for connecting deliberative processes with Citizen Science approaches, which could lead to the strengthening of both. Particularly decision-making processes with high conflict potential and low legitimacy (e.g. measures to reduce traffic in urban districts, construction of wind turbines) could contribute to strengthening deliberative processes by integrating Citizen Science approaches. Research results that are developed during Citizen Science projects and enjoy a high level of acceptance, legitimacy and credibility among all stakeholders could be fed into deliberative processes and objectify the discourse. This could strengthen deliberative processes. Thus far, we lack experience integrating Citizen Science approaches into deliberative processes in Germany. Having said this, relevant

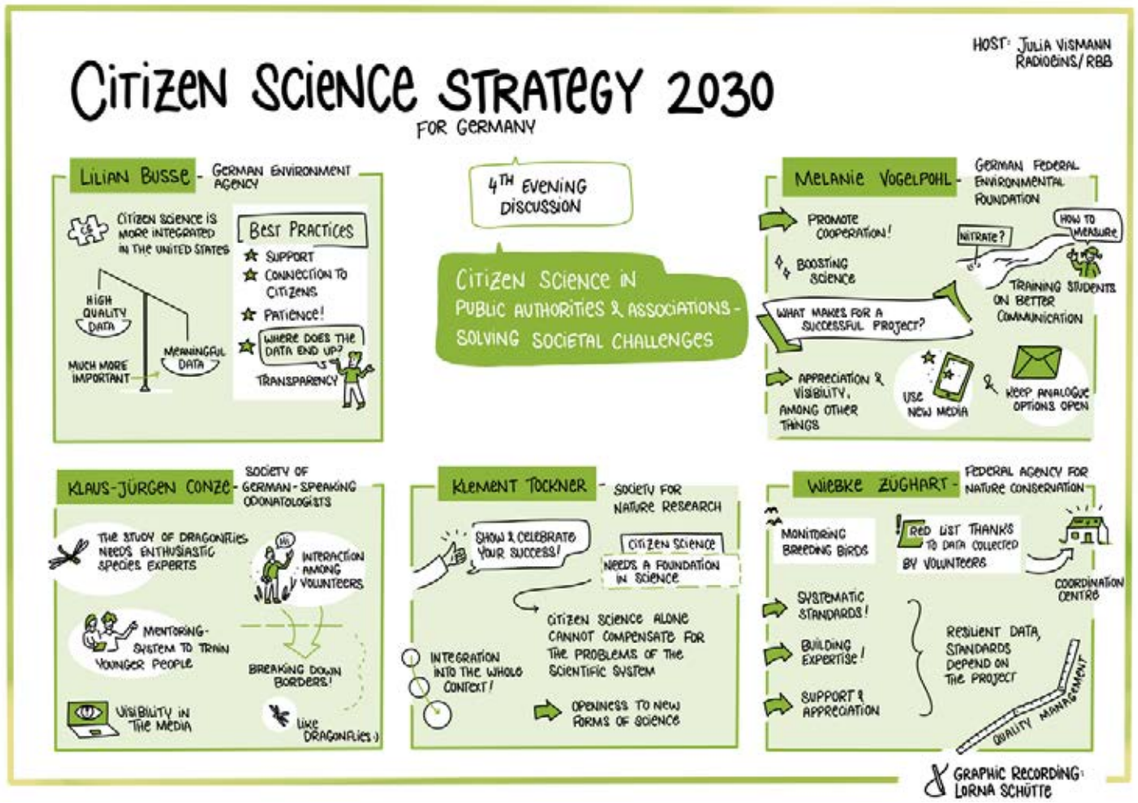


Figure 10: Results from the digital panel discussion on 29 September 2021 on "Citizen Science in public authorities and associations – solving societal challenges"

model projects should be performed in the sense of regulatory sandboxes, including a systematic evaluation of barriers and success factors (→ action area 8 "Integration into scientific processes"). Based on the experience gained from the model projects, structural conditions should be created in the medium term and appropriate capacities built so that Citizen Science approaches can be broadly integrated into deliberative processes if they are successful (→ Fig. 10).

Creating structural conditions to integrate Citizen Science results into decision-making processes

Integrating results from Citizen Science projects into political and societal decision-making processes involves many prerequisites and the intensive use of personnel. Coordination centres and other structural prerequisites should be created among the stakeholders involved (e.g. local points of contact in authorities, associations, museums and universities for Citizen Science) to design and coordinate the necessary processes. In organisational terms, coordination centres could be incorporated into places such as science shops and regulatory sandboxes that already exist. Creating structural conditions to successfully integrate Citizen Science in a mutually beneficial way into decision-making processes is a medium-term project. This can only be realised through sustainable structural funding. Short-term project funding is not suitable, as even at the end of multi-year projects there are usually discontinuities and accumulated knowledge is lost.

Building capacity to integrate Citizen Science into decision-making processes

The prerequisites to successfully integrate Citizen Science into political and societal decision-making processes range from the participatory determination of whether or not Citizen Science results can profitably contribute to decision-making processes and to what extent, to actually considering the results in political and societal decisions. Successfully integrating Citizen Science results into decision-making processes, i.e. incorporating the results into planning, monitoring or policy development, requires a wide range of competencies that are currently not yet available across the board. This was reflected in the CS Survey 2020 among other things, where 82% of the 88 participants wanted support and consultation on how to implement Citizen Science project results into policy and practice. Relevant education and training opportunities should be created at universities and non-university institutions (e.g. science shops) to meet the need to build capacity. In order to comprehensively strengthen the integration of Citizen Science into decision-making processes, services should be made available for citizen scientists and project coordinators as well as for politicians and employees in public authorities. Decision-makers in politics and funding institutions should create long-term incentive structures to support this.

10.3 Recommended actions for area integration into decision-making processes

10.1
Decision-makers in politics and management should incorporate the integration of Citizen Science into decision-making processes into their action-guiding strategies and firmly integrate collaboration with Citizen Science projects into their regulatory actions. For this purpose, they must equip their staff with sufficient capacities to enable consistent integration into decision-making processes.

10.2
In order to ensure usability of Citizen Science results in decision-making processes, the Citizen Science community, scientific institutions and the subsequent users of the results (e.g. authorities and agencies) should collectively define the standards to be observed. The mandatory standards should be observed starting in the conception phase of Citizen Science projects.

10.3
The Citizen Science community, civil society organisations and political decision-makers should test the integration of Citizen Science approaches into deliberative procedures such as citizens' petitions or citizens' councils during model projects. The model projects should be systematically and scientifically supported in order to identify barriers and success factors for successful integration and examples of best practice.

10.4
Civil society organisations and policymakers should create the structural conditions to successfully integrate Citizen Science into decision-making processes (e.g. coordination centres, defined workflows to integrate quality-assured Citizen Science data into policy development, planning and monitoring).

10.5
Civil society organisations and scientific and educational institutions should create opportunities to build capacity (e.g. education and training formats at universities and non-university institutions) that support stakeholders (e.g. project coordinators, public authority employees) in building the competences necessary to successfully integrate Citizen Science into decision-making processes. Practical advisory services for public authorities and agencies planning to increase the integration of Citizen Science could be offered at municipal and city conventions or at universities with a focus on administrative sciences, for example.

Addressees

Practitioners · Civil society · Science · Educational organisations · Policymakers · Funding bodies

Johannes Vogel
Director General of the Museum für Naturkunde Berlin,
Leibniz Institute for Evolution and Biodiversity Science

Photo: Pablo Castagnola

"You should actively implement the Citizen Science Strategy 2030 for Germany so that every voice is heard and together we advance the opening of science and exchange ideas across society, policy and business."

11 Medicine and health research

11.1 Situation analysis: Where do we stand since the Green Paper?

In the Green Paper, Citizen Science in the context of medicine and health research was not yet treated as a separate topic. In the evaluation survey, the majority of the stakeholders ascribed great future importance to the Citizen Science approach in the medical field. In fact, Citizen Science is still a comparatively young field in medicine in Germany, especially when Citizen Science is regarded as intensive, active participation of patients and their relatives (→ Box 9). However, there is a long tradition of participation by non-scientific stakeholders in public health and health promotion, which will not be discussed in depth here. In the participatory or community-based health research approaches, for example, the focus is often on the living conditions as they pertain to health of socially disadvantaged people [111, 112, 113]. In medical research, patient-reported outcomes are becoming increasingly important and are now perceived as beneficial to scientific knowledge [114], but the level of participation is rather low. Nevertheless, considering subjective perceptions and experiences (such as symptoms, quality of life and lifestyle habits) as a target criterion in medical and health research is an important first step towards strengthening the individual in the research context. Crowdsourcing methods are also used, for example to identify and classify cancer cells [115]. However, patients are typically not involved in this.

The reasons for this rather weak dissemination of Citizen Science in medicine are, inter alia, that medical knowledge competences are very specialised and are unilaterally ascribed to doctors. The experiences and perceptions of patients or citizens are usually dismissed as insignificant if they cannot be classified in the existing specialised knowledge. Also, in German-speaking countries, the medical terminology is an obstacle to citizen participation [116].

11.2 What are the requirements, opportunities and challenges?

Citizen Science in medicine and health research with the active participation of patients is special in many ways. The most striking peculiarity is that citizen scientists in medical projects are also patients or affected persons and are thus both subject and object of the research. The data they provide is usually highly personal. A second relevant feature is the motivation to participate in a Citizen Science project. While participation in traditional Citizen Science projects is often based on the joy of learning and participating in knowledge production, in medical and health-related Citizen Science projects the motivation lies more likely in shared suffering, concern for one's own health or even the desire to pass on the experience of one's own illness to others. Thirdly, communication between doctors and patients and their relatives is hierarchical. In the German-speaking countries, this hierarchy is exacerbated by the Latin medical terminology, which makes it difficult for citizens to participate in research. Fourthly, patients are always experts on living with their illness or on their illness as such. In light of all this, Citizen Science should be subject to specific criteria in medical research. With regard to patient expertise, for example, it makes sense to integrate patients into the Citizen Science project from the very beginning, i.e. when defining the research questions and the research design. So far, this has been implemented in only a few projects (→ Box 9).

Mission statement 11:

In 2030, patients will be frequently involved in all phases of medical and health research as citizen researchers.

In medicine, the experience and expertise of patients and their families is recognised as significant. Their involvement in research through Citizen Science increases the relevance and usefulness of research results, facilitates their practical implementation and improves the situation of the patients. New frameworks and structures have emerged that enable joint research, the mutual respect of all participants, responsibly handling the health data of the contributors, adequate funding and recognition in science and medicine.

The SMOVE CS project involves using the ActivPAL sensor, which records the total activity of the students over seven days – sitting, lying down and moving around. Photo: SMOVE/MCD

Involving patients more often and more actively in all phases of the research process has the potential to make the scientific knowledge process both more comprehensive and more needs-based [117] (→ Fig. 11). This can increase the relevance and usefulness of the results for healthcare as a whole. Furthermore, adherence and trust between healthcare professionals and patients may potentially increase if research is conducted jointly rather than hierarchically. This also increases the chance of citizen scientists distributing the results of the Citizen Science project they were involved in through their own patient networks.

In classical medical research, a strict set of rules is recognised and required worldwide [118]. These strict rules are sometimes to be questioned when patients are actively involved in the research project. For example, if patients are involved as citizen scientists (and not exclusively as persons being researched), they cannot consistently adhere to the required pseudonymisation of the data. In this respect, the requirements of medical ethics committees for Citizen Science projects in particular needs to be adapted. Simultaneously, high clinical research standards (e.g. regarding data quality) must be adhered to in Citizen Science projects, too.

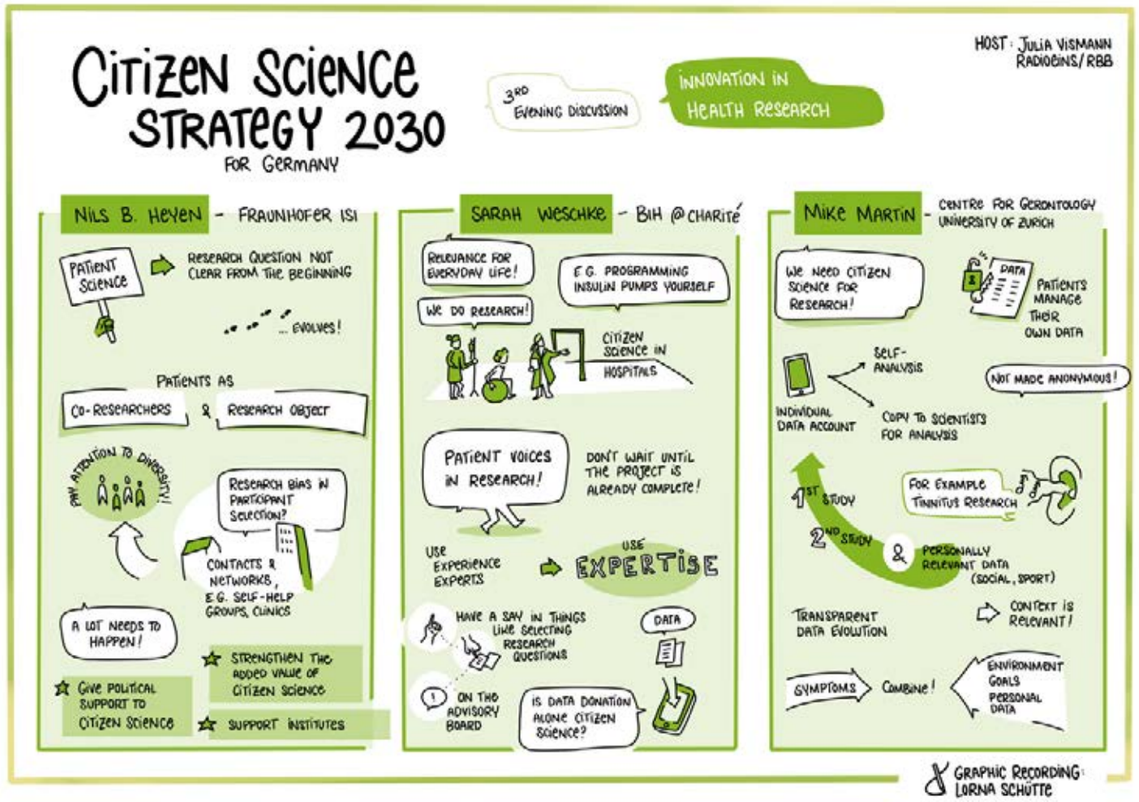


Figure 11: Results from the digital panel discussion on 22 September 2021 on "Citizen Science – Innovation in Health Research".

BOX 9 – Best practice examples for Citizen Science in medicine and health research

Type 1 diabetes (T1D) is a disease in which the pancreas no longer produces insulin, so it has to be administered externally. Technological systems have significantly improved the living conditions of people with T1D in recent years, but are still far from entirely replacing the function of the pancreas. Some people with T1D are now using innovatively enhanced DIY artificial pancreas systems that significantly outperform the effectiveness of commercial technologies. The Citizen Science project **TeQfor1**

www.itas.kit.edu/english/projects_woll19_teqfor1.php

provides the users of these systems with a scientific approach that enables them to make sound and valid assessments of DIY technologies, focusing on individual user criteria.

Patient Science is a co-creative Citizen Science approach for medical and health research that was developed and tested during a pilot project funded by the BMBF

www.buergerschaffenwissen.de/projekt/patient-science-patienten-schaffen-wissen

[117]: A team of co-researchers consisting of relatives and patients with the chronic rare disease cystic fibrosis as well as professional researchers from the social sciences, psychology and medicine, or medical and psychosocial practitioners, conducted a complete scientific study on everyday problems in living with cystic fibrosis, from the determination of the concrete research topic and design, to data collection and evaluation, to the utilisation and publication of results.

In the **Gestational Diabetes Aftercare** project

www.buergerschaffenwissen.de/projekt/nachsorge-schwangerschaftsdiabetes-was-ist-wichtig

research is being conducted on how women and those treating them assess the aftercare situation. Patients and citizens can participate by evaluating interviews, for example. The aim of the Citizen Science approach is to involve as many different people as possible who enrich the process through their different experiences and skills. In order to achieve this diversity, the aim is for participating co-researchers to be both men and women, to come from different age groups and professions, and to include people with a migration background.

11.3 Recommended actions

In order to realise the potentials mentioned above, patients and their relatives should be involved more frequently and more significantly in all phases of the research process. Research should be conducted with them, not only on them or about them. Mutual respect from all participants is a prerequisite for this. Citizen scientists should be given the opportunity to name research topics and to participate in designing projects. Due to the special features outlined above, Citizen Science projects in medicine have a responsibility to empower participants and patients and to strengthen their perspectives. At a minimum, the following actions must be performed to promote Citizen Science in medicine and health research and to reduce structural obstacles:

11.3 Recommended actions for area medicine and health research

11.1
Research actors and sponsors should be made aware of the potentials, requirements and challenges of Citizen Science projects in medicine and health research. To accomplish this, in particular the professional actors within participatory research must become active and raise awareness regarding the added value.

11.2
Participants and research actors should develop and implement specific training opportunities for existing personnel in healthcare and research to meet the specific needs of Citizen Science projects.

11.3
New professional staff at clinical institutions should be established that are medically educated but whose core tasks are to **coordinate and guide the research process with patients.**

11.4
New guidelines must be developed and institutionalised on how medical ethics committees should structurally deal with Citizen Science projects in medicine and health research. Ethical principles need to be adapted to strengthen the position of the patients in the research process and to enable equal participation. The initiative for this should come from Citizen Science stakeholders from research and civil society.

11.5
Funding institutions should provide additional financial resources to support Citizen Science projects in medicine and health research, which are usually particularly costly. This makes it possible to compensate patient volunteers and benefits patient organisations, which often have a great interest in the research projects but no capacity to participate. Funding opportunities should include the option for civil society organisations to apply, such as patient associations.

11.6
A culture of recognition for Citizen Science in medicine and health research should be established in the relevant research communities. Commitment to increasing patient involvement in the research process should be rewarded with incentives (e.g. competitions, credits in internal and external evaluation processes and should have a positive impact on professional careers.

11.7
The citizen scientists involved should be motivated to contribute to disseminating the Citizen Science project results by acting as multipliers and harnessing other communication channels. This way, a large and diverse audience can be reached to use the research findings.

Addressees

Practitioners | Civil society | Science | Educational organisations | Policymakers | Funding bodies

Otmar D. Wiestler
President of the Helmholtz Association of German Research Centres

Photo: David Ausserhofer

"I support the Citizen Science Strategy 2030 for Germany because the active participation of citizens is particularly important for the Helmholtz Association, conducting cutting-edge research for major challenges."

12 Sensor technology and artificial intelligence

New technologies shape developments in society. Citizen Science should contribute to making these technologies philanthropic and environmentally friendly and thus contribute to a sustainable, inclusive future. In this action area, we will pursue the correlation between Citizen Science and sensor technology and artificial intelligence as an example.

12.1 Situation analysis: Where do we stand since the Green Paper?

Artificial intelligence (AI) is the ability for machines to perform tasks independently, reacting to unknown situations in a similarly adaptive way as humans. Combined with sensor technology, the application of sensors, artificial intelligence offers new opportunities for digital transformation and social development. Machine learning is of particular importance as it applies to AI, in which technical systems with learning algorithms independently identify patterns and connections in data sets. The Citizen Science community is increasingly utilising these possibilities to actively shape a sustainable future for itself, even if it is far from exhausting the potential. One driving force for this development is the ever-improving availability of smart sensors. For example, the number of sensors sold is increasing by 17% each year, while their price is falling by 8% annually. This "democratisation of technology" means that Citizen Science projects can now collect data in a much more automated way. For example, the citizen scientists from the Sensor.Community have built an air quality measurement network of over 14,000 sensors in more than 70 countries.

As the amount of data generated in Citizen Science projects grows, so does the demand for efficient analytical tools. Artificial intelligence (AI) offers new possibilities for this. These possibilities did not exist in 2016, the year the Green Paper was published. A large proportion of the respondents from the CS Survey 2020 also addressed the increasing importance of sensor technology and AI in Citizen Science projects.

12.2 What are the requirements, opportunities and challenges?

The role of sensors and artificial intelligence in Citizen Science can theoretically be viewed from two perspectives: How does Citizen Science benefit AI and sensor technology? And how does AI and sensor technology benefit Citizen Science? Both of these approaches are important. Measurements using sensors provide high-quality input data for later analysis. AI can also help by determining the right measurement strategy before taking these measurements. Apart from this,

Mission statement 12:

In 2030, sensor technology and artificial intelligence will be established tools for Citizen Science activities.

In the projects, citizen scientists can take on different roles, operating the sensors, programming or analysing data. Cost-intensive tools are also provided by scientific institutions. Algorithms are an open and transparent foundation for decision-making processes.

data can also be enhanced by citizen scientists performing an initial quality check. For example, data on biodiversity, image processing or audio analysis are excellent for developing Citizen Science tools, such as plant identification apps (e.g. https://floraincognita.com, www.inaturalist.org). This also makes "data collection" interesting for data collectors because the data can also be used for secondary purposes while the project focuses on applying artificial intelligence (plant identification). Additionally, users can play around with the annotation which is important for machine learning, i.e. the qualitative description of certain data sections or labelling events that have produced certain data.

Furthermore, large amounts of data can be collected remotely from poorly accessible or inaccessible locations if applicable. Artificial intelligence helps to depict complex dynamic systems in a clear way to investigate them and also communicate them better. AL facilitates visualisations of complex data in Citizen Science projects or complex processes, such as infection events during a pandemic. As a result, AI and sensor technology can also become part of didactic concepts in schools, universities and other educational institutions.

Challenges

Citizen Science should focus more on **collaboration** between citizens and scientific institutions. Such collaboration also includes different participation in resources for sensors and artificial intelligence. Scientific institutions can also make **cost-intensive sensor technology available to involved citizens** (e.g. SMARAGD). The citizen scientists can contribute to sensor maintenance, contextually interpreting data and data utilisation. In such a model, citizen scientists should be integrated into the processes of the scientific institution

Citizen scientists collect climate data using a bike-mounted sensor. The climate data is uploaded to the open-source platform sensemap. CityCLIM CS project. Photo: Peter Barczewski/3d-artstudio

to enable training. **Networking** Citizen Science initiatives can also be an effective way to share resources and add value. For example, projects such as Data Science for Social Good and CorrelAid Programmers and Data Scientists offer their capabilities for non-profit purposes.

Components of an open-source closed-loop system of the TeQfor1 CS project. Photo: TeQfor1/KIT

Citizen Science projects often face the challenge of **bringing together a wide range of stakeholders in productive collaboration**. Citizen Science projects should be planned so that citizen scientists can take on different roles, from collecting to analysing and interpreting data, according to their motivation and level of knowledge (Bee Observer). Possible tasks should be defined and communicated before starting the project so that it is clear when the citizens can participate and which roles are available to them. In this regard, acceptance of public contributions is also important, because sensor technology and AI require participation from project participants with expertise. Citizen scientists should be trained to perform their task and lead citizens should be actively and carefully involved in various innovative processes.

Collaboration should be organised as a knowledge partnership (such as in exploration space by the Austrian Academy of Sciences: https://openinnovation.gv.at/portfolio/oeaw-exploration-space). This also includes ensuring the **sustainability** of a project beyond the project duration. We believe that working with existing groups, facilitating collaboration and developing workflows take precedence over the project objectives of tool development or data collection. The project should create the conditions for citizen scientists to continue independently.

In the CS Survey 2020, 74% of the respondents see the **cost** of using sensors and AI as a barrier for entry. Thus when discussing costs, it is important to consider the value of the data with regard to the financial consequences of decisions based on that data and the cost with regard to acceptance of decisions.

There are still **acceptance problems** for AI in the Citizen Science community despite the considerable potential that artificial intelligence has to analyse large amounts of data, which the majority of respondents in the Citizen Science survey also attest to. This is usually a matter of ethical aspects, reservations about information technology and fear of data misuse. AI must be non-discriminatory and fair, but also technically robust and secure. Approaches that transparently address the needs of users (human-centred design) and socially relevant issues (humanity-centred design) in technology development help to reduce these acceptance problems.

Algorithms used as the basis for decision-making processes should be **transparent**. AI can be made understandable to enable conscious use of it (e.g. with commercial data collectors). Citizens should be enabled to judge the results of artificial intelligence. In the field of AI and sensor technology, digital literacy is key to engagement. The Algorithm Inventarium project is based on participatory methods, citizen innovation and strong involvement from artists.

12.3 Recommended actions for area sensor technology and artificial intelligence

12.1
Participants and researchers should clearly demonstrate the potential added value of using artificial intelligence and sensor technology. Essentially, the more robust the information gained through the use of the technologies is, the more informed the conclusions and decisions derived from this information will be.

12.2
Scientists should clearly define the goals of using AI and sensors and evaluate milestone achievement during the project. Sensors and AI can be used in Citizen Science projects to answer research questions of varying complexity. At a low level, there are questions such as: How green is my neighbourhood? How high is the concentration of particulates in my neighbourhood? More complex questions involve analyses of seasonal trends. How have the properties of these elements changed over time and are there trends towards sustainable development or the other way around? The most complex studies combine different data sets and include how they affect individuals, such as: How does air quality affect my health and what does that mean for my environment?

12.3
Established research institutions should provide much more sensor technology and help maintain and calibrate Citizen Science projects. This concerns both specific laboratory-quality sensor technology and DIY standard sensor kits provided with detailed instructions on how to build and use the sensor technology for education and research. The sensors should be robust and reliable and able to transfer data to a database in real time. An appropriate legal framework must be created for scientific institutions to be able to make cost-intensive sensor technology available to participating citizens.

12.4
Policymakers should provide the infrastructure to process data generated by citizens and other freely available data (especially environmental, land use, urban structure, socio-economic and other geodata) and transfer them to a common **spatial data infrastructure** or data catalogue. With this step, citizens are given back their own data: "Bring the (geo)data back to the people". Analysis tools for relevant research questions should be made available on central platforms (e.g. SDG12 One Planet Network).

12.5
Educational institutions should provide low-threshold ways for citizen scientists to access information on AI and sensors and to get involved in networks. One possibility could be a **platform for networking and innovation** (→ action area 6 "Data quality and data management") that provides links to existing tools and lists demonstrators to establish communities and final innovation networks. It is important to involve local groups and to network with makerspaces and repair cafés.

12.6
Scientists and participants should provide various **online and offline tools** to promote dialogue between citizens, science and municipal stakeholders such as companies, politicians and NGOs. This especially includes citizen laboratories, a central web GIS with analytical functions and mobile apps. A key project objective is to **involve civil society stakeholders in a socially balanced and inclusive way in knowledge-based local and regional decision-making processes**. Citizens are involved at the beginning and through different levels of participation, especially by participating in data collection, collaborating to define the research question and in data analysis. Modern developments (e.g. the **Internet of Things**) can be used, and not only for data collection, but also to discuss data access, rights to data on a societal/political level and to create the knowledge background for informed discourse. One example could be to increase established use of sensor technology and AI through Citizen Science for data collection and data evaluation for processes to plan and realise infrastructure measures (e.g. sensor technology provision for citizens when determining environmental pollution, such as noise or air pollution).

12.7
In Citizen Science projects, researchers and participants can **specifically use the great potential of sensor technology and artificial intelligence in new fields of application**, such as: Species identification, biodiversity, Environmental DNA, medical research, animal welfare / environmental and climate protection, monitoring changing processes (land use) / urban development (identification of hotspots in environmental pollution, mobility, sociological aspects, migration) / medical research (e.g. using activity and health data) / art created using artificial intelligence, generated texts/consumer texts, lyrical texts, etc.

Addressees
Practitioners · Civil society · Science · Educational organisations · Policymakers · Funding bodies

Angelika Zahrnt
Honorary Chair of Friends of the Earth Germany (BUND)

Photo: private

"I would like to see a great deal of participation in the implementation of the Citizen Science Strategy 2030, which will help to ensure that citizens experience their involvement in science as individually enriching and at the same time as a contribution to research and solving societal questions and problems."

13 Archives, libraries, museums and science shops

13.1 Situation analysis: Where do we stand since the Green Paper?

Mission statement 13:

In 2030, archives, libraries, museums and science shops, along with other institutions at the interface of science and the public, will identify as knowledge spaces and educational institutions tasked with institutional mediation, and thus as memory and transfer organisations.

Citizen Science as a research and transfer approach is an integral part of the mission statements and image of the institutions at the interface of science and the public for active collaboration with citizens. They work as established contact points for professional societies and civic engagement to link science and society.

Citizen Science and open science projects have noticeably increased in number and range of subjects in Germany since the Green Paper was published. This also extends to archives, libraries, museums and science shops (ALMSs), which have not yet been addressed in the Green Paper. For example, the increasing digitisation of scientific collections enables citizen scientists living in different parts of the world to get involved and offers them common exchange platforms (→ Box 10) [119, 120]. Citizen Science has vast potential to be used as a creative approach with added value for society and science. But while open science is already firmly established, there is comparatively little participatory research at museums, archives and libraries in German-speaking countries beyond crowdsourcing projects [121, 122] that is seen as Citizen Science and is registered, for example, on the national platform "buergerschaffenwissen.de" [123, 124]. At the same time, there is a tradition of civic engagement in historical and cultural associations, some of which go back more than 150 years, which could be built on (using the example of historical associations [125]). Since the 19th century, libraries, museums and especially archives have been and continue to be firm cooperation partners with specialist societies and associations, providing rooms for meetings, offering and providing a place to collect and publish their publications. Current examples from the library sector that correlate with this tradition are the close connection between the Upper Lusatian Library of Sciences and the Görlitz Museum of History and Culture as municipal institutions with the Upper Lusatian Society of Sciences as a professional society organised by citizens, or between the SLUB Dresden as a state library, the Dresden Society for Genealogy and the Society for Saxon Regional History, which also collaborates closely with the Saxon State Archives, Main State Archives Dresden.

Science shops and public libraries approach Citizen Science from a participatory programme and methodology, while archives, academic libraries and museums are mostly active in Citizen Science contexts through their substantive focus as memory institutions, i.e. through their focus on holdings and collections. Both approaches in conjunction have a common value as transfer institutions that goes beyond a pure service function and focuses on enabling citizens to conduct independent research. This also conveys a new understanding of the role of memory institutions, which focuses on joint knowledge work for mutual knowledge transfer, builds on the traditional tasks of collecting, preserving and mediating and reinterprets

or updates them. Thanks to the positioning as transfer institutions, memory institutions can contribute to transforming the relationship between science and the public, in which the creation of scientific knowledge becomes part of a participatory process and it is accepted that this knowledge is constantly developing and changing. Particularly transfer institutions, along with continuing education institutions such as adult education centres and independent institutions (such as the Landeskuratorium Ländlicher Raum e. V. in Saxony), have a duty to promote an open approach to science in order to promote the credibility of science, especially in times of scientific scepticism (→ Fig. 12).

13.2 What are the requirements, opportunities and challenges?

Digital formats available today offer multiple opportunities to expand data collection and analysis, develop research questions and apply research results to real life issues as a collaborative activity between research "professionals" and "laypersons". Successful formats are characterised by the fact that the institutions flexibly adapt them to

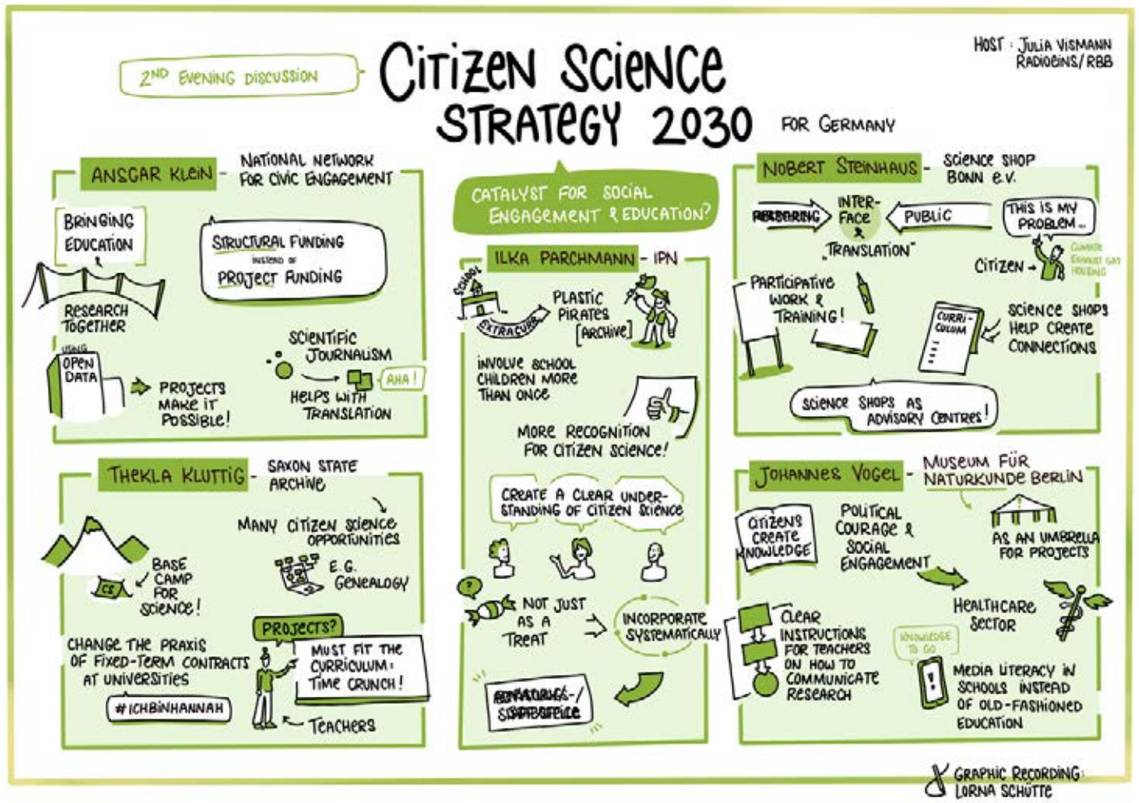


Figure 12: Results from the digital panel discussion on 15 September 2021 on "Citizen Science – engine for social engagement and education?"

the target groups or develop them with target groups, for example by using existing data material from collections to match with research questions from volunteer researchers. It does not make sense to use Citizen Science processes for every research process. In this context, it can be made operational as Citizen Science wherever citizens formulate questions that can be answered scientifically with the help of our collections and holdings – be it individually or during collaborations and projects.

Experience shows that the goals of researching citizens often vary greatly. Some want to explore issues close to their heart, others want to solve socially relevant problems, others want to explore connections or fundamentals, or they simply enjoy contributing to shared work and discovery. For archives, libraries and museums, for example, a motivation to participate in Citizen Science processes may be an interest in high-quality preparation of their collections and thus increased attractiveness of their particular institution. Defining the goals is a very important challenge, especially when "professionals" and "laypeople" are conducting research in a joint process. This clarification can also be the key to developing more openness for each other's research process. ALMSs can be a point of contact and a place to exchange ideas for all these special interests, beyond a concrete research interest, due to the broad range of topics they focus on. In doing so, they must ensure adherence to scientific standards and standards of good collaboration with citizen researchers and project partners, as well as legal requirements and ethical discussions (→ action area 7).

The task of transfer organisations such as archives, libraries, museums and science shops should be to repeatedly develop and apply flexible participation and communication formats. During this task, they should be open to the requirements and requests for such formats formulated by citizen research, as well as actively approaching the target groups for which they can create opportunities based on their holdings, methodological competence and research experience. One example of this is transcription workshops, in which participants work with staff from ALMSs on historical documents and are integrated into the academic work, e.g. through their own selection of documents.

Their task is also to define common and separate research paths so that all stakeholders on the interdisciplinary and transdisciplinary research team can achieve their own goal and do not feel overshadowed by each other. It may be valuable to work together on one part of the research process and then continue working separately. One example is the collaborative creation of corpora by transcribing historical data collections, and based on which different research questions can then be addressed. Beyond pursuing their own goals, such as supporting the development of individual inventory through crowdsourcing, ALMSs can support citizen researchers in their own projects and at various points in the research cycle by providing inventory, but also by teaching methods and techniques or by providing working plat-

The Kosmos cinema in Berlin: one of the postcards of various GDR cinemas from the archive holdings of the Cinema in the GDR project. Much of this evidence was made available to us by citizen scientists. Photo: Collection holdings “Cinema in the GDR”

forms and publication opportunities. This also applies to participatory projects by professional and voluntary researchers, such as the “Hallische Heiratsgeschichten” project by the Historical Data Centre Saxony-Anhalt, the Chair for Economic and Social History of the Martin Luther University Halle-Wittenberg and the Association for Computer Genealogy. Under certain circumstances, this can also entail memory institutions that act as transfer institutions becoming active beyond their own systems where citizen researchers themselves are active. Examples of this can be seen in the various Wikimedia portals such as Wikipedia, Wikisource, Wikidata and Wikimedia Commons, where numerous objects from the institutions are digitally preserved, indexed and edited [126, pg 165–169, pg 174–177].

However, participation and public engagement in projects or research processes are designed, they should also be understood by all participants as an “endeavour to learn” in addition to creating factual knowledge. Beyond a pure “participation capacity” of citizen researchers, ALMSs must also develop their own “cooperation capacity” [127], i.e. learn to adapt to different needs and interests and develop suitable structures and processes to do so. The existing variety of participatory formats and instruments for participation and engagement should be used or recombined. Experimental spaces need to be created, both physical as well as virtual and conceptual, in which exchange and collaborative learning can take place in the otherwise rather separate spheres of society and science [128, 129]. ALMSs are particularly suitable as interfaces because of their institutional stability and their role as meeting places visited by many thousands of people of different origins and backgrounds every year. It is essential that they also cooperate more closely with each other in the future for this purpose and for their inventories and col-

BOX 10 – Networks, WGs and best practice examples

On the networks, see also Box 3.

Networks

- Network of German-speaking science shops – Wissnet (www.wissnet.de)
- Network of European science shops and similar working institutions – living knowledge (https://livingknowledge.org/lk9)

Working groups

- LIBER Citizen Science Working Group: Working group on Citizen Science of the *Ligue des Bibliothèques Européennes de Recherche – Association of European Research Libraries* (https://libereurope.eu/working-group/liber-citizen-science-working-group)
- Open Archives Working Group in the Association of German Archivists (www.vda.archiv.net/arbeitskreise/offene-archive-1.html)

Best Practice Projects

- Volunteers help to create and complete a scientific database from the almost four million herbarium specimens at the Botanical Museum in Berlin-Dahlem (https://herbonauten.de)
- Citizens help to make the hymenoptera collection at the Natural History Museum Berlin accessible by transcribing the labels (www.zooniverse.org/projects/mfnberlin/bees-and-bytes)
- In the transcription workshop from the Historical Workplace of the Museum of Natural History Berlin, a dedicated group transcribes historical documents from Sütterlin and Kurrent and digitises the texts (www.museumfuernaturkunde.berlin/en/museum/participate/transcription-workshop)
- Citizens can either take photos themselves or share old photo albums with the German Maritime Museum for pictures of flood marks, of the labour dispute and strikes at the Bremerhaven shipyards and of artistic representations of the Bremen cog (www.dsm.museum/en/participation/citizen-science)
- The Association for Computer Genealogy (“CompGen”) runs various joint projects on family research with archives and libraries (www.compgen.de), e.g. “Kartei Leipziger Familien” with the Saxon State Archives, National Archives Leipzig (http://wiki-de.genealogy.net/Kartei_Leipziger_Familien)) and “Dresdner Totengedenkbuch (1914–1918)” with the SLUB Dresden (http://wiki-de.genealogy.net/Totengedenkbuch_Dresden/Projektbeschreibung)
- Archives and libraries support pupils nationwide in participating in the Federal President's History Competition, the largest historical research competition for young people in Germany

lections to relate more strongly to each other. Digitisation has more than ever created the conditions for this [130].

In terms of theses, the following conclusions can be drawn for the future development of Citizen Science in these institutions:

1) Memory institutions must leave the passive role of being visited or used and actively seek and promote collaboration with their users in order to fulfil their function as an interface.
2) As transfer institutions, archives, libraries, museums and science shops should use their potential to create spaces of shared experimentation and learning, thereby enabling trust in a science that is allowed to continuously question itself and review results.
3) In the face of limited resources, Citizen Science participation and scientific participation in general must be more effective by establishing and disclosing common and separate researcher goals.
4) Transfer institutions must also increasingly develop or support digital forms of communication and projects to place knowledge management on a broader basis.

Another picture postcard from the archive holdings of the Cinema in the GDR project – here a cinema hall in Potsdam. Photo: Collection holdings "Cinema in the GDR"

13.3 Recommended actions for area Archives, libraries, museums and science shops

13.1
Become active: Memory institutions such as archives, libraries, museums and science shops (ALMS) must leave the **passive role of being visited or used and actively seek and promote cooperation with their users** to fulfil their function as an interface. To do so, full-time equivalents must be planned, included in job descriptions and incorporated into calls for proposals. Appropriate financial frameworks and funding guidelines must be created in order to give full-time employees security and scope of action through permanent employment contracts. Citizen Science must be promoted as an operational objective by governments and included in corresponding strategies and budget plans.

13.2
Collaboration with communities: As transfer institutions, ALMSs should seize their opportunity to create both **physical and digital spaces for shared experimentation and learning.** ALMSs can act as a link between science and existing research communities (e.g. historical, genealogical or natural history societies or Wikimedia communities) and strengthen collaboration by providing appropriate tools and infrastructure. They can thus enable trust in a science that continually questions itself and is permitted to review results.

13.3
The method must fit the objective: Due to limited resources, participation in science and Citizen Science must become more effective by setting common and separate goals for researchers. ALMSs should focus on their respective core topics and competencies to provide effective research support.

13.4
Digitisation: Transfer institutions such as ALMSs must also increasingly develop or support digital forms of communication and projects to place knowledge management on a broader basis. ALMSs should therefore formulate digital strategies to promote Citizen Science activities that enable adequate technical equipment and access to necessary digital tools. Public spaces and inclusive access to technology and tools must be made possible and users must be trained to use them.

13.5
Employees of ALMSs participate in training courses on Citizen Science in order to be prepared for the requirements. They also exchange information with each other – both within their institution and with other institutions – in order to benefit from common experiences.

13.6
Citizen Science is part of the training in archives, libraries and museums in order to promote awareness and understanding of Citizen Science in these professions at an early stage.

Addressees

Practitioners | Civil society | Science | Educational organisations | Policymakers | Funding bodies

14 European perspective (D-A-CH)

14.1 Situation analysis: What have we achieved since the Green Paper?

There are different forms of cooperation within Citizen Science throughout Europe. European and international research institutions are successfully cooperating with civil society organisations in many projects within the Horizon 2020 or the Horizon Europe of the EU Framework Programme for Research. Those engaged in the European Citizen Science Association (ECSA) exchange ideas on mutual visions and develop strategic topics related to specific areas and funding applications. Prominent examples of cooperation are the publications on the *ECSA 10 Principles* (2016) and the Characteristics of Citizen Science (2020), both important milestones in the development of Citizen Science. The characteristics were identified and discussed through vignette analysis with the involvement of the community in a transnational work process focused on cooperation [131, 132]. The "EU-Citizen.Science" online platform also documents successful cooperation throughout Europe. The platform is the result of a joint effort and has functioned as a communication and information hub since 2019. In the *Citizen Science COST ACTION 15212*, the European community held important discussions on the content and strategic development of Citizen Science in Europe between 2016 and 2020 [7]. The first "European Citizen Science Conference" in May 2016 in Berlin with 29 international partners provided an opportunity for strategic networking, scientific exchange and the subsequent publication of a Citizen Science book. It was organised by the Helmholtz Centre for Environmental Research – UFZ, the "BürGEr Schaffen WISSen (GEWISS)" consortium of the Helmholtz and Leibniz Association with universities and 17 international partners [95, 61]. In October 2020, Berlin was also the venue for the conference on the Global Sustainability Goals (SDGs) and Citizen Science, funded by the European Commission, organised by the Museum für Naturkunde Berlin with many partners and supported by the European Commission and the BMBF. The conference resulted in policy recommendations entitled "Our world – our goals: Citizen Science for the Sustainable Development Goals". The declaration is a voluntary commitment by all stakeholders to define the roles, competencies and specific potential of Citizen Science to advance the SDGs. It was formulated in an open and participatory process. The combined effort between national development and the European perspective are particularly important for Citizen Science.

Cooperation between the DACH countries (D-Germany, A-Austria, CH-Switzerland) in Citizen Science is diverse and has developed significantly in recent years.

Mission statement 14:

The DACH network is an established stakeholder in the European Citizen Science Network on a political and professional level.

International measures and initiatives such as jointly developed capacities for the community, e.g. continued education and networking offers, as well as joint evaluations of various funding guidelines make Citizen Science an integral part of research and a central task of various organisations. The diverse cooperation at the political, scientific and network levels serves as best practice examples for European collaboration. This strengthens and promotes the national structures in Germany, Austria and Switzerland.

Reviewing cooperation, or: How do the DACH countries cooperate amongst each other?
Cooperation in Germany, Austria and especially the German-speaking part of Switzerland takes place at various levels, in informal networks to exchange experiences and also in standardised and formal formats for networking offered by institutions. A current example of this close cooperation is the joint citizen science Survey 2020, the results of which form the basis for this "White Paper Citizen Science Strategy 2030".

A central instrument for joint work is the D-A-CH Working Group (www.buergerschaffenwissen.de/Citizen-Science/arbeitsgruppen/dach). There are regular workshops, joint contributions and presentations at conferences and strategic activities, such as the exchange on results of the WG Quality Criteria for Citizen Science Projects on "Österreich forscht" in the context of a strategy workshop by "Bürger schaffen Wissen". At the respective national conferences in Switzerland, Austria and Germany, the advisory boards are jointly staffed, there are joint session submissions and the audience is made up of participants from the three countries.

Situational analysis, or: What is the current status in the DACH countries?
We will outline below the different situations and Citizen Science activities in Germany, Austria and Switzerland. The cooperation between these countries has decisively shaped the development of Citizen Science in the respective countries. While the development of the Citizen Science landscape in Austria can be understood as a grassroots, bottom-up process that was later complemented by top-down measures by the Ministry of Science, and in Switzerland various institutions worked together to build distributed structures and content, in Germany political support by the Federal Ministry of Education and Research was decisive from the beginning. However, all three routes have enabled each country to develop specific competences, structures and capacities, which have given rise to the specific national networks and shaped them in many ways.

Citizen scientists help to process an important source for social and family history – by deciphering the index cards for the still unpublished Dresden Book of Remembrance of the Dead for the First World War. Dresden Book of Remembrance of the Dead 1914 -1918 CS project. Photo: Peter Barczewski/3d-artstudio

Austria

Citizen science projects have a long tradition in Austria, although it has gone by different names (e.g. volunteer research, citizen research). The "Sparkling Science" funding programme in Austria by the Ministry of Science ran from 2007 to 2019 under the catchphrase 'research-education-cooperation'. The cooperation between researchers and school classes promoted through this programme can be understood as an early form of citizen science. With the founding of *Österreich forscht* (www.citizen-science.at/en) in 2014, a platform was created to present research projects with active citizen participation side by side under the term 'citizen science'. The platform is the result of a bottom-up initiative by citizen science stakeholders for citizen science stakeholders without an official founding mandate.

Until now, the two founders of Österreich forscht and the corresponding Citizen Science Network Austria (CSNA) (www.citizen-science.at/en/network) have been coordinating *Österreich forscht* in cooperation with the project coordinators and partners through "do-ocracy", in which the partners contributing resources get to steer the development. Especially due to the very limited resources in the beginning, this method worked well to distribute the workload and create a sense of community. This work also includes the "Austrian Citizen Science Conference". This conference has been organised annually since 2015 and in cooperation with the citizen science networks from Germany and Switzerland since 2019. In the meantime, about 50 projects currently running in different research areas by different organisations and citizens are presented on the *Österreich forscht* platform. These projects meet the quality criteria for citizen science projects on *Österreich forscht* (www.citizen-science.at/en/network/working-groups/wg-quality-criteria). *Österreich forscht* and the CSNA are funded by the University of Natural Resources and Life Sciences Vienna.

Simultaneously, the Ministry of Science launched the OeAD Centre for Citizen Science and, together with the Austrian Science Fund FWF, the "Top Citizen Science" funding initiative in 2015. The two funding programmes, "Top Citizen Science" (FWF 2016–present and Ministry of Science 2016–2018) and "Sparkling Science 2.0" (Ministry of Science 2007–2019, relaunched 2021), have supported the citizen science movement in Austria ever since. Furthermore, the OeAD Centre for Citizen Science supports research projects and contributes to making citizen science known to the public through the annual "Citizen Science Award" competition. Regional and local funding programmes have also increasingly fostered citizen science projects in recent years.

In 2019, the University of Natural Resources and Life Sciences Vienna committed itself to long-term support for both the CSNA and *Österreich forscht*, thus enabling citizen science activities to continue. It issued a specific work mandate to expand and strengthen citizen science in Austria with the tenured employment of the two coordinators. Today, numerous institutions have incorporated citizen science into their profiles, e.g. the Natural History Museum Vienna and the International Institute of Applied Systems Analysis (IIASA), and citizen science contact persons are in place at numerous other research institutions.

Switzerland

In Switzerland, the Citizen Science landscape also began to develop in 2014 with a situational analysis by the *Science et Cité Foundation*. This was followed by the establishment of the Citizen Science Network Switzerland and the Citizen Science office based at Science et Cité in 2015. The "Schweiz forscht" platform (www.schweizforscht.ch) makes Citizen Science projects visible and provides information. Additionally, the office focuses on network maintenance and mutual learning, and provides information and communication on Citizen Science. The Citizen Science Competence Centre (www.citizenscience.ch/en) focuses on digital tools and was founded as a joint initiative of the University of Zurich and ETH Zurich in 2017. The central element is the "Project Builder" (https://lab.citizenscience.ch/de), which can be used to classify data. In 2018, the Participatory Science Academy (PWA, www.pwa.uzh.ch/en) was also launched at the University of Zurich and ETH Zurich. It focuses on training and education for co-creation, such as international summer schools. The PWA also awards seed grants. In 2018, Science et Cité organised the second European Citizen Science Conference in Geneva along with other partner institutions, including the University of Geneva.

Nature observations by citizen scientists. Photo: Detlef Metzer/naturgucker.de

This was followed three years later in 2021 by CitSciHelvetia, the first Swiss Citizen Science Conference, during which the "Citizen Science Initiative of the Swiss Academies of Arts and Sciences" was announced under the leadership of Science et Cité. Existing activities are being intensified through the initiative and a participatory process has been set in motion to systematically and impactfully advance Citizen Science in Switzerland.

Currently, three organisations are primarily active in Switzerland at the institutional level. In addition to Science et Cité, these include the Participatory Science Academy and the Citizen Science Competence Centre at the University of Zurich and ETH Zurich. Additionally, there are important research groups in French-speaking Switzerland that are also involved in the network: the *Citizen Cyberlab* (University of Geneva) on the topics of Citizen Science and crowdsourcing, the research group "The Rise of the Citizen Science: Rethinking Public Participation in Science" (University of Geneva) and the *ColLaboratoire* on public participation in science and technology and scientific communication and mediation (University of Lausanne).

Citizen Science has also left its mark on education policy in Switzerland. For example, Citizen Science was mentioned in three papers from the Swiss Science Council (2017, 2018 and 2019) and in a report by Science et Cité for *swissuniversities*, the umbrella organisation of Swiss universities (Perception and Experience with Citizen Science at Higher Education Institutes, 2019).

A special feature of the Swiss Citizen Science landscape is the fact that all three language regions must be adequately represented. Particularly noteworthy is the commitment of three universities (UZH, ETH, University of Geneva), which have different focal points with complementary target groups and exper-

tise, and which also conduct internationally visible research in Citizen Science through their research groups.

In general, the number of stakeholders in Switzerland is manageable. The advantage of this is that communication channels are short and cooperation is carried out in an amicable manner. Swiss stakeholders are also involved in international initiatives (*Board of Directors of the European Citizen Science Association*, scientific advisory board of the Austrian Citizen Science Conference). Additionally, the media continuously reports on Citizen Science.

Germany

In Germany, the Ministry of Research and Education (BMBF) funded the "Bürger schaffen Wissen - Wissen schafft Bürger" (GEWISS) consortium project between 2014 and 2016 to build capacity in Citizen Science and to assess the potential and challenges of Citizen Science. Researchers from all fields, citizens, civil society organisations and scientific institutions contributed their ideas and experiences to a programme based on dialogue and participation to strengthen Citizen Science. The resulting Green Paper "Citizen Science Strategy 2020 for Germany" attracted a great deal of attention in the political arena and in international Citizen Science networks. Following this and based on the programme to build capacity and the Green Paper [1], the BMBF has launched two funding programmes for Citizen Science projects since 2016. Other institutions are also dedicated sponsors of Citizen Science projects. These include both federal ministries (e.g. the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) and foundations (e.g. German Federal Environmental Foundation) as well as non-university funding programmes.

The "Bürger schaffen Wissen" project was then continued by two consortium partners and now manages a project website, promotes the Citizen Science Network, offers numerous events for different target groups as well as advisory services for Citizen Science projects and organises the annual Citizen Science Forum. The platform also offered the first test run for training workshops for university staff in research and research management in 2020 and continued this in 2021. Regional and subject-specific working groups (e.g. WG Region West, WG White Paper and WG Law) and other regional networks have been formed in cooperation with the German Citizen Science Platform. Citizen Science activities take place in a variety of forms and sectors, e.g. in and through science shops, regulatory sandboxes, associations and universities (→ Box 4, → action area 1).

14.2 What are the requirements, opportunities and challenges?

Discrepancy between strategy papers and funding

Policymakers formulate their demands and expectations of Citizen Science similarly in Germany, Austria and Switzerland. egarding targeted collaboration between stakeholders from science and the non-scientific public, Citizen Science should integrate citizens into the field of science, implement global topics of the sustainability goals locally and establish trust in scientific knowledge processes. In contrast to these comprehensive demands, the Citizen Science community has jointly formulated demands for more recognition for Citizen Science as a valid research approach, upgrading science communication, stabilising necessary infrastructure and more recognition for the work they have done. There is, however, a discrepancy between these demands and the reality as Citizen Science activities and the associated costs (e.g. scientific communication, data management, volunteer management and clarification of legal issues) are largely taken for granted in both science and politics.

The goal is to establish Citizen Science projects as an integral part of research and a central task of various organisations by 2030, which would eliminate the current discrepancy between strategy papers and the implementation of specific funding. The existing structures in Germany, Austria and Switzerland should be strengthened and promoted. This includes both the established platforms and infrastructures

As part of the KnowledgeFlow: the Berlin Panke CS project, citizen scientists and schools are researching and collecting data on the occurrence of birds, insects, plants and macrozoobenthos in the Panke river and the wetlands in the area surrounding Berlin (Spreewald, Spandauer Forst and Karower Teiche). Photo: Kim Mortega

such as science shops, associations, voluntary agencies and others. A change of perspective in science is therefore required at the political level.

Building capacity and capabilities

Capacities and structures need to be established and expanded to develop sustainable structures for Citizen Science. Close cooperation and mutual support of Citizen Science networks is possible in the case of the three German-speaking countries, which is a unique situation for Europe. The collaborations already in place result in multiple approaches to create synergy effects which should be actively supported and expanded further, e.g. by making successful tools available on all platforms. We should also intensify and support the structural capacity building for the community in and through institutions and organisations, as it is already taking place in the three countries. The possibility of building an open infrastructure that could be used by all three DACH countries and possibly adapted by other countries should be examined as a combined effort with the open science movement.

The goal is to establish a DACH network by 2030 through transnational measures and initiatives at the political and professional level. Strengthening the DACH network in this way offers the following added values, among others: transnational knowledge exchange and capacity building, mutual consultation and support culture, intensive professional exchange and advancement of the research field of Citizen Science.

All measures take into account the existing structures and special features of the Citizen Science networks in Germany, Austria and Switzerland. Testing, developing and evaluating joint funding programmes offers political opportunities for transnational and interdisciplinary cooperation in Citizen Science.

A classic Zeiss TK 35 cinema projector was used for the opening event of the Cinema in the GDR project at the Kulturhaus Dacheröden in Erfurt. Photo: Martin Schlobach

14.3 Recommended actions for area European perspective (D-A-CH)

14.1
Funding and political institutions in the DACH countries should develop, test and evaluate joint international Citizen Science funding programmes in order to strengthen the links between the societies in the three countries.

14.2
Funding bodies should exchange information on the success of different funding programmes in the three countries and initiate joint learning processes.

14.3
The online platforms and Citizen Science stakeholders in the three countries should work together on overarching professional issues in order to sustainably strengthen Citizen Science stakeholders, e.g. the **conception of building competence for training and continuing education**, strategically **advancing quality criteria** and the necessary **structural changes in the various sectors and distributed organisations.**

Addressees

Practitioners | Civil society | Science | Educational organisations | Policymakers | Funding bodies

15 Accompanying Citizen Science research

Citizen Science is faced with high demands regarding its desired impact: It is supposed to impart knowledge, increase the understanding of research processes, strengthen social engagement and promote transparency in science. However, little research has been done so far on the extent to which Citizen Science meets or can meet these different demands. Accompanying research is a means to tackle this problem.

The term 'accompanying research' describes an application-oriented type of research aimed at assessing the effectiveness and benefits of economic, technical or political measures and programmes using qualitative and quantitative scientific methods. There are overlaps particularly with evaluation and innovative research. While the scientific methods used may be identical, evaluation is always based on an appraising perspective that focuses on the assessment of concrete benchmarks and goal attainment. In contrast, the focus of accompanying research is not primarily evaluative [133]. Accompanying research for Citizen Science aims to generate insights about Citizen Science projects, especially regarding their implementation and impact.

Accompanying research in Citizen Science is therefore defined as the scientific investigation of the implementation and effects of Citizen Science projects or programmes to expand the knowledge base. It describes all research activities that are not concerned with the project's research question but with the project itself. For example, the following questions can be addressed in the context of accompanying research: Which affective variables (e.g. motivation) and cognitive variables (e.g. scientific thinking) change in participants? Which factors influence this process? This research is essential to find out whether the demands on Citizen Science are being met. Only this knowledge makes it possible to advance Citizen Science in a scientifically sound manner – both conceptually and analytically. The achievement of goals in a Citizen Science project is verified through evaluation research. Even though the boundaries between accompanying research and evaluation research are often fluid, it is important to clearly define the goal and purpose of the research.

15.1 Situation analysis: Where do we stand since the Green Paper?

Accompanying research on Citizen Science was already mentioned in the Green Paper "Citizen Science Strategy 2020 for Germany". Since then, interest in accompanying research measures and the need for them have increased significantly in politics, society and science. In many funding programmes, however, the need for accompanying research on Citizen Science has not yet been sufficiently documented. Accompanying research is needed to sustainably and scientifically develop Citizen Science. It should be considered a distinct professional effort and be independently funded as such.

Mission statement 15:

In 2030, accompanying research will be an integral part of Citizen Science projects and will already be considered at the project planning stage and supported by appropriate financial resources.

Accompanying research is carried out by interdisciplinary teams and is oriented towards the scientific standards of empirical social research and evaluation research. Citizens are involved in order to clarify central points and questions.

Participants in the MigOst project share their personal migration stories in storytelling cafés. Photo: Paolo Le van

So far, expertise in researching Citizen Science in Germany is still limited. At the same time, there is little experience regarding the conception and implementation of study designs. The Science of Citizen Science Working Group in cooperation with "Bürger schaffen Wissen" is therefore trying to establish the perspective of accompanying research in Germany. The high demand for scientifically sound studies on the effectiveness of Citizen Science is also repeatedly emphasised in the international literature [134, 85, 135, 136, 137]. To be able to conduct accompanying research, the acceptance and understanding of accompanying research and thus the willingness of stakeholders to participate in data collection must be increased.

Following the inclusion of the requirement to evaluate Citizen Science projects in a large number of funding guidelines, the accompanying evaluation of an entire funding programme (BMBF's Citizen Science funding programme) was commissioned for the first time in July 2020. The results of this evaluation are meant to contribute to gaining knowledge about the effects of Citizen Science projects on science, on the participating institutions and on the citizen researchers and scientists involved. This accompanying evaluation of Citizen Science is an important development in quality management. However, research on Citizen Science should not be limited to evaluative observations, but should also advance theory developments in basic science. In particular, this includes findings that can be applied more broadly beyond project-specific target reviews.

15.2 What are the requirements, opportunities and challenges?

There are initial approaches to structurally incorporate accompanying research in German-speaking countries (e.g. the *Science of Citizen Science* WG, Citizen Science chair at the Friedrich-Schiller-Universität Jena and the WG "Citizen Science in Agricultural Areas" at the Thünen Institute), but accompanying research on Citizen Science projects needs to be more strongly established and promoted (→ Box 11).

One challenge for accompanying research is the diversity of Citizen Science projects. The research design of accompanying research must be specifically adapted to the goals, content and methods of each project, with qualitative and quantitative approaches being equally relevant and useful. In many cases, comprehensive accompanying research requires including an interdisciplinary perspective. Additionally, the transfer to other Citizen Science projects with different conditions must always be considered and discussed in the specific research designs. Empirical approaches generating findings on impact relationships that can be generally applied and transferred to other projects and topics are ideal. Thus, a classical impact measurement using suitable research designs is important to underpin research on Citizen Science with findings on cause-effect relationships.

A general challenge of scientific-empirical working methods, including Citizen Science accompanying research, is that they must adhere to quality criteria of empirical social research (including reliability, validity, objectivity, transparency and intersubjectivity) to ensure meaningful results. Accompanying researchers should be aware of these quality requirements. This also means that accompanying research requires the corresponding competencies and capacities, making it more than just an additional task for team members in Citizen Science projects. Furthermore, accompanying research needs to be visible beyond the Citizen Science community. Accompanying research addresses the current scientific discourse, and in addition it provides the empirical basis for strategic project development in Citizen Science practice.

BOX 11 – Best practice examples

A notable example of accompanying research is the joint project WTimpact by the Leibniz Institute for Zoo and Wildlife Research (IZW) in Berlin, the Leibniz Institute for Tropospheric Research (TROPOS) in Leipzig, the Leibniz Institute for Science and Mathematics Education (IPN) in Kiel and the Leibniz Institute for Knowledge Media (IWM) in Tübingen. The objective of the project was to determine what participants take away from Citizen Science projects. For example, it examined how the participants' topic-specific knowledge and their ability to think scientifically developed throughout the project, how the participants perceived their activities and the topics of the project, and whether their attitudes towards natural sciences and Citizen Science changed. The findings will be used to develop recommendations for the design and implementation of future Citizen Science projects.

Another example is the accompanying research of the "Plastic Pirates – Go Europe!" Citizen Science campaign (**www.plastic-pirates.eu**). The accompanying research is being carried out at the Chair of Research on Learning and Instruction at the Ruhr University in Bochum. The aim is to gain insights into the effect of participation in the campaign and to increase the visibility of the high rate of acceptance of the campaign within the EU. To measure causal effects in large-scale Citizen Science projects, a research design was created that combines the investigation of large samples with impact studies in controlled experimental settings. One question being investigated is whether knowing participation in the Citizen Science campaign has lasting effects e.g. on the interest and motivational quality of the pupils. The pupils' interest in the project topic, along with their motivation to apply scientific working methods and, among other things, a possible increase in topic-specific knowledge among the pupils as a result of their participation in the campaign will be assessed [139].

15.3 Recommended actions for area accompanying Citizen Science research

15.1
Citizen Science coordinators should see accompanying research as an opportunity for Citizen Science projects. Accompanying research should be carried out by interdisciplinary teams composed of the relevant disciplines and social scientists or educational researchers.

15.2
Researchers should develop new methods of accompanying research for Citizen Science and adapt the ones already in use.

15.3
Scientists, participants and funding institutions should communicate accompanying research and its results to interested members of the public.

15.4
Politicians should base funding decisions on Citizen Science on well-founded results of accompanying research. In this, both measuring the effects using empirical methods and investigating causal mechanisms with theory-based research approaches should be pursued. This is the only way to scientifically evaluate Citizen Science to see if it meets the heterogeneous demands placed on it – especially when such measures are financed using public funds. Accompanying research thus creates the prerequisites for the acceptance and long-term incorporation of Citizen Science in society.

Addressees

Practitioners · Civil society · Science · Educational organisations · Policymakers · Funding bodies

DEVELOPMENT PROCESS OF THE WHITE PAPER

The *White Paper Citizen Science Strategy 2030 for Germany* was developed in an open, participatory process over a period of 18 months. It involved 219 people from 136 organisations and institutions using various participatory formats and 14 public dialogue and workshop events. The process was primarily driven by the department heads of 49 subjects (→ Imprint and → Fig. 14) from institutes of the Helmholtz Association, the Leibniz Association, the Fraunhofer Society, various universities and libraries as well as non-university institutions, which led the development of the chapters. The development process was based on several components (→ Fig. 13, 15):

- The White Paper working group with bi-weekly meetings open to anyone interested
- Input from over 120 participants at two public dialogue forums on 26 June 2020 and 10 December 2020
- Online Citizen Science Survey 2020 with 420 participants from September to October 2020
- A strategy workshop and four writing workshops held by the White Paper WG
- Discussion on the draft of the courses of action at public workshops at the Citizen Science Forum in May 2021 and the annual conference from the Society for Ecology in September 2021
- Open online consultation on the White Paper in August and October 2021 During the online consultation period, a total of 1,343 contributions (posts, text annotations and votes) and 119 comments were made
- Five online discussion panels from August to October 2021
- Results from the submission of 31 position papers in September/ October 2021
- Communication of the results through a film
- Launch of the White Paper on 29 April 2022

The *White Paper Citizen Science Strategy 2030 for Germany* was developed in an open, participatory process over a period of 18 months. It involved 219 people from 136 organisations and institutions using various participatory formats and 14 public dialogue and workshop events.

The process was primarily driven by 49 thematic chairs from institutes of the Helmholtz Association, the Leibniz Association, the Fraunhofer Society, universities and libraries as well as non-university institutions, who led the development of the chapters.

The White Paper Working Group

The White Paper working group (WG) was initiated as a bottom-up network by various organisations in April 2020 to develop a White Paper based on the Green Paper "Citizen Science Strategy 2020 for Germany" [01]. Over 700 people from more than 350 organisations were involved in the participatory development of the Green Paper 2014–2016, which was funded by the BMBF. In the White Paper WG, anyone interested from the Citizen Science community in Germany was invited to critically review the visions and courses of action in the Green Paper and to formulate current and specific recommendations for action on how Citizen Science should develop in Germany by 2030 in order to strategically incorporate these into the White Paper.

The White Paper WG launched this strategic process in April 2020 with the cooperation of a total of 219 stakeholders from 136 organisations and institutions, including scientific institutions, professional societies, associations and federations, museums, libraries, foundations and individuals. Due to the COVID-19 pandemic, the process was conducted entirely virtually. This was a challenge, but it allowed for different stakeholders to participate in the various online formats of the participation processes. The entire process was facilitated by the steering committee.

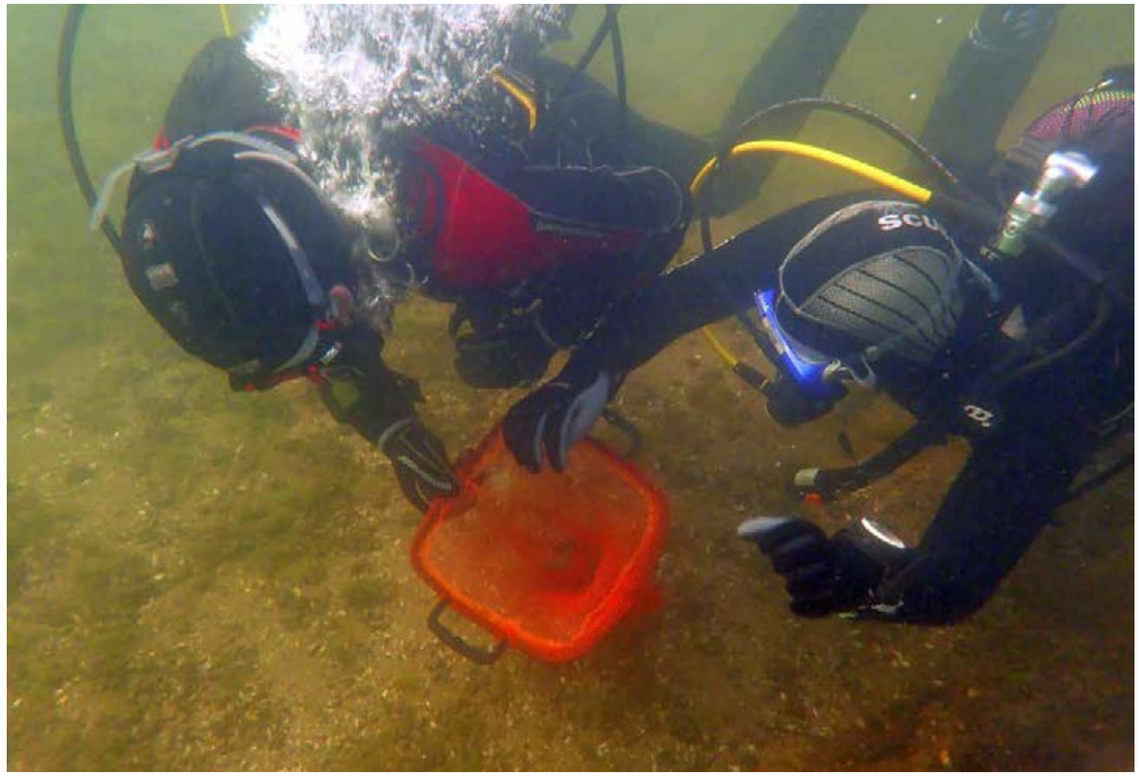
White Paper Steering Committee

The White Paper Steering Committee met weekly with Aletta Bonn – UFZ/FSU Jena/iDiv, Thora Martina Herrmann – UFZ/iDiv and Matthias Premke-Kraus – Leibniz Association office as speakers, along with Wiebke Brink – WiD, Susanne Hecker - MfN, Christin Liedtke – Helmholtz Association office, Silke Voigt-Heucke – MfN and Julia von Gönner – FSU Jena/UFZ/iDiv.

White Paper Working Group

The White Paper WG met every two weeks, with approximately 50 meetings attended by an average of 20 to 30 people.

Contributors to the White Paper WG include: Lena Albrecht – Nature And Biodiversity Conservation Union (NABU), Wilhelm Bauhus – University of Münster, Luiza Bengtsson – Max Delbrück Center for Molecular Medicine in the Helmholtz Association, Vanessa van den Bogaert – Ruhr University Bochum, Miriam Brandt



Scuba divers are predestined to observe aquatic plants – as seen here in an open-cast lignite mine in Saxony. Diving for Nature Conservation CS project. Photo: Silke Oldorff/NABU BFA Living Lakes

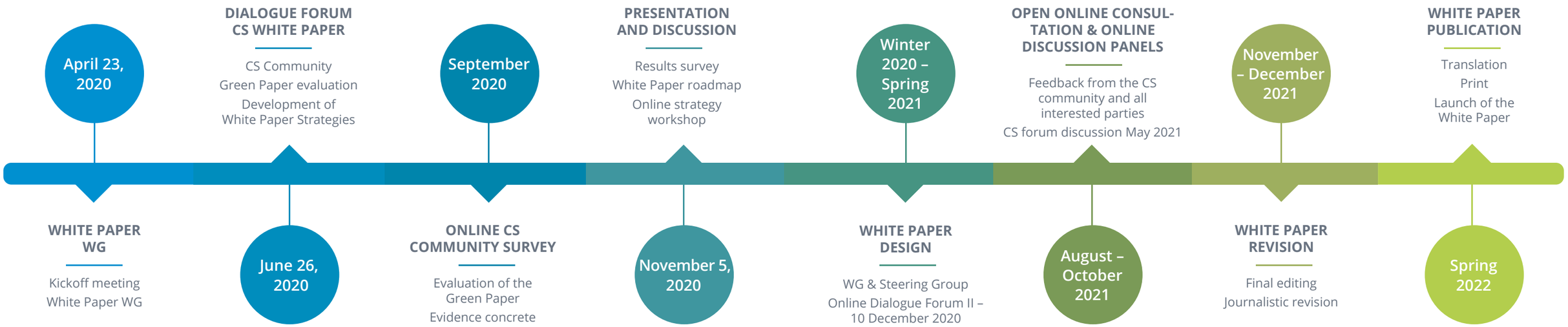


Figure 13: The participatory development process of the White Paper from April 2020 to the launch in April 2022

– Leibniz Institute for Zoo and Wildlife Research (IZW), Till Bruckermann – Leibniz University Hannover, Peter Dietrich – Helmholtz Centre for Environmental Research – UFZ, Daniel Dörler – University of Natural Resources and Life Sciences, Regina Eich-Brod – Forschungszentrum Jülich, Michael Eichinger – University Medical Centre Mannheim, Laura Ferschinger – Heinrich Heine University Düsseldorf, Linda Freyberg – Natural History Museum Berlin – Leibniz Institute for Evolution and Biodiversity Research, Agnes Grützner – Fraunhofer Information Center for Planning and Building (IRB), Gertrud Hammel – Helmholtz Zentrum für Umwelt und Gesundheit München, Florian Heigl – University of Natural Resources and Life Sciences, Nils B. Heyen – Fraunhofer Institute for Systems and Innovation Research ISI, Franz Hölker – Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Carolin Johannsen – University of Bremen, Sarah Kiefer – Leibniz Institute for Zoo and Wildlife Research (IZW), Friederike Klan – Institute of Data Science from the German Aerospace Center (DLR), Jörn Knobloch – Natural History Museum Berlin – Leibniz Institute for Evolution and Biodiversity Research, University of Lübeck, Thekla Kluttig – Saxon State Archives – State Archives Leipzig, Thorsten Kluß – University of Bremen, Valerie Knapp –Ruhr University Bochum, Monika Koop – University of Münster, Julia Lorke – IPN – Leibniz Institute for Science and Mathematics Education at the University of Kiel, Kim Mortega – Natural History Museum Berlin – Leibniz Institute for Evolution and Biodiversity Research, Martin Munke – Saxon State and University Library Dresden (SLUB), Carsten Pathe – Friedrich Schiller University Jena/Institute of Data Science from the German Aerospace Center (DLR), Anett Richter – The Thünen Institute German Federal Research Institute for Rural Areas, Forestry and Fisheries, Anna Soßdorf – Heinrich Heine University Düsseldorf, Tiina Stämpfli – Science et Cité, Ulrike Sturm – Natural History Museum Berlin – Leibniz Institute for Evolution and Biodiversity Research, Christian Thiel – Institute of Data Science from the German Aerospace Center (DLR), Susanne Tönsmann – Participatory Science Academy, Anke Valentin – Bonn Science Shop, Katherin Wagenknecht – Federal Office for the Safety of Nuclear Waste Management, Robert Wegener – Forschungszentrum Jülich and Silvia Woll – Karlsruhe Institute of Technology.

The Citizen Science Survey 2020

In September 2020, an online Citizen Science Survey 2020 was conducted to determine the state of Citizen Science in Germany, Austria and Switzerland. The survey was based on the results of the first dialogue forum in June 2020. The aim of this CS Survey 2020 was to gain a better understanding of the achieved objectives from the Green Paper "Citizen Science Strategy 2020 for Germany". The topics and questions of the survey were developed through participation in the White Paper WG on the 15 subject fields.

Overall, 420 people participated in the CS Survey 2020 (84% from Germany, 8% from Austria, 8% from Switzerland). This survey is thus the most comprehensive to date on this issue in the German-speaking world. Since 52% of the participants stated that they had never taken part in a Citizen Science event before, we were also able to reach Citizen Science stakeholders and those interested in CS outside the previously active networks. The survey results demonstrate that the implementation of Citizen Science 2020 has progressed in essential areas, but that the various action areas have so far been designed and implemented to varying degrees.

The survey gave respondents the opportunity to answer various questions depending on their interests and affiliation to different stakeholder groups (e.g. Citizen Science coordinators, academic scientists, citizen scientists). Therefore we always indicate the total number of answers in the text with (n = x) to enable classification of the data. Detailed explanations are given in von Gönner et al. (in preparation) [54] and in the planned handbook on Citizen Science.

The White Paper dialogue forums and writing workshops

In June 2020, the **first dialogue forum** from the White Paper WG was held online. 123 participants discussed current developments and action areas in Citizen Science during themed workshops based on the Green Paper 2016. There were a total of 15 topical sessions, each of which was led by a subject chair.

The thematic chairs of the 15 action areas

Networking and exchange

Wilhelm Bauhus & Monika Koop
Westfälische-Wilhelms-Universität Münster

Christin Liedtke
Helmholtz-Gemeinschaft, Geschäftsstelle Berlin

Funding instruments

Matthias Premke-Kraus
Geschäftsstelle der Leibniz-Gemeinschaft

Franz Hölker
Leibniz-Institut für Gewässerökologie und Binnenfischerei (IGB)

Volunteer management

Andrea Büermann & Julia von Gönner
Helmholtz-Zentrum für Umweltforschung-UFZ/ Deutsches Zentrum für integrative Biodiversitäts-forschung (iDiv) Halle-Jena-Leipzig

Synergies with scientific communication

Wiebke Brink
Wissenschaft im Dialog

Luiza Bengtsson
Max-Delbrück Centrum für Molekulare Medizin in der Helmholtz Gemeinschaft

Regina Eich-Brod
Forschungszentrum Jülich

Anna Soßdorf
Heinrich-Heine-Universität Düsseldorf

Recognition culture in and for Citizen Science

Anett Richter
Johann Heinrich von Thünen-Institut Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei

Laura Ferschinger
Heinrich-Heine-Universität Düsseldorf

Data quality and data management

Friederike Klan
Institut für Datenwissenschaften des Deutschen Zentrums für Luft- und Raumfahrt e.V. (DLR)

Carsten Pathe
Friedrich-Schiller-Universität Jena/Institut für Datenwissenschaften des Deutschen Zentrums für Luft- und Raumfahrt e.V. (DLR)

Legislation and ethics

Linda Freyberg & Jörn Knobloch
Museum für Naturkunde Berlin, Leibniz-Institut für Evolutions- und Biodiversitätsforschung

Integration into scientific processes

Thora Herrmann
Helmholtz-Zentrum für Umweltforschung - UFZ/ Deutsches Zentrum für integrative Biodiversi-tätsforschung (iDiv) Halle-Jena-Leipzig

Agnes Grützner
Fraunhofer-Informationszentrum Raum und Bau (IRB)

Integration into educational processes

Julia Lorke
Leibniz-Institut für die Pädagogik der Naturwissenschaften und Mathematik-IPN

Ulrike Sturm
Museum für Naturkunde Berlin, Leibniz-Institut für Evolutions- und Biodiversitätsforschung

Till Bruckermann
Leibniz-Universität Hannover

Christian Thiel
Institut für Datenwissenschaften des Deutschen Zentrums für Luft- und Raumfahrt e.V. (DLR)

Integration into decision-making processes

Michael Eichinger
Universitätsmedizin Mannheim

Kim Mortega
Museum für Naturkunde Berlin, Leibniz-Institut für Evolutions- und Biodiversitätsforschung

Aletta Bonn
Helmholtz-Zentrum fürUmweltforschung-UFZ / Friedrich-Schiller-Universität Jena / Deutsches Zentrum für integrative Biodiversitätsforschung (iDiv) Halle-Jena-Leipzig

Medical and health research

Gertrud Hammel
Helmholtz Zentrum für Umwelt und Gesundheit München

Nils B. Heyen
Fraunhofer-Institut für System- und Innovationsforschung ISI

Silvia Woll
Karlsruher Institut für Technologie

Sensor technology and artificial intelligence

Robert Wegener
Forschungszentrum Jülich

Peter Dietrich
Helmholtz-Zentrum für Umweltforschung - UFZ

Thorsten Kluß & Carolin Johannsen
Universität Bremen

Archives, libraries, museums and science shops

Silke Voigt-Heucke
Museum für Naturkunde Berlin, Leibniz-Institut für Evolutions- und Biodiversitätsforschung

Thekla Kluttig
Sächsisches Staatsarchiv – Staatsarchiv Leipzig

Martin Munke
Sächsische Landesbibliothek – Staats- und Universitätsbibliothek Dresden (SLUB)

Anke Valentin
Wissenschaftsladen Bonn

European perspective (D-A-CH)

Katherin Wagenknecht
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Figure 14: The department heads of the 15 action areas

In October 2020, the results of the CS Survey 2020 were presented at the **Strategy Workshop** I and the structure of the White Paper was collectively developed. Based on the survey results, the 97 participants worked out needs, potentials, challenges and recommended actions at the public **Dialogue Forum II** in December 2020. The proposed position papers were collected into one document and revised by the subject chairs and the steering committee in December. The subject chairs (→ Fig. 14) drew up a joint document during the **Writing Workshop I** in January 2021. The **Writing Workshop II** in February 2021 was used to finalise the position papers and refine the content of the White Paper. **Writing Workshops III and IV** in October 2021 served to incorporate the comments from the online consultation and the results of the online panel discussions into the revision of the White Paper.

Online panel discussions (lunch break and evening talks)

In order to facilitate lively personal discussions, the White Paper WG organised a series of moderated online "evening talks" and digital lunch breaks to serve as panel discussions with the patrons of the Citizen Science Strategy and other individuals from society, politics and research. The results of the discussions were recorded in the graphic recordings by Lorna Schütte (Figures 7, 10, 11,12, 15) and have been incorporated into the revision of the White Paper text.

- 27. August 2021: Digital lunch break by "Bürger schaffen Wissen" for online consultation with participants Manfred Ronzheimer, freelance journalist, Gaby Schulemann-Meier, Naturgucker Platform, and Anke Valentin, Bonn Science Shop (→ Fig. 15)
- 8 September 2021: First evening discussion on "Citizen Science in Science and Research – Quo vadis?" with participants Christine Ahrend, first Vice President of the Department of Research, Appointment Strategy and Transfer at TU Berlin, Michael Quante, Prorector for International and Transfer Students at the University of Münster, Tobias Holle, netzwerk n, and Anne Overbeck, BMBF, Division 115 - Strategic Foresight / Participation and Citizen Research (→ Fig. 7)

As part of the VielFalterGarten CS project, 15-minute point counts of butterflies are carried out on urban green spaces. Photo: Peter Barczewski/3d-artstudio

Figure 15: Results of the digital lunch break by "Bürger schaffen Wissen" for the online consultation on 27 August 2021

- 15 September 2021: Second evening discussion on "Citizen Science – an engine for social engagement and education?" with participants Ansgar Klein, CEO of the Federal Network for Civic Engagement (BBE), Thekla Kluttig, Saxon State Archives, State Archive Leipzig, Ilka Parchmann, Leibniz Institute for Science and Mathematics Education (IPN), Norbert Steinhaus, Bonn Science Shop, and Johannes Vogel, Director General Natural History Museum Berlin (→ Fig. 12)
- 22 September 2021: Third evening discussion on "Citizen Science - innovation in health research" with participants Nils B. Heyen, Fraunhofer Institute for Systems and Innovation Research (ISI), Mike Martin, Centre for Gerontology, University of Zurich, and Sarah Weschke, Berlin Institute of Health at Charité (BIH) (→ Fig. 11)
- 29 September 2021: Fourth evening discussion on "Citizen Science in public authorities and associations - solving societal challenges" with participants Lilian Busse, Vice President of the Federal Environment Agency (UBA), Klaus-Jürgen Conze, Organisational Chairman of the Society of German-Speaking Odonatologists (GdO), Matthias Meissner, Head of Biodiversity Department at Friends of the Earth Germany (BUND), Klement Tockner, Director General of the Senckenberg Gesellschaft für Naturforschung, Melanie Vogelpohl, Head of Division Sustainability Education Digitalisation & MINT of the German Federal Environmental Foundation (DBU), and Wiebke Züghart, Head of Terrestrial Monitoring at the Federal Agency for Nature Conservation (BfN) (→ Fig. 10)

The White Paper online consultation

After finalising the editing of the complete document at the beginning of 2021 during the two writing workshops mentioned above, an open **online consultation** was held in August and September 2021. This offered an additional opportunity to actively contribute to the preparation of the White Paper to anyone interested. The online consultation was published and actively advertised to the public on the website www.citizen-science-weissbuch.de. The users of the consultation process were able to participate in many ways through contributions and comments by commenting on the text, evaluating specific recommendations for action and naming particular challenges for Citizen Science. A total of 1,343 contributions (contributions, text annotations and votes) and 119 comments were submitted. Participation in the online consultation was largely anonymous, so no statements can be made about the origin of the participants. Members of the steering committee and the White Paper WG carefully reviewed the comments and proposed changes, categorised them and incorporated them into the final document, taking into consideration transparent criteria. The diverse comments from the online consultation provided many valuable contributions and contributed to the constructively critical revision of the White Paper draft. The development of the White Paper for the Citizen Science Strategy 2030 benefited from this kind of collaboration and was able to incorporate the knowledge and expertise of many.

The position papers

Various organisations and institutions from science and society also submitted 31 position papers on Citizen Science, as was done during the process of creating the Green Paper "Citizen Science Strategy 2020 for Germany". The majority of the position papers were submitted by name and are publicly available upon request. A detailed evaluation of the position papers and the consultation will be published separately. A well-balanced mix of organisations from science and society participated. The position papers contributed important points to help develop the White Paper. The consultation process was very inspiring and we would like to thank all the participants for their time and expertise.

Listed below are the participating organisations and institutions that submitted position papers. The views and opinions expressed in this White Paper do not necessarily reflect those of the participants or their organisations.

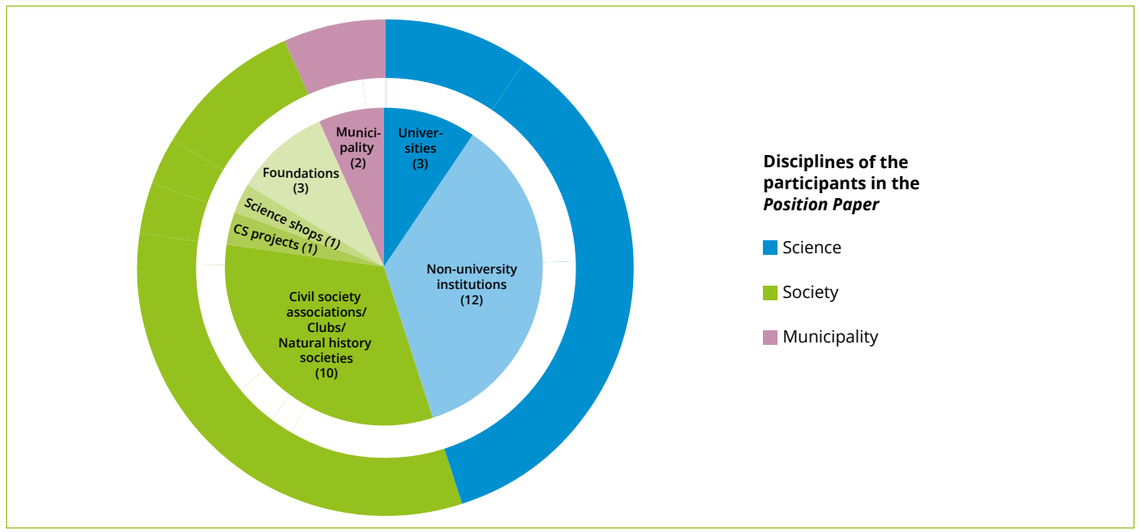

Figure 16: Distribution of position paper participants (n = 31) according to form of organisation

PARTICIPATING ORGANISATIONS THAT SUBMITTED POSITION PAPERS

Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (Alfred Wegener Institute – AWI)

German Arachnological Society

Berlin Institute of Health at Charité (BIH)

Federal Network for Civic Engagement (BBE)

German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig

Forschungszentrum Jülich

Friends of the Environmental Education Centre Pleistalwerk

Helmholtz Centre for Environmental Research UFZ/butterfly monitoring

IANUS Association for Peace-Oriented Technology Design e.V./IANUS Peacelab

Institute for Technology Assessment and Systems Analysis (ITAS) at the Karlsruhe Institute of Technology (KIT)

Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forests and Fisheries/Citizen Science Working Group at the Thünen Institute for Biodiversity

Körber Foundation/Science Division

Leibniz Institute for the Analysis of Biodiversity Change (LIB)/ZFMK, Public Law Foundation/Zoological Research Museum Alexander Koenig and Zoological Museum Hamburg

Leibniz Citizen Science Working Group

Leibniz Centre for Agricultural Landscape Research (ZALF)

Martin Luther University Halle-Wittenberg: Didactics of Biology

Natural History Museum Berlin, Leibniz Institute for Evolutionary and Biodiversity Research

naturgucker.de non-profit association

Lower Saxony Heritage Society

POLLICHIA, Association for Nature Research, Nature Conservation and Environmental Education

Ruhr University Bochum

Senckenberg Society for Nature Research SGN/Civic Engagement

Rhineland-Palatinate Nature and Environment Foundation/ArtenFinder Rheinland-Pfalz

VdA – Association of German Archivists

German Diving Association/Environment and Science Section

German Association for Computer Genealogy

Wikimedia Deutschland e. V./Education, Science & Culture

Science in Dialogue

Bonn Science Shop

Centre for General Scientific Continuing Education(ZAWiW) at the University of Ulm/Humanities Department

Another organisation that does not wish to be named.

ORGANISATIONS OF THE AUTHORS AND CONTRIBUTORS

Authors and contributors to the dialogue forums and to the writing and review processes were active in the following organisations (The views and opinions expressed in this White Paper do not necessarily reflect those of the participants or their organisations):

University of Freiburg • Alfred Wegener Institute – Helmholtz Centre for Polar and Marine Research (AWI) • basis.wissen.schafft e. V. • Bavarian Research Institute for Digital Transformation • Berlin Institute of Health-QUEST Center • Vocational College • BIO-Diverse • Bliesgau Biosphere Association • Botanical Garden and Botanical Museum Berlin (BGBM) • Brandenburg University of Technology Cottbus-Senftenberg • BUND – German Federation for the Environment and Nature Conservation • Federal Ministry of Education and Research (BMBF) • German National Network for Civil Society (BBE) • German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig • German Federal Environmental Foundation • German Research Foundation • Deutsches Museum in Munich • ECSA European Citizen Science Association • European Institute for Participatory Media • European Commission • Familia Austria • Forschungszentrum Jülich • Fraunhofer Information Center for Planning and Building Stuttgart • Fraunhofer Institute for Systems and Innovation Research ISI Karlsruhe • Fraunhofer Institute for Factory Operation and Automation Magdeburg • Fraunhofer Institute for Industrial Engineering Stuttgart • Fraunhofer Center for International Management and Knowledge Economics Leipzig • Freie Universität Berlin • Heidelberg Volunteer Agency • University of Jena • Austrian Science Fund • University of Göttingen • German Council for Scientific Information Infrastructures (RfII) • Helmholtz Association's Berlin Head Office • Leibniz Headquarters • Helmholtz Open Science Office • Helmholtz-Zentrum Hereon • Helmholtz Centre for Infection Research • Helmholtz-Zentrum München – German Research Centre for Health and Environment • Helmholtz Institute for Pharmaceutical Research Saarland (HIPS) • GFZ German Research Centre for Geosciences • Helmholtz Centre for Environmental Research - UFZ • Heimatmuseum Egling • Heinrich Heine University Düsseldorf • Hof University of Applied Sciences • Weihenstephan-Triesdorf University of Applied Science • Eberswalde University for Sustainable Development • Heilbronn University of Applied Sciences • Institute for Community Medicine University of Greifswald • Institute of Data Science at the German Aerospace Center (DLR) • Institute for Research on Higher Education Halle-Wittenberg • IEM Institute of Environmental Medicine Helmholtz Munich • Institute for Quality and Efficiency in Health Care (IQWiG) • Jade University of Applied Sciences Wilhelmshaven/Oldenburg/Elsfleth • Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forests and Fisheries • Julius Kühn-Institut (JKI) Federal Research Centre for Cultivated Plants • Karlsruhe Institute of Technology KIT • Kiel Science Factory • Culture Management Network • Regional Association for Bird Protection • Leibniz Citizen Science Working Group • Leibniz Research Network Biodiversity (LVB) • Leibniz Institute for Evolutionary and Biodiversity Research (MfN) • Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB) • Leibniz Institute for Regional Geography (IfL) • Leibniz Institute for Science and Mathematics Education (IPN) Kiel • Leibniz Institute for Zoo and Wildlife Research (IZW) • Leibniz University Hannover • Leibniz Centre for Agricultural Landscape Research (ZALF) • Martin Luther University Halle-Wittenberg CompGen • Max Delbrück Center for Molecular Medicine (MDC) • Max Planck Institute for Biogeochemistry • Mehr Demokratie Deutschland – LV Sachsen • Museum of Labour • Natural History Museum Berlin • NABU naturgucker.de • NABU-Münsterland Nature Conservation Station – Federal Botany Committee • National Institute for Science Communication • Natural Research Society of Emden of 1814 • Natural History Museum Vienna • CitizenScience@Helmholtz Network • Bürger schaffen Wissen Network • OeAD Centre for Citizen Science • Open Knowledge Lab • Ostfalia University of Applied Sciences – Healthcare Wolfsburg • Österreich forscht: University of Natural Resources and Life Sciences, Vienna • Participatory Science Academy – University of Zurich and Swiss Federal Institute of Technology • Project Management Agency German Aerospace Center (DLR) • Ruhr University Bochum • Saxon State Library – Dresden State and University Library • Schweiz forscht: Science et Cité • Berlin Senate Department for the Environment, Transport and Climate Protection • Senro.Community • Donors' Association • Rhineland-Palatinate Nature and Environment Foundation • Technical University of Wildau • Technical University of Munich • Federal Environment Agency • Environmental Education Centre • Pleistalwerk e. V. • University of Bremen – Cognitive Neuroinformatics • University of Innsbruck • Leipzig University • University of Potsdam – Inno-UP • University of Rostock • University of Salzburg • University of Stuttgart • University Centre for Health Sciences at Augsburg Hospital (UNIKA-T) • Frankfurt University Hospital – Christiane Herzog CF Centre • Association for Biology, Biosciences and Biomedicine in Germany – VBIO • German Association for Computer Genealogy • University of Münster • Science in Dialogue (WiD) • Bonn Science Shop • Wuppertal Institute for Climate, Environment and Energy • Centre for Social Innovation • Civil Society Platform Forschungswende

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Successful sampling at the Großer Stechlinsee in the Diving for Nature Conservation CS project. Photo: Silke Oldorff/NABU BFA Living Lakes