Step Change

The Step Change navigator in citizen science

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Concept

The *Step Change navigator* in citizen science draws upon the experience of the Step Change project, aiming to generalise and upscale its learnings for the benefit of other citizen science practitioners embarking on their own journeys. It is complemented by the *online database* that allows users to search and navigate dozens of resources collected in late 2023 and early 2024.

The *Step Change navigator* in citizen science is intended as a valuable resource for anyone interested in citizen science. It provides a comprehensive overview of the field, practical guidance for project development, and inspiring insights from the Step Change project.

The book explores theoretical aspects and presents reflections on the lessons learned by the project partners during their three-year journey. It also provides an overview of the project itself and its activities.

Key features:

- Presents a comprehensive overview of the citizen science landscape, including key concepts, and benefits.

- Offers practical guidance on planning, implementing, and evaluating citizen science projects.

- Shares insights and best practices from the Step Change project, including lessons learned, challenges faced, and successes achieved.

- Provides a wealth of resources, including case studies, toolkits, and training materials.

The book's most original section is Section 5, *Key Trends in Citizen Science Initiatives from Step Change*, which offers valuable insights and guidance for the future of citizen science.
This book is intended for a wide audience, including:

- Citizen science practitioners and researchers

- Policymakers and funders

- Educators and students

- Anyone interested in learning more about citizen science.

02 Navigator main tasks

This section embarks on a voyage of discovery, exploring citizen science with the help of a navigator, both as a human role and a technological tool. We begin by charting our course through the definition provided by Wikipedia, understanding a navigator's primary responsibility: maintaining constant awareness of their vessel's position.

According to Wikipedia, "A navigator is the person on board a ship or aircraft responsible for its navigation. The navigator's primary responsibility is to be aware of ship or aircraft position at all times. Responsibilities include planning the journey, advising the ship's captain or aircraft commander of estimated timing to destinations while en route, and ensuring hazards are avoided." As an extension, a navigator is also a device (such as a computer) that is used to plan or find the route to a place.

2.1. Citizen science approach

Citizen science projects function like well-equipped vessels, bringing together individuals from diverse backgrounds and expertise. They work collaboratively to investigate, explore, collect data, observe, create, and experiment across various fields, ranging from ecology and astronomy to medicine and computer science.

Citizen science engages individuals, groups, and networks of volunteers of any age or background who are not professional researchers together with scientists in a common project. Through this collaborative effort, citizen science acts as a powerful tool, granting scientific research access to fresh resources and facilitating the publication of thousands of studies. The level of participation in these projects can vary, ranging from simple data collection to co-creation, where volunteers actively contribute to shaping the research itself.

By putting the participants in front of the open questions of contemporary research, questions often linked to their personal and local experience, and making them establish a live and direct contact with researchers, citizen science is an ideal way to increase the science capital of the participants. Through the collaboration between citizens and scientists, new knowledge and awareness on the practices and methods of research are generated. The direct involvement of students and the connection between science and their life experience are facilitated and made clear.

To navigate the vast and complex sea of citizen science, two key resources serve as your compass and guiding stars: the *10 Principles of Citizen Science* (*https://ecsa.citizen-science.net/documents/*) and the *Characteristics of Citizen Science* (*https://ecsa.citizen-science.net/wp-content/uploads/2020/05/ecsa_characteristics_of_citizen_science_-_v1_final.pdf*).

Nautical charts

03

3.1. Step Change

Step Change is a project funded by the European Union (under EC grant agreement No 101006386) lasting from March 2021 to April 2024 with the aim to ensure that research institutes make the most of what citizen science has to offer, whilst also identifying, analysing, and limiting the associated risks.

Step Change builds on the assumption that citizen science can play an even broader societal and scientific role than is generally acknowledged. The project explored the potential of citizen science and formulated recommendations and instruments for better cementing this approach within R&I institutions as well as changing researchers' mindsets on its value.

To maximise its impact, Step Change made use of a multifaceted methodology not only fostering alignment with local contexts, but also nurturing mutual learning, encouraging self-reflection, and performing participatory evaluation exercises.

The core of Step Change are five citizen science initiatives, developed in the fields of health, energy and environment. These initiatives tackle the issues of wildlife conservation in Slovenia, non-alcoholic fatty liver disease in the United Kingdom, energy communities in Germany, infectious disease outbreak preparedness in Italy, and off-grid renewable energy in agriculture in Uganda.

The project draws on the expertise of 11 partners from 7 European countries and Uganda, to increase the mutual responsiveness of science and society while boosting the capacity of scientific investigation over phenomena that cannot be completely seized within conventional disciplinary boundaries.

As a final result and legacy for future citizen science initiatives, Step Change presents now *The Step Change Navigator* in citizen science. This book is associated with a web-based database that collects theoretical and practical insights about different citizen science applications.

Web: *https://stepchangeproject.eu/*

The Step Change navigator in citizen science: *http://cs_navigator.stepchangeproject.eu*

Facebook: *@StepChangeEU*

LinkedIn: *@stepchange-eu*

X: *@StepChangeEU*

Instagram: *@stepchange_eu*

YouTube: *@stepchangeproject1925*

3.2 The Step Change crew

University of Primorska, Slovenia

Univerza na Primorskem is Slovenia's third largest public university, was established in 2003 as a centre of knowledge implementing European educational strategies. Its main objective is to carry out high quality study and research programmes, implementing and integrating them with educational, intellectual and research potential in accordance with European strategies. It satisfies regional demands and needs for quality higher educational programmes in the bilingual area, where Slovenian and Italian cultures are historically intertwined. It also aims to produce beneficial co-existence and close collaboration with industry. University of Primorska provides an active, interdisciplinary research and study environment based on two fundamental pillars: mathematics, natural sciences and technology, and humanities and social sciences. By incorporating both pillars in research and study activities, University of Primorska achieves improved interdisciplinary collaboration and improved international co-operation with the world's leading institutions and researchers.

University of Primorska is the lead project partner responsible for project management and coordination. University of Primorska is also responsible for the implementation of the citizen science initiative on wildlife conservation in Slovenia.

Aarhus University, Denmark

Aarhus University is a leading European research university with education and research activities in all scientific disciplines. The University attracts 25% of the Danish research funding and has been awarded several European Research Council advanced and starting grants. The Danish Centre for Studies in Research and Research Policy (CFA) is a research centre at the Department of Political Science, responsible for carrying out both basic research and long-term competence building, together with more practical oriented analyses, evaluations and policy investigations. The Danish Centre for Studies in Research and Research Policy is active in the areas of RRI (Responsible Research and Innovation), citizen science, structural transformations, gender and implementation of gender action plans in research organisations, evaluation, capacity building, comparative studies and research policy.

Within Step Change, Aarhus University is part of the evaluation team, working synergically with Knowledge & Innovation. More specifically, Aarhus University is responsible for the evaluation components aimed at the assessment of societal impact according to MoRRI (and SUPER MoRRI) and SDG frameworks.

Action for Rural Women's Empowerment, Uganda

Action for Rural Women's Empowerment (ARUWE) is a gender focused organisation that strengthens women's leadership so that collectively they can break the chains of poverty, patriarchy, class and sexual repression. We do this through advocating for rural women's economic justice, sexual and reproductive health and rights, promoting education and lifelong learning, enabling communities to adapt to climate change and challenging the negative impact of rigid and oppressive gender stereotypes.
ARUWE is a non-profit, non-government organisation working with marginalised groups of people, especially women and girls in Uganda. ARUWE was established in 2003 as a community-based organisation and later registered as a non-profit, non-government organisation in 2008. The organisation

started its operations in Wakiso district supporting women to increase agricultural production for household food security and income generation. Currently, ARUWE operates in the central and north-eastern regions of Uganda focusing on socio-economic empowerment of women and girls. We envision seeing a world in which women and girls realise their full social potential. We empower women to initiate and manage their socio-economic development processes through strengthening community participation, advocacy and service delivery.

ARUWE is responsible for the implementation of the citizen science initiative on off-grid renewable energy in rural Uganda.

Centre for Social Innovation, Austria

The **Zentrum für Soziale Innovation** (ZSI - Centre for Social Innovation) is a trans-disciplinary, non-for-profit, social science research institute. Located in Vienna, Austria, the institute employs around 60 people, most of them researchers from different disciplinary backgrounds. The ZSI offers analyses and concepts for promoting and implementing social innovation in its thematically focused areas from a transdisciplinary perspective.

Within Step Change, ZSI is responsible for mutual learning and training. The work focused on supporting the research activities carried out in the citizen science initiatives by strengthening the citizen science initiative teams in trans-disciplinary work and responsive stakeholders' engagement. ZSI also fostered synergies among the citizen science initiatives and between the citizen science initiatives and other relevant citizen science experiences.

European Citizen Science Association

The European Citizen Science Association (ECSA) is a non-profit organisation set up to support citizen science as a recognized and well-established approach in Europe and beyond. ECSA advocates for enhancing the participation of the general public in scientific processes as a way to advance science while increasing the social relevance and sustainable impact of research. Through the initiation and support of citizen science projects and the performance of research on citizen science, ECSA fosters scientific literacy and contributes to the democratisation of science.

ECSA manages the eu-citizen.science platform, an online platform for sharing knowledge, tools, training and resources for citizen science – by the community, for the community.

As part of Step Change, ECSA conducted a stocktaking process to leverage the knowledge and lessons learned from the implementation of the five citizen science initiatives. This information set the basis for the present Citizen Science Navigator to guide researchers in different fields wanting to apply a citizen science approach.

European Science Engagement Association

EUSEA is an international community of public engagement professionals, science festival and science event organisers. The association comprises about 120 members, including universities and scientific institutions, science festival organisations, science centres and museums, municipalities and NGOs.

The network has developed from a knowledge-sharing platform for European science festivals to a collaborative community of public engagement professionals, developing and testing new formats of science communication, building relationships with researchers, policy-makers and stakeholders from scientific institutions, higher education institutions, municipalities and regions. EUSEA is the initiator of the *European Science Engagement Platform*, a resource of recommendations, best practices and innovative event formats for practitioners working in the field of science-society dialogues.

EUSEA is the leading partner responsible for communications and dissemination activities.

Knowledge & Innovation, Italy

Knowledge & Innovation is a social research institute, whose mission is to promote, plan and carry out applied research projects in different areas connected with the processes of change that are affecting contemporary societies. Knowledge & Innovation is currently involved in several research funded projects on issues such as the socialisation of scientific research, responsible research and innovation and public engagement, gender in science, ethics and integrity of research, migration, environmental sustainability and energy transition, privacy, security and digitisation.

Knowledge & Innovation is the leading partner responsible for the evaluation component of the project. The evaluation exercise adopted a participatory method aiming to involve citizen science initiative teams at every stage of the evaluation process.

Oxford University Hospitals NHS Foundation Trust, United Kingdom

The NIHR Oxford Biomedical Research Centre is based at the Oxford University Hospitals NHS Foundation Trust and runs in partnership with the University of Oxford. The Oxford Biomedical Research Centre undertakes translational research, which means taking laboratory research into a clinical setting. This kind of research is about first-time studies of medical innovations in patients, which are intended to improve healthcare delivery for the benefit of all patients. The Oxford Biomedical Research Centre is divided into 20 themes and four clusters: Precision Medicine, Technology and Big Data, Immunity and Infection, and Chronic Diseases.

The Oxford Biomedical Research Centre is the leading partner responsible for the implementation of the citizen science initiative on non-alcoholic fatty liver disease in the United Kingdom.

Science for Change, Spain

Science for Change is a company born from the will to tackle societal and environmental challenges affecting communities using innovative solutions. It specialises in developing user-centred, innovative services and products based on citizen science, participatory strategies, community engagement and co-creation processes to facilitate social innovation.

Within Step Change, Science for Change led work focusing on the scoping process, focusing notably on ensuring citizen scientists' recruitment for each citizen science initiatives as well as establishing institutional arrangements and other accomplishments for citizen science initiatives implementation, to increase sustainability of the initiatives since the very beginning.

University of Rome Tor Vergata, Italy

Established in 1982, the **University of Rome Tor Vergata** currently offers 106 graduate programmes and 32 PhD courses. Our 18 Departments and 48 Research Centers are active in numerous disciplines to expand basic and applied research. Tor Vergata is part of several important networks such as YERUN (Young European Research Universities Network), VIU (Venice International University) and UNICA (Network of Universities from the Capitals of Europe). The Department of Biology at the University Tor Vergata, established in 1983, focuses its training and research mission on cutting-edge issues regarding studies on life at all its levels of organisation and diversity. The various research areas contribute to developing a multidisciplinary platform through constant scientific activity in the biomedical, biotechnological, bioinformatics, ecological, evolutionary and agri-food fields, both through basic research and through collaborations with public and private partners as well as national and international entities. The Department of Biology is attentive to the themes of Responsible Research and Innovation and Sustainable Development with activities aimed at structural change in research institutions. The UNESCO Interdisciplinary Chair in Biotechnology and Bioethics, involved in Step Change, has been present in the Department of Biology since 1998, carrying out numerous national and international collaborations in research and education mainly in the infectious diseases (HIV, Ebola, Zika, COVID-19) and immunology fields.

The University of Rome Tor Vergata is the leading partner responsible for the implementation of the citizen science initiative on infectious disease outbreak preparedness in Italy.

Women Engage for a Common Future, Germany

Women Engage for a Common Future (WECF) is a non-profit network dedicated to a gender just and healthy planet for all. The international network consists of over 150 women's and civil society organisations implementing projects in 50 countries. WECF believes that a sustainable future and environment needs holistic solutions reflecting the lives of people on the ground, and in feminist solutions based on partners' visions and needs. The network works on transformative gender equality and women's human rights in interconnection with climate justice, sustainable energy and chemicals, less toxic waste, safe water and sanitation for all. WECF has expertise in three thematic areas: sustainable development, climate action, and a toxic free healthy environment. WECF implements solutions locally while influencing policy internationally.

WECF is responsible for the implementation of the citizen science initiative on energy communities in Germany.

Navigating the five routes plus one

04

This section embarks on a journey through five unique citizen science initiatives explored by Step Change, highlighting their efforts to find common ground in the realms of health, energy, and environment through Mutual Learning Exercises.

4.1 Wildlife conservation | Slovenia

Our first stop on this voyage takes us to the Hunters Association of Slovenia (HAS), the main Slovene hunting organisation of nearly 21,000 members. Their mission emphasises sustainable wildlife management, hunter education, and environmental protection.

To achieve these multifaceted goals, the HAS has developed a pioneering tool called the Hunting Information System (HIS). This innovative tool serves as a comprehensive national wildlife data repository.

While collaboration between the HAS, decision-makers, and researchers exists, the full potential of the HIS for advanced analyses and scientific exploration remains untapped.

The University of Primorska team set out to improve the collection of evidence for wildlife presence in Slovenia. Their strategy involved recruiting citizen scientists, including outdoor enthusiasts and nature observers, through an experimental campaign. Establishing data collection and verification procedures was crucial for ensuring the quality and reliability of the information gathered.

Diverse tools, shared goal

The team employed various tools to collect wildlife data from citizen scientists, including the development of the *SRNA app* and the use of camera traps. This citizen science initiative served as a test bed for evaluating the potential of citizen science in supporting evidence-based wildlife management and raising public awareness about biodiversity and conservation.

Facing the winds of experience

Utilising the innovative SRNA app and camera traps, the University of Primorska team swiftly gathered a significant amount of wildlife observation data that would have been impossible through traditional scientific monitoring alone. Camera traps provided valuable insights into animal presence and abundance in specific locations. Collaboration with HAS hunters and the participation of nature enthusiasts via the SRNA app were both successful aspects of the project. Additionally, the Step Change project facilitated knowledge transfer and awareness-raising about wildlife and nature through connecting the University of Primorska team with diverse stakeholders and decision-making bodies.

Navigating challenges

Despite their successes, the University of Primorska team encountered obstacles. Raising awareness about wildlife conservation research and the SRNA app among local communities proved challenging. While reaching established stakeholders was smoother due to existing connections, maintaining user engagement with the SRNA app posed another hurdle.

Charting a new course

To address these challenges, the University of Primorska team embarked on several initiatives. Work-

shops and events were organised to reignite community interest, and an active social media presence was maintained to emphasise the importance of wildlife conservation efforts.

Unforgettable encounters

During the European Researchers' Night 2023, the University of Primorska team encountered a delightful challenge. A workshop initially designed for Slovenian children was adapted on the fly to accommodate a group of children from various backgrounds, including Italian speakers. Despite the unexpected change, the team successfully provided engaging activities and valuable information about wildlife, leaving the children with a positive experience.

Figure 1-3. A photo trap and some images captured by it within the citizen science initiative in Slovenia

Messages for future navigators

This section shares valuable messages gleaned from the University of Primorska's expedition, serving as a compass for new navigators embarking on their own citizen science journeys.

Assembling a diverse crew

Reflecting on their experience, the team emphasises the significance of a diverse crew in citizen science projects. They recommend including nature observers from various cultural backgrounds, genders, social statuses, and vulnerable groups. A dedicated strategy for enrolling and engaging such diverse participants is crucial to promote the project effectively.

Setting sail with a plan

Before embarking on any citizen science voyage, careful pre-voyage planning is essential. This includes mapping your stakeholders and identifying your target groups of citizen scientists.

Charting your course

Clearly define your main objective and strategize how citizen participation can contribute to achieving it within your specific research context. This ensures your journey has a clear destination.

Sending out the signals

Communication and dissemination are key to attracting a robust crew of citizen scientists. Utilise various social media platforms for large-scale promotional campaigns, and organise events and workshops to engage your target audience.

Equipping your crew

The SRNA app served as a valuable tool on this voyage, but the team acknowledges potential for improvement. They recommend incorporating interactive and game-like elements, like points, badges, and competition, to boost user motivation and enhance data collection.

Building a community

Adding a community tab within the app could foster engagement. This space would allow users to ask questions of researchers and other citizen scientists, sharing wildlife observations and experiences. Additionally, the wildlife identification quiz could benefit from minor refinements.

Navigation tips

The team emphasises the importance of meticulous data planning. Collecting data with analysis in mind ensures you have the necessary tools and knowledge to interpret your findings once you reach your destination.

Ethical considerations

Ethical considerations must be addressed throughout your research. If you develop an app, be transpa-

rent about the collection of any personal data. Similarly, be mindful of the potential for camera traps to capture bystanders and ensure appropriate protocols are in place.

4.2 Non-alcoholic fatty liver disease | United Kingdom

This section embarks on a journey to explore the NIHR Oxford Biomedical Research Centre's investigation into non-alcoholic fatty liver disease (NAFLD). This research, conducted in Oxfordshire, England, where over half the adult population grapples with being overweight or obese, utilises a citizen science approach to shed light on this prevalent health concern.

Charting the course

The research team, led by the Oxford Centre for Diabetes, Endocrinology and Metabolism, seeks to unlock the secrets of steroid hormones and their role in the development, assessment, and treatment of metabolic diseases like NAFLD.

A translational expedition

This citizen science initiative serves as a translational experiment in the field of metabolic endocrinology. Its primary mission is to gain a deeper understanding of diurnal variations in hepatic lipid metabolism among overweight individuals under different conditions. The project also includes a lifestyle intervention involving a weight loss program.

Relevance and impact

This research holds particular relevance for the region, given the high prevalence of overweight and obese individuals in Oxfordshire.

Defining our objective

The project set out to explore the adoption of a citizen science approach within the realm of metabolic endocrinology. This involved conducting a translational medicine research experiment focused on NAFLD, incorporating a 12-week lifestyle and weight loss intervention.

Assembling the crew

The citizen science initiative brought together a diverse crew of 24 participants, including individuals with and without NAFLD, alongside approximately six citizen scientists. The recruitment of these citizen scientists, a crucial element of the project's success, utilised various channels, as detailed in Figure 4.

For further in-depth information on the methodological details of this citizen science initiative, you can refer to the publication by Shah et al. (2023) in the "Citizen Science Theory and Practice Journal."
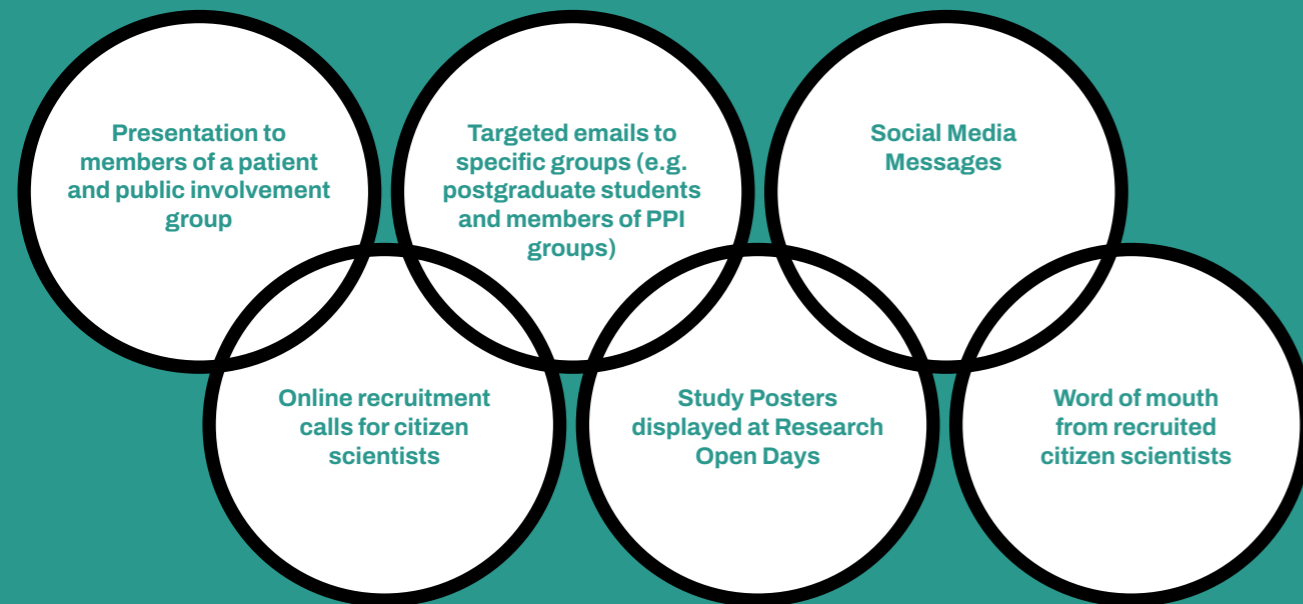
Figure 4. Successful methods of citizen scientists' recruitment

Presentation to members of a patient and public involvement group

Targeted emails to specific groups (e.g. postgraduate students and members of PPI groups)

Social Media Messages

Online recruitment calls for citizen scientists

Study Posters displayed at Research Open Days

Word of mouth from recruited citizen scientists

Citizen scientists' activities

Citizen scientists were involved in different research activities as shown in Figure 5 below. However, before embarking on their research voyage, the citizen scientists received essential training to ensure they were well-equipped. This training focused on research skills development, particularly in the areas of biomedical research ethics and data analysis, encompassing both quantitative and qualitative aspects.

Review of participants' reflective diaries and questionnaire surveys

Participation in training on ethics in research and data analysis

Co-analysis of fully anony mised qualitative and quantitative data

Co-synthesis of the findings

Review of deliverables and manuscript(s)

Participation in the participatory evaluation of the CSI on NAFLD

Participation and input in the CSI stakeholders' workshop

Involvement in communication and dissemination activities of the project

Figure 5. Citizen scientists' activities in the citizen science initiative on non-alcoholic fatty liver disease

Learning the ropes

During the final participatory evaluation workshop, the citizen scientists expressed their satisfaction with their participation and immense appreciation for the research skills development training provided. These training sessions fostered positive and productive relationships between the citizen scientists and professional researchers, ultimately boosting motivation and engagement in the project.

Unveiling personal treasures

The citizen scientists reported a sense of significant personal benefit from participating in the research, expressing a strong willingness to contribute to future health research projects. However, they highlighted the need for sustainable structures and mechanisms to facilitate ongoing citizen involvement in research initiatives.

Valuable cargo

To sustain participation, retention, and interest throughout the project, the citizen scientists received various incentives, which they found valuable and motivating.

Training in research skills

Hands on research experience

Understanding of the research process

Learning about the health condition and the intervention

Development of expertise as a citizen scientist

Nomination as a citizen scientist of the month

Reimbursement of travel and caring costs

Social learning and networking

Opportunities to write and publish articles and blogs

Certificate of participation as a citizen scientist

Recognition of contributions in the acknowledgements
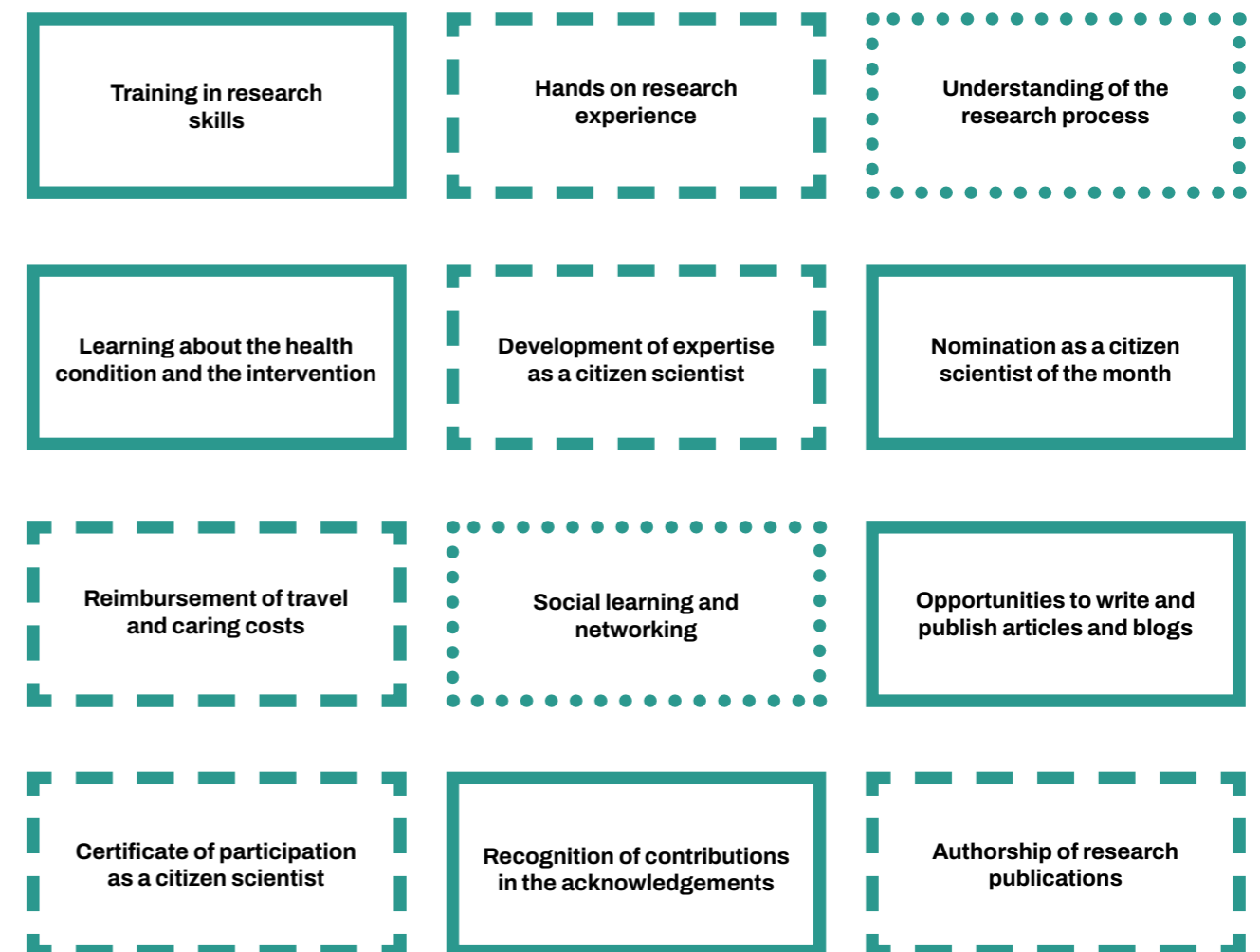
Authorship of research publications

Figure 6. Incentives offered to citizen scientists.

Navigating challenges

While the project yielded positive outcomes, involving citizen scientists also presented challenges. This section dives into the key challenges encountered, as illustrated in Figure 7.
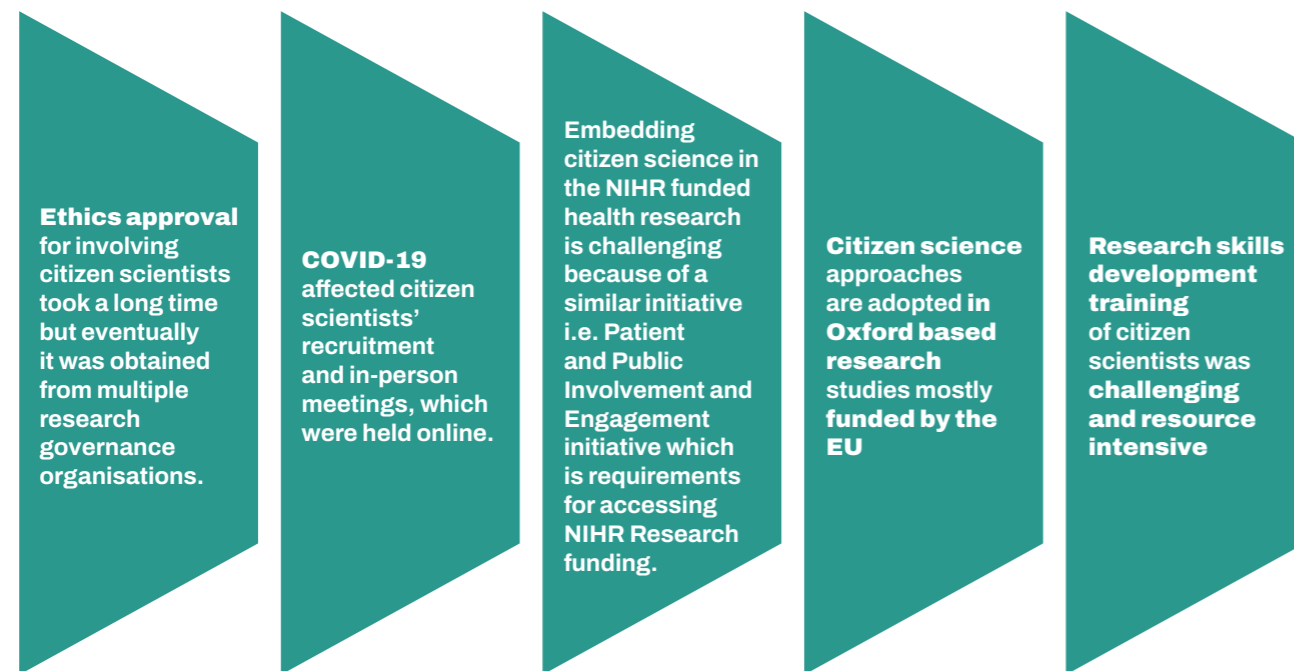

Ethics approval for involving citizen scientists took a long time but eventually it was obtained from multiple research governance organisations.

COVID-19 affected citizen scientists' recruitment and in-person meetings, which were held online.

Embedding citizen science in the NIHR funded health research is challenging because of a similar initiative i.e. Patient and Public Involvement and Engagement initiative which is requirements for accessing NIHR Research funding.

Citizen science approaches are adopted **in Oxford based research** studies mostly **funded by the EU**

Research skills development training of citizen scientists was **challenging and resource intensive**

Figure 7. Challenges encountered in the citizen science initiative on non-alcoholic fatty liver disease

Unforgettable moments

"It was really nice to get a refresher on going through the basics of statistics and working up to actually applying… I found that interesting. I would like to learn more about that as well. For me, I felt in a way that I was given a lot. I perhaps would like to have done more back. Really positive experience. Very positive. The meetings were always, you know, very useful."

"Lots of new knowledge and lot of learning. I also would like to give back more. I don't have the science background… when I learned about this. I can do this. I can be part of a scientific project. It was like, wow!"

"The training was brilliant… First of all, it was great the fact that it was offered and being offered because those you were all in different parts of the country or even abroad. So that was nice. I introduce myself as citizen scientist rather than PPI member."

Charting a new course: reflections and recommendations

Lessons learned

The NAFLD citizen science initiative serves as a beacon, illuminating the value of collaborative research practices. It demonstrates the tremendous potential of citizen scientists' involvement in health research, particularly in harnessing their experiences, expertise, knowledge, skills, and perspectives. This collaborative approach fosters the co-creation of scientific knowledge, enriching the research journey.

Navigating uncharted waters

However, the project also steers us towards uncharted waters, highlighting the challenges of widespread adoption of citizen science within the realm of clinical research. The strict regulatory landscape and ethical considerations surrounding patient privacy in the United Kingdom present significant hurdles. These headwinds pose a substantial challenge to integrating citizen science seamlessly into clinical research practices.

Finding new horizons

Despite these challenges, the path forward is not entirely shrouded in mist. The potential for integrating citizen science with existing initiatives, such as the patient and public involvement agenda in health research, presents an exciting avenue for exploration. By charting a course that leverages existing frameworks and prioritises ethical considerations, we can work towards a future where citizen science plays a more prominent role in shaping and advancing clinical research within the UK healthcare system.

4.3 Energy communities | Germany

Harnessing solar potential: a citizen science voyage in Germany

This section embarks on a journey to explore a citizen science initiative in Germany focused on unlocking the untapped potential of photovoltaic systems in multi-family buildings. These buildings, housing over half of Germany's apartment dwellers, offer a significant opportunity for sustainable energy generation.

Following the legislative wind

The Tenant Electricity Law, introduced in 2017, serves as a favourable wind, creating incentives for residents and tenants to increase self-consumption, reduce energy costs, adapt their energy use, and contribute to CO2 mitigation. This law allows for neighbourhood electricity sharing mechanisms, paving the way for a more sustainable urban energy landscape.

Charting a course for change

Despite the law's potential, the tenant electricity model remains underutilised in multi-family buildings, presenting a vast uncharted territory for exploration. This citizen science initiative set out to navigate these uncharted waters, focusing on the model's potential in this setting.

Assembling a diverse crew

The project embraced an inclusive research approach, bringing together a diverse crew of citizen scientists, scientists, policymakers, and private sector representatives. This collaborative effort aimed to investigate the barriers and drivers influencing the adoption of the tenant electricity model, while also exploring the motivations of citizen scientists participating in the initiative. Additionally, the research delved into the behavioural changes experienced by the citizen scientists (based on the energy culture concept) due to their involvement in local electricity production and consumption.

Unforgettable encounters

The most rewarding aspect for the research team was witnessing the positive shifts in the energy culture of the citizen scientists. One tangible outcome was observed through the feedback provided on energy data collected from installed smart metres. This data revealed an average reduction in electricity consumption for over half of the participating households compared to the project's initial phase.

Figure 8. Installation of intelligent metering systems at citizen scientist household (Ph: WECF)

4.4 Infectious disease outbreak preparedness | Italy

Navigating uncertain waters

This section embarks on a journey to explore a citizen science initiative in Italy aimed at enhancing preparedness for future infectious disease outbreaks. This project navigates the uncharted territory of citizen science in the realm of public health preparedness.

Learning from past voyages

The research team at Tor Vergata initially focused on participatory action research and popular epidemiology approaches, which have proven effective in various past outbreaks, including Zika, Ebola, Avian flu, Swine flu, SARS/MERS, and COVID-19. These approaches, like sturdy vessels, have demonstrated their potential to support public health practices during outbreaks.

Charting a new course

Building upon this foundation, the project delved deeper, investigating how citizen science and similar approaches could be applied specifically within the context of the COVID-19 pandemic. This investigation led to the development of a taxonomy for citizen science interventions, categorising potential applications based on different disease types and epidemiological behaviours. This taxonomy serves as a valuable map for future citizen science endeavours in public health.

Exploring existing voyages

Next, the team undertook a voyage of analysis, examining relevant citizen science initiatives that had already set sail. Additionally, they conducted an on-site visit to the locations where these initiatives were implemented, gaining valuable firsthand insights.

Preparing for the future

Drawing upon the knowledge gathered, the project team co-designed a citizen science strategy specifically tailored to boosting Italy's preparedness for future outbreaks. This strategy aims to raise awareness about the valuable role citizen science can play when incorporated into institutional and scientific practices for effective infectious disease outbreak management.

Engaging the crew

The project involved citizen scientists, who actively participated in analysing, discussing, and developing strategies for civil society engagement in the fight against infectious disease outbreaks. This collaborative approach ensured that diverse voices and perspectives were incorporated into the strategy.

Facing rough seas

The initial stages of the project, however, were not without their challenges. The Tor Vergata team encountered resistance from the public, who were weary of topics related to the COVID-19 pandemic, including prevention measures like social distancing, masks, and vaccines. This public fatigue significantly impacted the recruitment phase for citizen scientists. Many individuals were distrustful of the project's proposal to collaborate with researchers, and some viewed preparedness efforts as unnecessary due to the recent pandemic experience. The initial meetings often became platforms for citizens to express their disappointments with the difficulties they had faced during the pandemic, sometimes holding the research community partially responsible. This initial phase, characterised by listening and understanding the public's perspective, proved crucial for the team to adjust their approach and acknowledge the public's state of distrust and apprehension about future outbreaks.

Adapting the course

Recognizing the societal shift between 2022 and 2023, the research team adapted their approach accordingly. They focused on recruiting citizen scientists from highly responsive groups directly impacted by past outbreaks or those directly involved in emergency response, such as school operators, healthcare workers, and citizen associations. This targeted approach aimed to engage individuals with a vested interest and relevant experience in preparedness efforts.

Unforgettable encounters: a shift in the tide

This section highlights the unforgettable moments experienced by the Tor Vergata team during the citizen science initiative. These moments mark a positive shift in public perception and engagement.

Dialogue and understanding

Events like the European Researchers' Night in 2023 finally provided an opportunity for meaningful dialogue with the public. The project team presented their findings, including insights from citizen science experiences in other countries. This presentation sparked considerable interest, with attendees asking questions and engaging in constructive discussions, a stark contrast to the criticism faced in 2022. This positive shift in public receptiveness within a year signifies a growing interest in the crucial topic of infectious disease preparedness.

Listening and learning

Throughout 2023, the team organised dedicated meetings with citizens to discuss infectious disease preparedness. After navigating the initial challenging phase marked by public distrust, the team found themselves sailing in calmer waters. They were met with active participation and interest from the citizens involved. These meetings fostered open dialogue, allowing each individual to share their voice on preparedness, recounting their own experiences and raising various relevant issues from diverse societal perspectives. The Tor Vergata team adopted a listening approach, transitioning from being the "scientists" dictating protective measures to becoming "scientists" who actively listen to the public's concerns and perspectives on protection and preparedness for infectious diseases.

> "The interactions with the public made us reflect on the need to identify the right times, places, ways and, above all, targets to communicate and collaborate on citizen science projects."

Figures 9-10. The presentation of the Italian citizen science initiative at the European Researchers' Night in 2023 in Rome

4.5 Off-grid renewable energy in agriculture | Uganda

Cultivating sustainability: setting sail for a greener future

This section embarks on a journey to explore a citizen science initiative in Uganda that investigates the potential of renewable energy in agricultural production. This initiative aims to navigate towards a future of increased energy sustainability and environmental responsibility within the agricultural sector.

Empowering the crew

The project team at Step Change recognized the inherent potential of renewable energy technologies to enhance agricultural productivity in rural Uganda. To guide their exploration, they assembled a diverse crew of citizen scientists. This crew comprised farmers from six agricultural cooperatives, along with interested community members.

Charting the course

The project set sail in three Ugandan districts: Kyankwanzi, Kiboga, and Luwero. Here, the citizen scientists, equipped with necessary training and mobilisation, embarked on utilising various renewable energy technologies.

Exploring new horizons

The project delved into the impact of these technologies across various dimensions. This included their environmental benefits, their contribution to individual and community autonomy, their role in combating corruption, their potential for knowledge transfer, and their ability to develop improved skills that translate into economic gains.

Unveiling the treasures

Through this exploration, the project aimed to assess the effectiveness of adopting renewable energy in agricultural production. This assessment considered both its ability to address the sector's growing energy demands and its potential to become a vehicle for fostering social and environmental sustainability.

Learning from the land

Building upon the lessons learned throughout the voyage, the citizen science initiative aimed to collect valuable evidence. This evidence would illuminate the potential for upscaling these experiences across the entire region and inform potential nationwide implementation.

Unwavering dedication

One of the most rewarding aspects of the journey was the commitment and goodwill demonstrated by the small-scale farmers. They actively participated in various research stages, contributing data, case studies, analyses, and even the dissemination of findings to support the project's upscaling goals. Their enthusiasm to contribute to new knowledge and evidence for wider adoption of renewable energy in agriculture was truly remarkable.

Unearthing hidden gems

The project also highlighted the wealth of undocumented local knowledge and scientific practices possessed by small-scale farmers. Often, their ingenuity in improving renewable energy technologies, such as using local gins charcoal briquettes to accelerate combustion, goes unrecognised and undisseminated. This initiative aimed to shed light on such valuable local expertise.

Navigating challenges

Despite the project's success stories, some challenges arose. The limited awareness of certain renewable energy technologies within the communities hindered widespread adoption. However, the project documented remarkable agricultural advancements in areas where these technologies were implemented. These advancements included year-round production, increased productivity, income generation, cost savings in the long run, and environmental conservation.

Solar power leads the way

Among the implemented technologies, solar energy emerged as the clear leader, with a 77.2% adoption rate, compared to 4.1% for briquettes and 3.1% for biogas. This dominance can be attributed to several factors:

- Advocacy efforts by both public and private sectors promoting solar energy.
- Accessibility due to the presence of local solar equipment vendors.
- Scalability allowing for installations tailored to individual needs and financial capabilities.
- Immediate solution to the challenges of low grid coverage and high installation costs in rural areas.

Managing expectations

The project also acknowledged the importance of managing expectations among the participating farmers. Initially, some farmers harboured certain expectations about the research. However, when the research goals were clearly explained by the ARUWE organisation, some individuals chose not to participate. This highlights the importance of transparent communication throughout the citizen science process.

Unforgettable encounters

This section highlights some unforgettable moments experienced by the citizen scientists and researchers during the project, showcasing the rewarding aspects of their collaboration.

A story of resilience

One of the most inspiring encounters occurred during the collection of case study data. A small-scale farmer shared his motivations for adopting solar irrigation in his garden:

> "There is too much sunshine most of the time, and many crops do not survive due to much heat. What this means is that you don't grow crops when there is not enough rain. On the other hand, I needed to increase production. So, with solar irrigation, I keep on with all my farm activities regardless of the season. I am not restricted and held back by unpredictable weather patterns. I still do my farming activity and when the rain comes, it takes over from there. The other issue was the technology/machine was easy to use, it only required a one-time demonstration, and we could use it. Moreover, it is portable."

This farmer's story exemplifies the resilience and resourcefulness of small-scale farmers and their eagerness to embrace innovative solutions that address the challenges they face. Her experience highlights the positive impact of renewable energy technologies on agricultural productivity and climate resilience.

Briquettes: A Spark of Innovation

Another memorable encounter involved a farmer who shared his experience with biomass briquettes:

> "Those briquettes have helped me to save. I use some for cooking and others for my chickens. With briquettes, one can use the available resources to mould them. For example, a bag of charcoal costs 60,000 shillings in this region but much higher in other regions and I was using it for one month. When I started using briquettes mixed with charcoal, I saved 50% of what I was initially spending on charcoal. It's expensive to keep the chicks warm, especially at night. And if those chicks are not getting enough warmth, they can die. With the chicks, the entire brooder must be well covered. If you don't do so, wind can still enter and affect your chicks, but these briquettes help to warm the room more easily and for a longer period. Actually, I do also earn from selling briquettes to community members as well as from training other community members to make the briquettes."

This farmer's story not only demonstrates the cost-saving benefits of briquettes but also showcases the potential for income generation and knowledge sharing within the community. It highlights the ingenuity of farmers in finding locally-sourced solutions to address their energy needs.

Lessons learned

These unforgettable encounters offer valuable lessons for future citizen science initiatives.

Empowering participation: as exemplified by ARUWE's experience, integrating training and capacity building is crucial to ensure inclusive participation of all community members, regardless of their educational background.

Managing expectations: clear communication from the outset, especially during the recruitment phase, is essential to manage expectations and ensure informed participation.

Sharing the harvest: disseminating research findings through various channels is key to raising awareness about the benefits of renewable energy technologies. This can encourage broader adoption and influence policy reforms that promote affordability and sustainability.

Figure 11. Miss. Tumwebaze Faith Executive Director of Tumwebaze Fruit Farming showing banana production after using slurry from biogas as fertilisers

Figure 12. Solar powered system installed at Nkokonjeru Area Cooperative with support from Ugandan Government

Figure 13. Solar panel which power the irrigation system at Nkokonjeru Area Cooperative

4.6 The Mutual Learning Exercises

Setting sail on a sea of knowledge

This section embarks on a journey to explore the Mutual Learning Exercises (MLEs), a crucial component of the Step Change project. These exercises serve as a valuable platform for collaboration, knowledge exchange, and collective growth among the various citizen science initiatives within the project.

Unveiling the map

The MLEs were conceived as part of a cross-cutting work package focused on mutual learning and training. This work package aimed to achieve several objective.:

Supporting research activities: the MLEs provided valuable guidance and feedback to the research teams engaged in the five citizen science initiatives.

Empowering teams: the exercises aimed to strengthen the capacity of the citizen science initiative teams in two key areas.

Transdisciplinary work: this involves fostering collaboration across different academic disciplines and incorporating diverse perspectives into the research process.

Responsive stakeholder engagement: this emphasises the importance of meaningful engagement with various stakeholders throughout the project, ensuring their voices and needs are heard and addressed.

Fostering synergy: the MLEs aimed to encourage communication and collaboration between the different citizen science initiatives, allowing them to learn from each other's experiences, share best practices, and identify potential synergies. Additionally, the exercises facilitated knowledge exchange between the project initiatives and the broader citizen science community.

The power of diverse currents

Mutual learning events bring together various stakeholders, including project partners and external experts, creating a powerful synergy. These gatherings foster the exchange of diverse valuable perspectives and expertise. Each participant contributes their unique viewpoint and experiences, enriching the overall understanding of the project and the citizen science field at large. External experts provide specialised knowledge and fresh insights, helping to identify and address potential challenges or blind spots within the project.

More than the sum of its parts

This cross-fertilization of ideas leads to several positive outcomes:

- Enhanced creativity and innovation: the infusion of diverse perspectives stimulates creative thinking and fosters the development of innovative approaches to citizen science initiatives.

- Improved problem-solving: by drawing upon a wider pool of knowledge and expertise, the project becomes better equipped to tackle complex challenges and navigate unforeseen obstacles.

- Increased adaptability: the exchange of experiences allows the citizen science initiatives to learn from one another and adapt their approaches to various contexts and circumstances.

Expanding the horizon

Beyond knowledge exchange, these events also serve as essential networking platforms. This networking fosters:

- Scaling solutions: by connecting various stakeholders, the MLEs create opportunities for collaboration beyond the project's boundaries, potentially leading to the scaling and replication of successful citizen science approaches.

- Sustainability: building a network of connections increases the potential for long-term sustainability of the project and its outcomes.
-
- Enhanced visibility and credibility: engaging with a broader range of stakeholders increases the project's visibility and strengthens its credibility, potentially attracting further support and resources.

In essence, the Mutual Learning Exercises act as catalysts for growth and improvement. By harnessing the power of collective intelligence, these events propel the citizen science initiatives forward in a more informed, inclusive, and impactful manner.
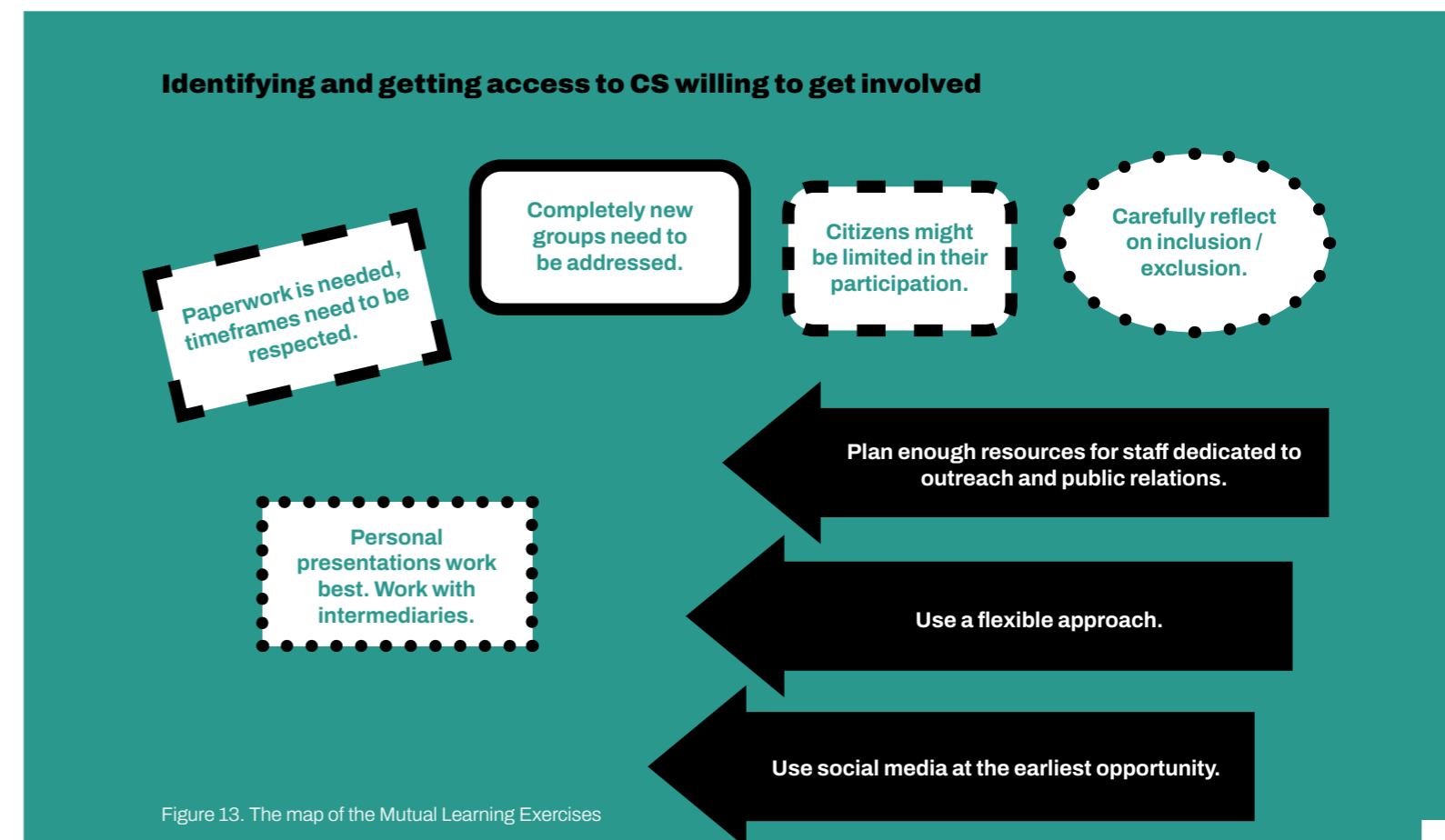

Identifying and getting access to CS willing to get involved

Paperwork is needed, timeframes need to be respected.

Completely new groups need to be addressed.

Citizens might be limited in their participation.

Carefully reflect on inclusion / exclusion.

Plan enough resources for staff dedicated to outreach and public relations.

Personal presentations work best. Work with intermediaries.

Use a flexible approach.

Use social media at the earliest opportunity.

Figure 13. The map of the Mutual Learning Exercises

Unforgettable moments and outcomes

This section delves into the outcomes and memorable moments associated with the Mutual Learning Exercises (MLEs) in Step Change. It highlights how these exercises fostered collaboration and knowledge sharing to address common challenges faced by the citizen science initiatives.

Charting solutions together

Following the presentation of various challenges and the solutions implemented by the citizen science initiatives, external experts shared their own experiences and insights. These experts, equipped with advance preparation on the specific challenges, provided valuable perspectives through practical examples. This facilitated engaging discussions, allowing the citizen science initiatives to:

- Ask questions
- Explore unresolved issues
- Learn from the wider citizen science community.

Documenting the voyage

Following each MLE, the ZSI team, acting as facilitators, compiled a Mutual Learning Report. This report served as a valuable record, capturing the following:

Experiences: The report documented the various challenges and experiences shared by the citizen science initiatives.

Tested solutions: It outlined the different approaches implemented by the CSIs to address the identified challenges.

Results: The report summarised the outcomes achieved through the implementation of these solutions.

By clustering these elements by challenge, the report provided a comprehensive overview and facilitated future learning and reference.

Unforgettable encounters

An internal evaluation revealed the positive reception of the MLE approach by the Step Change partners, despite their initially diverse expectations regarding training and support activities. Here are some excerpts from the evaluation that showcase the value of the MLEs:

"I think that overall, the approach worked very well as it allowed all partners to find and reflect on common challenges and coping strategies."
"I found the mutual learning activities very helpful!"
"I think the Mutual Learning activities are useful because we can discuss others' experiences on the topic (...) and share advice."

These quotes emphasise the appreciation for the opportunity to:

- Share experiences and learn from others
- Develop collective coping mechanisms for common challenges
- Enhance the overall quality of the Step Change project.

A platform for inspiration

The evaluation also highlighted the inspirational aspects of the MLEs, particularly the participation of external experts.

"(...) the workshops seem to offer (also through the external guests) additional inspiration."

This cross-pollination of knowledge and experience proved to be a valuable asset in the journey of the citizen science initiatives, propelling them towards more effective and impactful citizen science initiatives.

05

Navigational equipment

5.1 Key trends in citizen science initiative from Step Change

This section delves into the key trends in citizen science initiatives, drawing insights from the Step Change project. It emphasises the importance of responsible and ethical practices in citizen science.

Guiding principles

The evaluation of the Step Change initiatives employed a framework based on the *10 Principles of Citizen Science:* these principles serve as fundamental guidelines for designing, implementing, and evaluating citizen science projects effectively.

In addition to the *10 Principles of Citizen Science*, the five Step Change initiatives were evaluated based on three dimensions, within the Evaluation work package for which the **Knowledge&Innovation** partner is responsible.

1. **Scientific dimension:** this dimension focused on the scientific merit and innovation within the initiatives.

2. **Citizen science process:** this dimension examined the participatory processes employed throughout the various stages of the initiatives.

3. **Social-ecological and economic dimension:** this dimension considered the broader societal impacts of the initiatives, with a particular focus on the specific social sector each initiative addressed.

By analysing the Step Change initiatives through this framework, the project team was able to establish a valuable matrix. This matrix serves as a navigational tool for understanding current trends in citizen science and planning future initiatives effectively.The evaluation of the Step Change citizen science initiatives has provided valuable insights into the potential of citizen science to address societal challenges. The evaluation has also identified some of the challenges that need to be addressed to ensure that citizen science is conducted in a responsible and ethical manner.

The findings of the evaluation can be used to inform the development of future citizen science initiatives and will also be used to raise awareness of the potential of citizen science among policymakers, scientists, and the public.

Framing the findings

To facilitate comprehension and application, the key findings will be presented in relation to the *10 Principles of Citizen Science.*

> **Principle 1. Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding. Citizens may act as contributors, collaborators, or as project leader and have a meaningful role in the project.**

1.a Defining citizens' roles based on their skills and knowledge

Citizen science flourishes on collaboration, but to truly thrive, it's crucial to ensure citizens undertake roles aligned with their unique skills and knowledge. This requires careful navigation from the very beginning:

Firstly, during the design stage, it's vital to delineate the knowledge and skills citizen scientists can bring to the project. This involves understanding their strengths and expertise, and recognizing the added value they contribute to the research endeavour.

Next comes aligning project activities with the realistic capabilities of various stakeholders. This ensures everyone feels valued and engaged by having activities that match their skill sets. By differentiating activities to leverage the diverse knowledge and skills of citizen scientists, we unlock their full potential and maximise their contributions.

Finally, to equip participants for success, training programs should be specifically tailored to the roles citizens and stakeholders will play. These programs should be action-oriented, focusing on providing the practical skills needed to effectively contribute to the project in their designated roles.

By meticulously considering these factors, we can ensure citizen science projects create a collaborative environment where everyone feels valued, their strengths are harnessed, and their contributions meaningfully contribute to the project's shared goals.

1.b Engaging intermediary organisations

Intermediary organisations play a crucial role in citizen science as they act as bridges between various social actors. Notably, they excel at promoting the involvement of individuals and actors within the local community. This translates to valuable support in recruiting citizen scientists and facilitating project activities. However, it's important to remember that not all intermediary organisations possess the same level of effectiveness in mobilising participants. Therefore, it's vital to assess their mobilisation capacity on a case-by-case basis to ensure successful collaboration within the citizen science project.

1.c Adapting the project timing

Unlike traditional research projects, citizen science initiatives often require a more flexible and open-ended approach to planning. Engaging citizens and stakeholders effectively can be a time-consuming process, and the effort required can be challenging to predict in advance. This flexibility may contradict the established planning methods of conventional research. To navigate this difference, the project

team needs to embrace a more adaptable mindset. This means being prepared to:

- Adjust timelines and project plans: Allow for adjustments as needed to accommodate the engagement process and ensure effective collaboration with citizen scientists.

- Redefine project aspects: Be open to revisiting and potentially redefining certain aspects of the original project if necessary. This ensures the project remains aligned with the evolving engagement process and maximises its potential for success.

1.d Involving qualified citizens and stakeholders

Recruiting citizen scientists is often the most nuanced and resource-intensive step in a citizen science project. It requires a dedicated action plan that meticulously considers several crucial aspects:

- Motivation and Incentives: understanding what drives individuals to participate and offering relevant incentives are essential for fostering engagement.

- Organisation and scheduling: convenient participation times, clear instructions, and a well-organised experience are key to minimising barriers to involvement.

- Training: Providing necessary training equips citizen scientists with the knowledge and skills to effectively contribute to the project.

However, citizen science goes beyond simple citizen engagement. It thrives on the epistemic value of participants, meaning it seeks individuals with specific knowledge, skills, or direct experience relevant to the research topic. These "qualified citizens," who may not be professional scientists, can offer unique perspectives and expertise, potentially addressing knowledge gaps that traditional research methods might miss.

Therefore, it's crucial to move beyond the concept of "ordinary citizens" and recognize that everyone has the potential to contribute meaningfully to scientific research, depending on the specific research topic and their unique qualifications.

1.e Engaging technical partners

In citizen science projects, collaboration with technical partners proves crucial, as they bridge the knowledge gap between professional researchers and citizen scientists. These partners offer invaluable expertise in various areas.

Technical equipment: they can provide access to specialised equipment or resources essential for the project, filling gaps in what researchers or citizen scientists might individually possess.

Citizen scientist recruitment: their networks and expertise can be leveraged to identify and recruit individuals with relevant skills and knowledge, enriching the citizen science participant pool.

Data processing and interpretation: their technical knowledge allows them to handle, analyse, and interpret the data collected from citizen science activities, ensuring its proper utilisation.

Exploiting results: they can explore and contribute to potential avenues for utilising the research findings, maximising their impact and potential for societal benefit.

By establishing these partnerships, citizen science projects gain access to a wider range of expertise and resources, fostering a more robust and impactful research endeavour.

1.f Keeping citizen scientists engaged: organising a rewarding journey

Citizen science thrives on the collective effort of passionate individuals. To keep them engaged throughout the project, it's crucial to understand and nurture their motivations. Here's some ideas on how to achieve it.

Acknowledge diverse motivations: recognize that people participate for various reasons, from personal growth and skill development to a desire to contribute to meaningful scientific discovery. By understanding these motivations, project organisers can tailor the experience to better meet individual needs.

Fueling the fire of learning: provide opportunities for citizen scientists to continuously acquire new knowledge and gain new experiences. This can be achieved through workshops, training sessions, or even incorporating learning modules into project activities. Equipping them with relevant skills empowers them to contribute more effectively and fosters a sense of accomplishment.

Meaningful contributions, lasting satisfaction: structure the project to ensure citizen scientists feel their contributions are valued and have a real impact. This can involve providing regular feedback, highlighting their contributions in project publications, or even inviting them to participate in data analysis discussions. By fostering a sense of accomplishment, you keep them engaged and motivated throughout the scientific journey.

By prioritising these aspects, citizen science projects can cultivate a rewarding and enriching experience for participants, ultimately leading to a more successful and impactful research endeavour.

> **5. Citizen scientists receive feedback from the project. For example, how their data are being used and what the research, policy or societal outcomes are.**
>
> **8. Citizen scientists are acknowledged in project results and publications.**

5 and 8.a Define effective feedback tools

Citizen science projects weave together a rich tapestry of individuals – a vibrant mix of backgrounds, interests, expectations, and commitment levels. This diversity, while fostering innovation and collective knowledge, can also present challenges. Here's where feedback loops emerge as a powerful tool for navigating these complexities.

Bridging the gap: Feedback loops create a continuous communication channel, keeping all actors – from citizen scientists to researchers – informed and engaged. This fosters a sense of community and shared purpose, despite differing perspectives or commitment levels.

Early warning system: By providing a platform for open communication, feedback loops allow for the prompt detection of potential tensions. This proactive approach allows for early intervention and conflict resolution, preventing issues from escalating and derailing the project.

Empowering participation: feedback loops go beyond simply informing; they empower participation. They offer a platform for citizen scientists to voice their concerns, suggest improvements, and even contribute to the research process itself. This fosters a sense of ownership and shared responsibility for the project's success.

The importance of feedback loops becomes even more pronounced with larger and more diverse project teams. By fostering open communication and collaboration, these loops ensure that everyone feels valued and has a voice, ultimately leading to a more cohesive and successful citizen science initiative.

5 and 8.b Maintaining a long-term perspective on citizen science

Introducing citizen science elements into the academy or into an established system, requires structural changes in the institutions involved, such as the creation of new operational units, the diffusion of specific skills, or the introduction of new procedures. In many cases, citizen science can only have a significant impact in a long-term perspective that allows these structural changes to take place.
It's important to recognize that these structural changes often require patience and a long-term perspective. Achieving significant impact through citizen science necessitates fostering a culture of collaboration and a willingness to adapt within the established system. Patience and persistence are key to navigating this transformative journey.

By understanding the need for structural changes and committing to a long-term approach, institutions can pave the way for the successful integration of citizen science, ultimately fostering deeper engagement and reaping the benefits this collaborative approach offers to research and society as a whole.

5 and 8.c Developing multiple tools to recognise the citizen scientists' contribution

Citizen science is widely discussed in the literature. However, there is a tendency to focus on their recognition in scientific publications produced by professional researchers, yet different types of recognition can be used. Citizen scientists can be, for example, encouraged to independently write an article about their research experience, and participate as speakers at events. In addition, their opinions and observations must be taken seriously by the research staff, and they need to always receive feedback on their contributions.

> **Principle 3. Both the professional scientists and the citizen scientists benefit from taking part. Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to scientific evidence e.g. to address local, national and international issues, and through that, the potential to influence policy.**

3.a Managing the interactions among citizens and stakeholders

Interactions between citizens and stakeholders should be carefully managed to avoid negative synergies or dominant voices.

3.b Exploring the tech terrain in citizen science

As we navigate the citizen science landscape, exploring the potential of new technologies emerges as a powerful tool for fostering social innovation. These technologies can serve as valuable allies, paving the way for:

Mass data collection: citizen science projects often rely on specialised applications that empower individuals to contribute significantly to data collection efforts. This allows for the gathering of vast amounts of data that would be impossible to acquire through traditional methods alone. This collective effort expands the scope and reach of research, leading to richer and more comprehensive datasets. However, venturing into the technological realm also necessitates acknowledging the potential need for social innovation. Here are some key considerations:

Bridging the digital divide: unequal access to technology and digital literacy can create barriers to participation, potentially excluding certain segments of the population. Navigating this challenge requires innovative approaches, such as developing alternative participation methods or providing digital literacy training, to ensure inclusivity and equitable access.

Data privacy and security: as data collection scales, robust measures must be implemented to protect the privacy and security of citizen scientists' data. This necessitates transparency in data collection practices, informed consent mechanisms, and secure data storage and management protocols.

Ensuring responsible use of technology: the integration of technology should be guided by ethical principles and responsible use considerations. This includes ensuring citizen scientists understand how their data will be used, fostering responsible data collection practices, and safeguarding against potential misuse of technology or data.

By thoughtfully navigating these considerations and harnessing the potential of technology, citizen science projects can leverage social innovation to overcome these challenges and unlock the full potential of citizen science for scientific advancement and positive societal impact.

3.c Strengthening stakeholder interest in science as a tool for change

Citizen science is based on two acts of recognition. On the one hand, scientists must recognise the importance of the knowledge and opinions of non-scientists in achieving scientific results. On the other hand, stakeholders must recognise the importance of scientific knowledge in addressing the complex problems they face. This means encouraging both researchers to adopt citizen science practices and principles and stakeholders to learn about and contribute to scientific practices. It is recommended to promote the idea that participation in scientific research can be a powerful tool for social change, especially through educational interventions in schools and through information and awareness-raising activities aimed at different stakeholders.

By fostering this two-way dialogue and empowering stakeholders, citizen science can become a powerful catalyst for bringing people together and harnessing collective knowledge to address complex societal challenges and drive positive change.

4.d Defining a strategy for building the core team

In citizen science projects, the composition of the team should follow a precise strategy, taking into account the context and the relevant variables. These may include, for example, the type of promoter and its strengths and weaknesses, the skills and knowledge needed to carry out the project, the degree of citizen and stakeholder involvement required (and hence the relevance of skills such as mobilisation and communication) in the core team, and of course the content and characteristics of the project.

> **Principle 2. Citizen science projects have a genuine science outcome. For example, answering a research question or informing conservation action, management decisions or environmental policy.**

2.a Tailoring citizen science initiatives to the social and economic context

There is a tendency to view citizen and stakeholder participation in research as largely detached from the social context in which the research is funded. It is important to vary the nature of the approach to citizen science according to the socio-economic context. The methods of recruitment, training, communication, and involvement must be different from place to place.

> **Principle 4. Citizen scientists may, if they wish, participate in multiple stages of the scientific process. This may include developing the research question, designing the method, gathering and analysing data, and communicating the results.**

4.a Using boundary concepts

Citizen science projects can be more easily realised if interpretative concepts are adopted acting as 'boundary objects', i.e. concepts that are immediately understandable by experts, researchers, stakeholders, and citizen scientists and that serve as drivers for the research process. These concepts facilitate cooperation, make the objectives to be pursued clearer and can motivate the actors involved, albeit in different ways.

> **Principle 6. Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for. However unlike traditional research approaches, citizen science provides opportunity for greater public engagement and democratisation of science.**

6.a Favouring interdisciplinarity

Citizen science is based on combining different types of knowledge (scientific, experiential, political, social, and knowledge) to produce new scientific knowledge. This combination is greatly facilitated by an interdisciplinary approach that brings together both STEM and SSH knowledge. Including social researchers brings great benefits and helps to better define the involvement strategies and interpret the input coming from citizens and stakeholders.

7.a Adopting strong data quality verification tools

The involvement of citizen scientists requires systems for verifying the quality of the data produced that should be more stringent and continuous than those normally used in conventional research. Despite the training they may receive, citizen scientists' capacity to collect data can never be the same as that of professional scientists.

7.b Ensuring the use of reliable research quality control tools

The involvement of many social and political actors in research risks turning citizen science projects into a kind of negotiation over facts and their interpretation. This risk increases when there is a potential conflict between the actors involved. To avoid this risk, the results of citizen science projects must therefore meet the quality standards of any scientific product, so that the involvement of social actors does not run the risk of bending the research results to suit interests. Various tools and procedures must be implemented to ensure that all the data collected (both those obtained through technological tools and those collected by citizen scientists) were scientifically reliable and comparable with those obtained through conventional research tools.

Principle 9. Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.

10. The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data sharing agreements, confidentiality, attribution, and the environmental impact of any activities.

9 and 10.a Allowing time for impacts to emerge

The timing of research is more controllable than the timing of social, environmental, or political impacts. When designing citizen science projects, especially those with clear change objectives, it is necessary to allow sufficient time, for example, for the dissemination of project results and the involvement of political and social actors, so that these results can be used effectively. If the time planned to achieve the expected impacts is too short, the risk is that activities to fully exploit the research products for change will have to be slowed down or interrupted after the project period.

Charting a course: the crucial role of communication in citizen science

While the 10 Principles of Citizen Science lay a solid foundation, communication and dissemination remain an often-underestimated aspect, fraught with challenges and risks arising from insufficient resources (both human expertise and funding). Navigating these challenges requires a strategic approach to communication, ensuring it becomes a seamless journey throughout the entire citizen science voyage, not just a final destination.

Diversifying and adapting your communication approach

Unlike traditional research where communication often occurs at the project's end, citizen science demands a multifaceted and adaptable communication strategy throughout all stages.
This includes:

Identifying research questions: engaging diverse stakeholders and the public can spark valuable insights and shape research questions relevant to the community.

Designing the project: effective communication fosters collaboration and ensures all involved understand the project's goals and methodologies.

Implementing the project: clear and consistent communication keeps participants informed, engaged, and motivated throughout the research process.

Interpreting and analysing data: collaborative interpretation allows diverse perspectives to inform the analysis and ensures results are well-understood by all stakeholders.

Exploiting and disseminating findings: effective communication ensures research findings reach relevant audiences, maximising their impact and potential for change.

Securing the necessary provisions for a smooth voyage

Establishing a dedicated budget for communication and awareness-raising activities is crucial.
This investment allows for:

Engaging with diverse audiences: utilise a variety of communication channels and resources to reach individuals with essential knowledge and perspectives relevant to the research topic.

Optimising data collection and usage: effective communication empowers citizen scientists to contribute meaningfully and ensures collected data are used effectively.

Maximising project impact: by effectively communicating findings and engaging stakeholders, citizen science projects can have a significant and lasting impact on society.

Navigating the seas of collaboration

Managing relationships between social actors (stakeholders and citizens) is vital in citizen science, as interactions can be complex and multifaceted. Potential challenges include:

Divergent viewpoints: stakeholders and citizens may hold differing perspectives on the project's purpose, objectives, or management of research results.

Collaboration conflicts: disagreements or conflicts can arise during project implementation, requiring effective communication and conflict resolution strategies.

To navigate these challenges, project organisers must develop a clear picture of stakeholder relationships – understand the roles, interests, and potential points of conflict between various stakeholders – and strategize engagement and determine who to involve, how to involve them, and how to facilitate productive communication and collaboration.

Maintaining a strong public image

The public image of the promoting institution significantly influences citizen engagement. A strong reputation fosters trust and increases the likelihood of individuals participating in the project.
Therefore:

- Be mindful of your public image: recognize the role of your institution's reputation in attracting citizen scientists and actively manage this image to inspire trust and participation.

- Integrate trust-building strategies: design your project with the importance of trust in mind, employing communication strategies that foster transparency, openness, and accountability.

- By prioritising and effectively managing communication throughout the citizen science journey, you can ensure smooth sailing, fostering collaboration, maximising impact, and ultimately achieving the transformative potential of citizen science.

Charting a course through challenges and opportunities in citizen science

06

6.1. Key citizen science challenges

Citizen science, while brimming with potential, faces several challenges that demand thoughtful navigation. Ensuring data quality, fostering participant diversity, managing project logistics, and maintaining sustained engagement are all crucial aspects requiring careful attention.

Maintaining data quality is the bedrock of any scientific endeavour, and citizen science is no exception. Implementing rigorous data validation and quality control measures, such as data cleaning procedures, cross-referencing with existing datasets, and providing clear instructions to participants, is essential for safeguarding the integrity of the collected information.

Guaranteeing diversity and inclusion within citizen science projects remains an ongoing challenge. Actively engaging with underrepresented communities and individuals, listening to their perspectives, and valuing their unique contributions are fundamental steps towards achieving inclusivity. Additionally, promoting accessible and inclusive project design by offering materials in multiple languages, providing various participation options (online or offline), and incorporating assistive technologies, ensures that the project welcomes individuals of all backgrounds and abilities. Furthermore, providing training and support tailored to different levels of experience empowers volunteers with the necessary skills to contribute meaningfully. Ultimately, fostering a welcoming and respectful environment where diverse voices are acknowledged and appreciated is crucial for creating a truly inclusive citizen science community.

Effective project management is the engine that keeps citizen science initiatives running smoothly. Utilising project management platforms, communication tools, and efficient data storage solutions helps streamline processes and ensures that project tasks are completed efficiently.

Sustaining participant engagement over time is vital for the long-term success of citizen science projects. Fostering a sense of community and purpose among participants is key to achieving this. Creating communication channels for participants to connect, share experiences, and learn from each other fosters a sense of belonging and collaboration. Recognizing and celebrating individual contributions further reinforces ownership and engagement, motivating participants to remain actively involved.

Despite these challenges, the potential of citizen science remains significant. By acknowledging and addressing these hurdles, citizen science can unlock the power of collective intelligence, contribute meaningfully to diverse fields, and empower individuals to actively participate in scientific discovery.

6.2. Key citizen science opportunities

A catalyst for societal transformation

Citizen science, as Dorte Riemenschneider (managing director of ECSA) and Silke Voigt-Heucht (head of the Citizen Science Unit at Berlin's Museum für Naturkunde) aptly stated in a 2022 European Research Council article, transcends mere data collection. It serves as a powerful tool for uniting diverse stakeholders towards tackling pressing societal challenges. By fostering dialogue and collaboration between science and society, citizen science unlocks a multitude of opportunities, empowering individuals and communities to become active agents of positive change across various domains:

1. Building a more informed society: citizen science fosters scientific literacy by enabling individuals to engage directly with scientific processes. This firsthand experience equips them with the knowledge and critical thinking skills necessary to navigate an increasingly complex world.

2. Empowering communities: active participation in hands-on research empowers communities by giving them a voice and a sense of ownership over issues impacting their lives. This fosters a sense of agency and encourages individuals to take an active role in shaping their communities.

3. Bridging the gap between science and society: citizen science initiatives serve as bridges between researchers and the public, fostering mutual understanding, trust, and collaboration. This collaborative approach allows for the exchange of valuable perspectives and fosters a sense of shared responsibility in addressing societal challenges.

4. Democratising research: by actively involving the public, citizen science initiatives demystify the research process, making it more transparent and accessible. This ensures that research activities are aligned with the needs and concerns of the public they aim to serve.

5. Igniting innovation: citizen science serves as a breeding ground for innovation, where fresh perspectives from the public meet the expertise of the scientific community. This unique combination fosters novel ideas and approaches to addressing complex issues.

In essence, citizen science goes beyond simply aiding scientific endeavours. It empowers individuals, fosters societal transformation, and equips all of us to collectively shape a brighter future.

Transforming education through collaboration

Citizen science is emerging as a powerful tool for public engagement, not only with science and technology but also with education. This approach fosters meaningful collaboration between citizens and scientists, offering a wealth of opportunities for transforming educational landscapes.

Citizen science initiatives in schools create a unique environment where students can generate new knowledge and awareness about scientific practices and methodologies. This firsthand involvement allows them to connect science to their everyday lives and experiences, fostering a deeper understanding of the scientific method through active learning and critical thinking.

Citizen science empowers learners to become active participants in authentic scientific research, forging a real connection with the research process. This approach transcends the traditional model of passive knowledge transmission, positioning educators as facilitators and collaborators who support learners in their exploration and discovery.

The role of scientists and experts also undergoes a shift in citizen science education. Scientists become partners who provide essential scientific expertise and materials, ensuring the accuracy and effectiveness of data collection and other scientific processes. They also play a crucial role in contextualising the activities within the curriculum and everyday classroom experiences.

Numerous pioneering citizen science projects in various fields, from conservation biology and biodiversity to economics, astrophysics, and computer science, showcase the transformative potential of this approach (Scientix report, 2019; Roche et al, 2020). These projects demonstrate that citizen science can be a powerful catalyst for structural change and democratisation within society.

Citizen science empowers learners and educators to move beyond being mere observers of science. By actively engaging in scientific projects, they become contributors who shape the objectives, strategies, and values of the research endeavour. This shift in roles fosters deeper engagement, meaningful learning, and a more inclusive and collaborative approach to scientific exploration.

In essence, citizen science in education offers a powerful framework for transforming learning by fostering active participation, collaboration, and connection between learners, educators, and scientists. This collaborative approach empowers individuals to become active agents in their own learning journeys and contribute meaningfully to the advancement of scientific understanding.

A collective force for tackling global challenges

The 21st century presents us with a multitude of complex global challenges, the most pressing of which is the climate emergency. Thankfully, individuals now have the opportunity to contribute significantly to addressing these challenges through citizen science. This collaborative approach is gaining recognition at various levels, including the 2018 IPCC report which emphasised the crucial role of citizens in tackling climate change.

Citizen science empowers individuals to contribute to addressing global challenges in several ways:

- Sharing knowledge: individuals can contribute their knowledge and expertise, including indigenous knowledge, to inform research and decision-making processes.

- Shaping policy: citizens can actively participate in shaping environmental policy through advocacy and engagement with policymakers.

- Raising awareness: citizen science initiatives can be powerful tools for raising public awareness about pressing issues and fostering a sense of collective responsibility.

- Taking action: by participating in data collection, research activities, and advocacy efforts, individuals can take concrete actions to address global challenges.

Citizen science demonstrates its versatility and effectiveness across various sectors.

Energy

- Citizens are collecting valuable data on energy use and efficiency.

- Individuals are actively involved in researching and developing renewable energy technologies.

- Citizen advocacy efforts are influencing the creation of sustainable energy policies.

Health

- Citizens contribute by collecting data on diseases and their risk factors.

- Individuals actively participate in clinical trials for new treatments.

- Citizen advocacy strengthens public health initiatives through promoting relevant policies.

Environment

- Citizen-collected data helps monitor environmental conditions and track changes.

- Individuals participate in efforts to protect endangered species and ecosystems.

- Citizen advocacy plays a crucial role in influencing the creation of environmental protection policies.

The Step Change project serves as a prime example of how citizen science can be harnessed to address multiple global challenges simultaneously. This project fosters collaboration between citizens, scientists, and policymakers, uniting them in seeking solutions to some of the world's most pressing issues related to energy, health, and the environment.

By empowering individuals to contribute their knowledge, skills, and passion, citizen science offers a powerful and promising avenue for tackling the complex challenges facing our planet. Through collective action and collaborative problem-solving, we can collectively shape a brighter future for generations to come.

A bridge towards a more democratic science

(source: ECSA, Frequently asked questions on citizen science)

Citizen science helps to make scientific research more democratic, inclusive and accessible. Rather than research projects only being undertaken by academic researchers (perhaps with some citizen participation in the final phases), citizen science strives to involve citizens in many phases of a research project. Citizen science projects also raise awareness on specific relevant topics and issues such as climate change, protecting biodiversity and transforming our urban surroundings.

By involving a broader range of people, citizen science projects benefit from different kinds of knowledge and different sources of information, such as practical and experiential knowledge.

In addition, by involving more people in the scientific process, research can be facilitated on a broader scale and generate far more data. This is essential if we are to tackle some of the biggest societal and environmental challenges that we face, particularly the climate crisis.

As mentioned in the *10 Principles of citizen science*, citizen science projects have a genuine scientific outcome, and both professional scientists and citizen scientists benefit, e.g. from the publication of research, learning opportunities, addressing local and international issues, and influencing policy. Academic researchers and scientific institutes can gain a better understanding of the areas of society they are working with, and citizens can benefit from increased engagement with the scientific process and satisfaction from contributing to scientific evidence.

Navigating the citizen science landscape

Citizen science is a rapidly evolving field with a wealth of information and resources available. Here, we present valuable resources that can guide your exploration.

7.1 The eu-citizen.science platform

The *eu-citizen.science* platform is an online platform for sharing knowledge, tools, training and resources for citizen science – by the community, for the community. There you can find more than 3500 users, more than 250 citizen science projects and over 250 organisations involved in citizen science, more than 200 resources, dozens of training resources and other platforms, among other things.

7.2 The resources of the Step Change Navigator

Overview of available toolkits

This section provides an overview of the toolkits available at the time of publication (March 2024). They were selected from recent resources that offer useful tools for programming, managing, and evaluating citizen science programmes and initiatives in various sectors. This list is certainly not exhaustive, however it represents a good portion of what is currently available.

The toolkits were selected based on the following criteria:

- Relevance to citizen science

- Recent publication date

- Usability and practicality

- Coverage of different sectors.

The digital Navigator: cs_navigator.stepchangeproject.eu

Given that many resources are developed within the framework of projects with a limited lifespan (typically projects funded by the European Union), we have downloaded and collected them all on the Step Change website. This digital collection, together with the tools to navigate it, constitutes the digital database of this Navigator.

The digital database is to be considered a living resource, available to the community and that can be updated as new tools become available. The community is encouraged to contribute to the database by submitting suggestions for new toolkits or updates to existing ones.

The digital database is a valuable resource for anyone involved in citizen science. It provides a comprehensive overview of available tools and resources, and facilitates the planning, implementation, and evaluation of citizen science projects. The database is a living resource that will continue to grow and evolve over time, and the community is encouraged to contribute to its development.

Title	Author	Link	Year of publication	Short description
AfriAlliance handbook on data collection	AfriAlliance project	*http://web.archive.org/web/20220127154312/https://afrialliance.org/files/downloads/2019-03/AfriAlliance_Handbook_on_data_collection_2018_ENG.pdf*	2018	The **AfriAlliance Handbook** will describe how to design citizen science projects; how to implement the data collection process; how to combine the collected data with other data sources; how to analyse the data to gain insights and make informed decisions; and how to make the data openly available.
Anecdata	MDI Biological Laboratory, Maine, USA	*https://www.anecdata.org/*		A guide for scientists and data collectors in steps on how to set up and develop a citizen science project.
Biodiversa toolkit	BioDiversa+ project, Belgian biodiversity platform, Belgium	*https://www.biodiversa.org/1810/download* and *https://www.biodiversa.eu/wp-content/uploads/2023/01/citizen_science_toolkit.pdf*	2020	It aimed at researchers and scientists working in biodiversity or environmental sciences who are involved or interested in involving citizens in their research projects. It includes examples and challenges, resources and bibliography.
Citizen science for all. A guide for citizen science practitioners	Bürger Schaffen Wissen, Germany	*https://www.buergerschaffenwissen.de/sites/default/files/assets/dokumente/handreichunga5_engl_web.pdf*	2016	This guide describes how citizen science is practised in Germany and how this participatory approach can be used in different research disciplines and issue areas – such as education, conservation or the arts and humanities. This guide is primarily intended for those initiating citizen science projects, but also for anyone participating in such projects.
Citizen science for local government	Scivil, Belgium	*https://www.scivil.be/en/book/citizen-science-local-government*	2021	The guide introduces the concept of citizen science to local policymakers. A step-by-step guide to setting up a project is included, as well as an overview of the roles a local government body can take up in different citizen science projects. Also, it focuses on data and measurement tools, success factors and potential risks. Finally, the guide is full of inspirational examples of citizen science projects.

Title	Author	Link	Year of publication	Short description
Citizen science guide	LIBER Europe (Association of European Research Libraries), The Hague, The Netherlands	*https://libereurope.eu/working-group/liber-citizen-science-working-group/citizen-science-guide/*	2021-2023	The publication is designed to be a practical and compact gateway for the purpose of assisting research libraries to start setting up a citizen science programme.
Citizen science project design template	NSW Department of Planning, Industry and Environment, Australia	*https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Research/Citizen-science/citizen-science-project-design-template.pdf?la=en&hash=7AD3B7AE50BF6708CF7E1FA1FA69B6057D48B543*		This toolkit is a project template, developed to help in the design, delivery and ongoing running of citizen science projects. It contains useful insights and considerations aimed at guiding users to establish and maintain a project. This includes: • possible methods and tools to collect data • ways to connect with participants • a template to help plan core elements of a project.
Citizen science toolkit	CitieSHealth EU project	*https://citizensciencetoolkit.eu/*	2022	It presents four phases to design and implement a citizen science project. Examples and case studies to get inspiration are also presented, and there is the possibility to upload your own tool.
Citizen science toolkit	California Academy of science, USA	*https://www.calacademy.org/educators/citizen-science-toolkit*		This toolkit is designed to help educators integrate citizen science projects into classroom curricula or afterschool programming. It contains resources—including lessons, readings, and worksheets. Teaching resources.
Citizen sciene toolkit	Leave No Trace Center, Colorado, USA	*https://lnt.org/wp-content/uploads/2019/06/Citizen_Science_Toolkit.pdf*	2019	The Leave No Trace Center has developed this toolkit as a guide to implementing Leave No Trace citizen science programming in diverse natural areas. Groups interested in establishing their own citizen science programming are encouraged to seek consulting support from the Center.

Citizen science toolkit for biodiversity scientists	BiodivERsA, Paris, France	*https://zenodo.org/record/3979343#.ZC6U3OxBzvU*	2020	The **Citizen science toolkit** is aimed at researchers and scientists working in the fields of biodiversity or environmental sciences who are involved or have an interest in involving scientists in their research projects. The objective of this toolkit is to inform about the potential benefits of citizen science, and to highlight rationales for doing citizen science, current best practices, and useful resources in the field.
Citizen science tools	Citizen Science Zürich, Switzerland	*https://lab.citizenscience.ch/en/*	?	The Citizen Science Center Zurich proposes a set of tools that make it easy for scientists and citizens to engage with citizens science projects.
Citizen sensing	Making sense project	*http://making-sense.eu/wp-content/uploads/2018/01/Citizen-Sensing-A-Toolkit.pdf*	2018	The guide is organised in key stages of activity with their corresponding set of cross-cutting principles, specifically geared towards projects aimed at supporting community action. This framework sets out a process that you, as community organisers, project teams, community members or individual citizens, can use as a reference guide when developing and delivering a citizen sensing project.
Citizen science starter kit	Eutopia project	*https://doi.org/10.5281/zenodo.7014861*	2022	The **Citizen science starter kit** provides information to researchers who are new to citizen science and who are considering initiating citizen science research projects, regardless of the scientific discipline. It is a how-to guide for beginners, a foundation course, with the most essential information to get started.

Coastal Cooperative Research Centre citizens science toolbox	Coastal Cooperative Research Centre, Australia	*http://processarts.wagn.org/Participatory_Processes/*		A free resource of over 60 principles and strategies to enhance meaningful stakeholder involvement in decision-making. Stakeholders include not only communities but also scientists and decision-makers. Meaningful involvement of all stakeholders occurs through a commitment to social learning – learning on the part of communities, other stakeholders and institutions.
Data ethics toolkit	Association for Advancing Participatory Sciences	*https://participatorysciences.org/resources/data-ethics/*	2023	This **Toolkit for data ethics in the participatory sciences** is a resource developed for considering ethical issues surrounding data, the bedrock of science. The toolkit aims to help project leaders understand their role as data handlers in identifying, satisfying, and/or balancing ethical obligations of a project to participants, partners, science, and society.
Federal crowd-sourcing and citizen science toolkit	Association for Advancing Participatory Sciences	*https://www.citizenscience.gov/toolkit/#*	2015	This toolkit shows five basic process steps for planning, designing and carrying out a crowdsourcing or citizen science project. At each step, you'll find a list of tips you can use to keep your project on track. Resources and case studies are also available.
Guide to citizen science	Natural History Museum and NERC Centre for Ecology & Hydrology for UK-EOF, UK	*https://nora.nerc.ac.uk/id/eprint/20678/1/N020678BK.pdf* and *https://www.nhm.ac.uk/content/dam/nhmwww/take-part/Citizenscience/citizen-science-guide.pdf*	2012	This guide aims to support people already involved in citizen science, and those new to it, within the UK. It is based on detailed information gathered and analysed as part of the UK-EOF funded project "Understanding Citizen Science & Environmental Monitoring". It will help you to design and implement a citizen science project relating to biodiversity or the environment.

Guide to citizen science	University of Novi Sad, Serbia	http://star.ff.uns.ac.rs/genius/vodic_za_gradjansku_nauku.pdf	2022	This guide contains practical instructions for success in creating a citizen science project. The guide's goal is to provide everything necessary and sufficient information for project planning and implementation of civic (volunteer) science, as well as his dissemination and evaluation.
Handbook of youth citizen social science	YouCount project	https://doi.org/10.5281/zenodo.10566411	2024	This handbook and its toolkit build on the experiences from the H2020 YouCount project (2021-2023) and represent a unique contribution to the field of citizen social science. It is, overall, an exercise on social science communication that can be useful to a wide array of publics: practitioners, academics, policymakers, youth organisations and anyone interested in citizen social science as a way of creating a future shaped by more inclusive, participatory research and social innovation.
Helpful tools	Austria's Agency for Education and Internationalisation (OeAD), Austria	https://zentrumfuercitizenscience.at/en/citizen-science-2/helpful-tools		This is a collection of tools and resources for citizen science in different fields: a) project planning, b) project creation, c) apps development, d) do-it-yourself tools, e) volunteer computing, f) editing of texts, images, audio and videos
Helping you do great science	Citizen science platform Colorado University, USA	https://www.citsci.org/		This tool helps users to create projects, build data sheets, collect data, and view results in real-time.
A manual for citizen scientists starting or participating in data collection and environmental monitoring projects	Harvard Law School, Emmett Environmental Law and Policy Clinic, USA	https://citizenscience-guide.com/sites/default/files/images/Citizen%20Science%20Manual%20March%202019%20_FULL%20VERSION_0.pdf	2019	This manual aims to empower individuals in their roles as citizen scientists and to promote the practice of community-based citizen science as a vehicle for environmental justice. This manual outlines practical suggestions for how to design and carry out a citizen science project.

Models to identify background factors associated with the citizen science activity	CS Track project	https://zenodo.org/record/6005549#.YwSPMexBzvX	2022	It summarises the characteristics of citizen scientists, discusses how learning and knowledge building occurs and explicates the structure and basis needed to build models that illustrate the associations between background factors and different forms of citizen science activities.
Mutual learning exercise on citizen science initiatives. Policy and Practice	EU Commission	https://ec.europa.eu/research-and-innovation/en/statistics/policy-support-facility/psf-challenge/mutual-learning-exercise-citizen-science-initiatives-policy-and-practice	2023	The Mutual learning exercise aims to facilitate the exchange of information, experiences and lessons learned, as well as to support and scale up citizen science through identifying the good practices, policies and programmes of the various approaches at local, regional and national level, towards supporting and scaling up citizen science. Another objective is to identify citizen science campaigns that have high potential to be implemented in a collaborative way across the European Research Area.
Participatory science toolkit against pollution	Action EU project	https://actionproject.eu/toolkit/ the pdf is here: https://actionproject.eu/wp-content/uploads/2022/04/ACTION_Toolkit_11.04.2022.pdf	2022	This toolkit features four steps to design and implement a citizen science project on pollution. Resources and masterclasses are also available.
Practicing citizen science in Zurich – Handbook	Citizen Science Center Zurich, Switzerland	https://citizenscience.ch/files/handbook_november%202021.pdf	2021	This handbook is a practical guide on how to successfully design and run co-created citizen science projects, with some specific tips for practitioners in Zurich. The handbook is organised in parts that can be seen as a sequence of consecutive steps, or can be accessed at one's convenience for suggestions and recommendations on different aspects of designing, implementing, and running citizen science projects.

Self-assessment checklist	Citizen Heritage project	*https://www.citizenheritage.eu/self-assessment-checklist/*	2023	This tool was developed for institutions in the process of planning an activity with cultural heritage collections that includes citizen participation in the light of collecting feedback and inputs from local communities, seniors, students, amateurs.
Time4CS reflection tool	TIME4CS project	*https://zenodo.org/record/7022933#.ZEp4lexBxaQ*	2022	The **TIME4CS reflection tool** for institutional changes in citizen science is dedicated to anyone that would like to pursue sustainable institutional changes towards citizen science.
Toolbox for citizen engagement	PREP4BBLUE project	*https://prep4blue.eu/portfolio/toolbox-for-citizen-engagement/*	2023	The toolbox supports the design and application of deliberative democratic mechanisms to organise and manage the process of citizen mobilisation and engagement, as well as provide practical advice and case studies useable by project teams tasked with supporting such participation.
Tools for measuring outcomes and evaluating citizen science	Cornell Lab of Ornithology, New York, USA	*https://www.birds.cornell.edu/citizenscience/measuring-outcomes/*	2014	This guide is designed for practitioners who seek assistance in evaluating outcomes from their citizen science projects, which are also known as Public Participation in Scientific Research (PPSR) projects.
Weobserve cookbook	WeObserve project	*https://www.weobserve.eu/weobserve-cookbook/*	2021	The **WeObserve cookbook** is designed as a guide to help citizen observatory practitioners access existing resources that can help them in setting up and/or running a Citizen Observatory.

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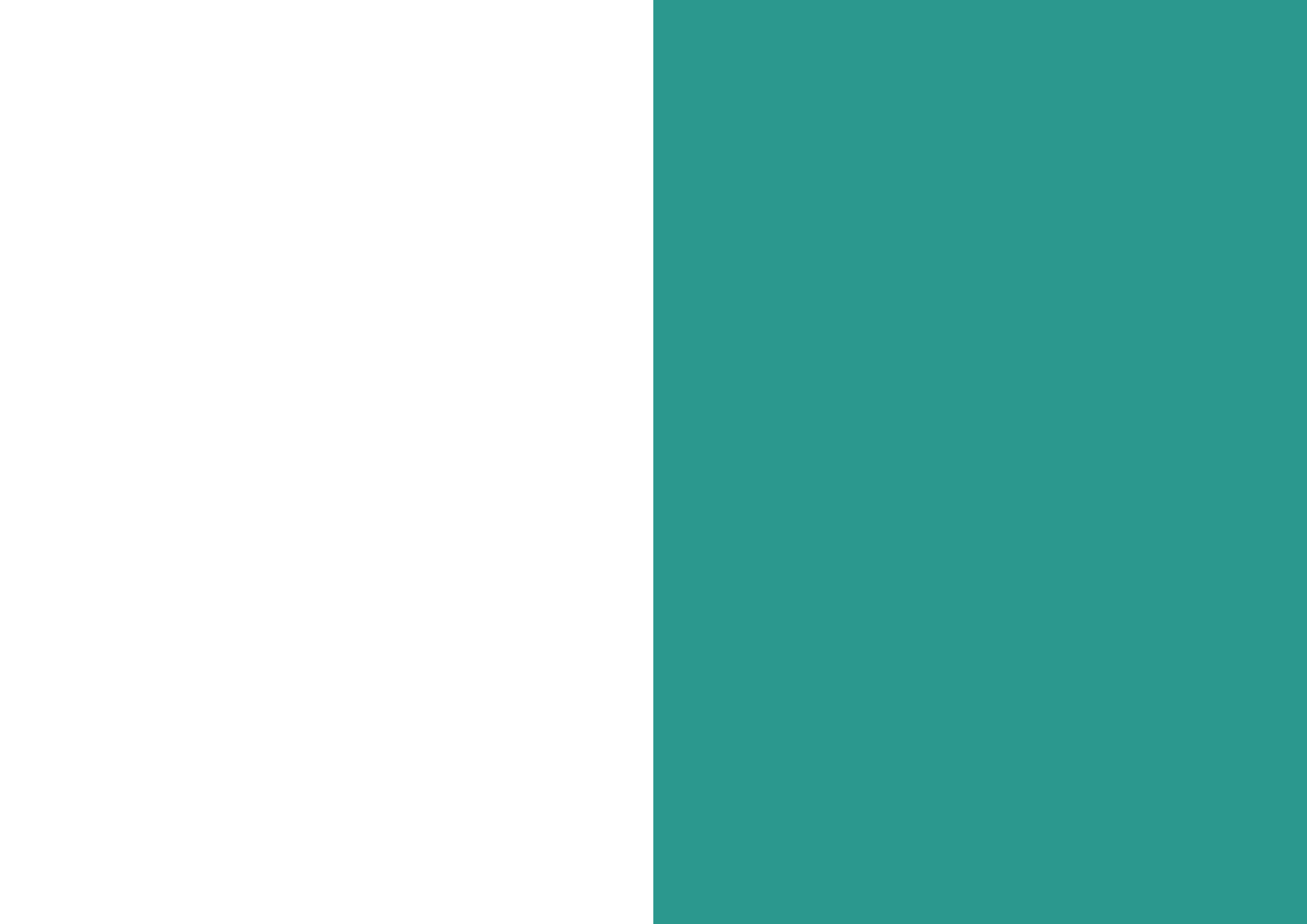
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