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How to get started with the backcasting approach

Independent Expert Report

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Mutual Learning Exercise on Citizen Science Initiatives – Policy and Practice
How to get started with the backcasting approach

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Mutual Learning Exercise on Citizen Science Initiatives – Policy and Practice

How to get started with the backcasting approach

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1. Introduction

The Mutual Learning Exercise (MLE) on Citizen Science has gathered the experiences, insights and recommendations of 11 participating countries in a range of Discussion Papers and Thematic Reports that provide examples and guidance for embedding and sustaining participatory and inclusive research practices at the national level, to create a supportive environment for Citizen Science in all of its forms.

Embedding Citizen Science at the national level can help to achieve greater societal impact and increase trust in science through the leveraging of collective societal capabilities and insights, and to enlarge the scope and impact of Research and Innovation through increased societal relevance, responsiveness and transparency. In order to bring Science and Society more closely together in this way, setting a clear national vision for Citizen Science is essential, which can be anchored in the national strategy for Open Science, which in turn underpins many of the enabling conditions for Citizen Science.

The Final Report of the MLE[1] presents a summary of the learning and recommendations generated throughout the year-long process[2] as an inspiration, guide and resource for national policy makers and other key actors in the national science landscape, along with some tangible examples of progress made by the participating countries during the MLE itself.

Countries are encouraged to co-create their own national vision for Citizen Science in collaboration with key national stakeholders to move forward from the current state-of-play in a way that is consistent with their own national context. To avoid describing a linear roadmap that may be too simplistic or formulaic - the Final Report recommends taking a more flexible, context-specific but also ambitious approach, building on the substantial foundation for cross-national learning and inspiration that this MLE provides.

To this end, the Final Meeting of the MLE introduced the 'backcasting' strategic planning technique for setting a strategic vision for Citizen Science within the national research and policy-making landscape, which starts from the current status of Citizen Science in their own country and then identifies the pathways and potential steps towards achieving those aims.

The backcasting approach is particularly useful for developing a unique roadmap for action on a country-by-country basis, as any given country will be in a different stage of development in their Citizen Science practices, often working from different historical starting points and how they are supported by which actors (such as Citizen Science Hubs in Research Libraries[3], or Citizen Science Hubs / Science Shops in Public Libraries[4]). No two countries will have the same 'footprint', and therefore a prescriptive and linear set of recommendations would be less effective.

In this companion 'How To' guide to the Final Report, we describe the backcasting approach in more detail, and provide an example of how it can be applied in practice.

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[1] Available at: https://ec.europa.eu/research-and-innovation/en/statistics/policy-support-facility/psf-challenge/mutual-learning-exercise-citizen-science-initiatives-policy-and-practice

[2] The full repository of Thematic Reports, Discussion Papers, workshop presentations, and the MLE factsheet can be found on the PSF website: https://ec.europa.eu/research-and-innovation/en/statistics/policy-support-facility/psf-challenge/mutual-learning-exercise-citizen-science-initiatives-policy-and-practice .

[3] See for example the reports of the LIBER Citizen Science Working Group https://libereurope.eu/working-group/liber-citizen-science-working-group/

[4] Cigarini A, Bonhoure I, Vicens J, Perelló J. *Citizen science at public libraries: Data on librarians and user perceptions of participating in a citizen science project in Catalunya, Spain*. Data Brief. 2021 Dec 13;40:107713. https://pubmed.ncbi.nlm.nih.gov/35005128/

2. The Backcasting Approach

The term 'backcasting' was first coined by John Robinson in 1982[5], and is often applied as a planning approach for long-term complex issues that involve many aspects of society as well as technological innovations and culture change. This makes it a useful and highly relevant tool for developing a course of action to more fully embed and support Citizen Science at the national level.

Backcasting first looks ahead to define a desirable future end-state or vision, and then works backwards to identify the steps and solutions necessary to get there, starting from an assessment of the current situation, context, gaps, and needs. This is illustrated in Figure 1 below.

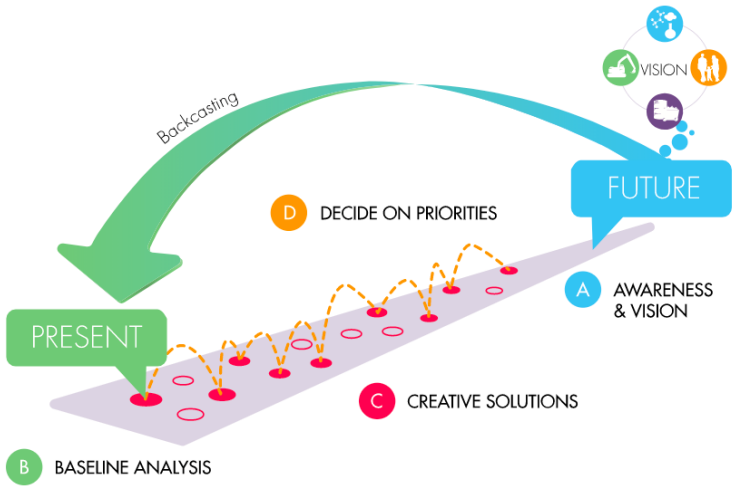


Figure 1: The backcasting planning approach as illustrated by The Natural Step[6]

2.1. Setting the Long-term Aims and Vision (Step A)

In the context of this MLE, the first step of the backcasting approach has been to establish the long-term goals for Citizen Science as a practice, the value it can deliver, and the national vision for the partnership between Science, Policy & Society (**A = Aims & Vision)**. We have done this together with representatives from the participating countries in the MLE. However, any application in practice should be collaboratively established together with key actors across the national science landscape and Citizen Science practitioners across the quadruple helix[7].

Drawing on the work of Topic 4 '*Enabling Environments for supporting and sustaining citizen science*'[8], we have based the MLE strategic vision on the **five key elements to achieving a**

[5] Holmberg, J., & Robèrt, K. H. (2000). Backcasting—A framework for strategic planning. International Journal of Sustainable Development & World Ecology, 7(4), 291-308. https://www.tandfonline.com/doi/abs/10.1080/13504500009470049

[6] Our Approach: The Natural Step Framework (215) The Natural Step. https://thenaturalstep.org/approach/

[7] See the Topic 4 Discussion Paper for a range of recommendations from Project Reports, Policy Briefs, and Roadmaps produced by projects supported by the Horizon 2020 funding programme. https://ec.europa.eu/research-and-innovation/sites/default/files/rio/report/Discussion%20Paper%20Topic%204%20Enabling%20Environments%20FINAL_BT.pdf

[8] See the Topic 4 Thematic Report: European Commission, Directorate-General for Research and Innovation, Mutual learning exercise on citizen science initiatives: policy and practice. *Fourth Thematic*

national strategic vision for a strong partnership between Science, Society & Policy that can fully deliver on the potential of Citizen Science:

1. **Embed Citizen Science** as part of mainstream research, funding, education and innovation processes.

2. **Integrate Citizen Science Data** into mainstream processes for research, policy making and decision making.

3. **Support Citizen Science Practices** by identifying and addressing the needs of the wide range of different actors initiating, leading, and participating in Citizen Science.

4. **Strengthen Citizen Science Networks** and enable an active national community of Citizen Science practitioners who collaborate closely with other key stakeholders across the quadruple helix, exchanging knowledge and know-how, and furthering innovation in the field.

5. **Make Knowledge Production Inclusive** such that all stakeholders interested in the outcomes of scientific research and innovation have the opportunity to participate in open and collaborative processes of scientific knowledge creation, evaluation, and communication, in all domains of research.

These are shown in Figure 2 below, as the five Aims in **Step A (Aims & Vision)** of the MLE backcasting process.

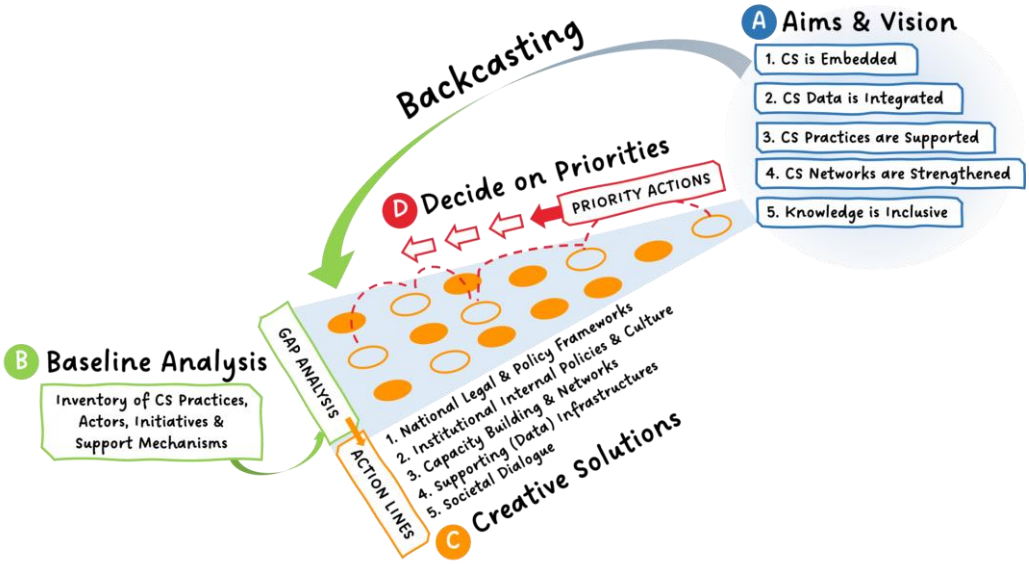


Figure 2: Backcasting in the MLE, following the A-B-C-D method developed by The Natural Step[9]

Agreement on these strategic aims should be reached via a process of dialogue and iterative development together with key members of the national science landscape and Citizen Science community. The national Open Science (and Citizen Science) strategy-setting

Report, Enabling environments and sustaining citizen science, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/305248

[9] Our Approach: The Natural Step Framework (215) The Natural Step. https://thenaturalstep.org/approach/

process recently conducted in the Netherlands is described in Box 1 below as an example. This not only ensures that there is wide agreement and 'ownership' of the strategic aims, but also that the aims are set realistically within the national context.

The first National Plan for Open Science was signed in the Netherlands in 2017 by a large group of stakeholders from the Dutch research landscape. As collaborations towards Open Science developed and strengthened, it evolved into a programme structure and became the National Programme Open Science (NPOS). The aim of the programme is to achieve a coordinated effort towards the transition to Open Science, and to disseminate its importance.

The NPOS Steering Committee has the task of managing the transition to Open Science on a national level, with advice (both solicited and unsolicited) from an Advisory Board. These two groups consist of the directors of the largest research performing and funding organisations in the Netherlands, the National Library and Royal Academy of Sciences, and research supporting organisations such as the eScience Center. Implementation rests with the various parties involved.

A group of active Dutch Citizen Science practitioners formed a Working Group in 2020 in a bottom-up initiative to embed Citizen Science within the NPOS Programme - resulting in a report recommending Citizen Science become a third Programme Line within NPOS, alongside FAIR Data and Open Access (actualised in 2021), and that a national network for Citizen Science be established (launched in 2022).

The NPOS strategic goals and ambitions (to which 78 institutions, networks, communities and individuals have given their constructive feedback via an open consultation process) are aligned with the UNESCO Recommendations, the first goal being: "*Close collaboration between knowledge institutions, government, industry, and citizens to strengthen the international position of Dutch science and optimise the processes of creating, sharing, and communicating knowledge for the benefit of society*".

On 17 June 2022, the Minister of Education, Culture and Science (OCW) Robbert Dijkgraaf announced in a Policy Letter on Open Science[10] that 20 million euros will be allocated for Open Science each year from 2023 to 2031, with explicit support for multi-stakeholder participation in the knowledge chain, bottom-up research practices that tackle societal issues, and participatory collaborations between scientific and societal actors.

He has asked the Dutch Research Council (NWO) to take responsibility for the spending of these funds and to set up a temporary Governing Body for Open Science. To inform the effective investing

[10] Policy Brief from the Dutch Minister of Education, Culture and Science: Hoger Onderwijs-, Onderzoek- en Wetenschapsbeleid, Nr. 964, Brief van de minister van Onderwijs, Cultuur en Wetenschap Aan de Voorzitter van de Tweede Kamer der Staten-Generaal, Den Haag, 17 juni 2022

of these funds, NPOS has co-developed a Rolling Agenda to achieve the NPOS Ambition 2030, the first Agenda Line of which is '*Towards Societal Engagement and Citizen Science*', and the respective Programme Lines have developed detailed Actions within these together with their communities of practice.

The Citizen Science Nederland network (CS-NL) currently consists of approximately 260 members, and as the network has grown, the members have been playing a key role in setting the strategic aims of the Citizen Science Rolling Agenda and defining and developing the Action Lines therein to create an enabling environment for Citizen Science in the Netherlands. This has happened in a co-creative fashion, through a series of Roundtable discussions, Delphi-method feedback rounds on the core objectives, and active co-writing of the Action Lines according to interest and need. Additionally, 120 attendees of the first CS-NL network day actively contributed further inputs during break-out sessions addressing the 5 categories of enabling factors and the strategic aims for the CS-NL network itself.

More information:
https://www.openscience.nl/en/docs/
https://zenodo.org/communities/npos
https://zenodo.org/communities/cs-nl

Box 1: The Dutch National Programme Open Science (NPOS) process towards co-developing the national strategy for Citizen Science, as a central pillar of Open Science.

2.2. Performing a Baseline Analysis (Step B)

The second step of the Backcasting approach is to create a landscape review and/or inventory as a baseline (**B = Baseline Analysis**) of the Citizen Science practices and support mechanisms already present and thriving in that country, across as wide a range of domains and contexts as can be found. From that baseline, a gap analysis can then be conducted to highlight where further support and infrastructure is needed. In this way, key actors across the national landscape can design strategic actions to address their own contextual needs and sustainability issues.

Recent developments in the field of Citizen Science to aid this process include the analytics and analysis framework developed by the Citizen Science Track project for monitoring the Citizen Science landscape[11], the PPSR core meta-data model[12] for describing Citizen Science projects to ensure interoperability with other platforms (such as the EU-Citizen.Science platform[13]), the Citizen Science / Citizen Observatory description template developed within the WeObserve project[14], and the Joint Research Centre's inventory of Citizen Science activities for environmental policies[15].

The primary purpose of a landscape review is to **identify where the gaps and needs might lie**, so that further supportive mechanisms and infrastructure can be put in place, and a more robust enabling environment for Citizen Science be developed. The gaps analysis thus forms the baseline with regard to the strategic vision. An inventory of projects, resources and support mechanisms can serve a similar purpose, but when shared online (for example on a

[11] De-Groot, R., et al. "*Developing a framework for investigating citizen science through a combination of web analytics and social science methods—The CS Track perspective*." Frontiers in Research Metrics and Analytics (2022): 62.
[12] The Public Participation in Scientific Research (PPSR) Data Standard for Public Participation in Scientific Research. https://core.citizenscience.org/
[13] The EU-Citizen.Science platform for sharing projects and resources for Citizen Science https://eu-citizen.science/development/, and the EU-Citizen.Science API https://eu-citizen.science/swagger/
[14] Gold, M., Wehn, U., Bilbao, A., & Hager, G. (2020). *EU Citizen Observatories Landscape Report II: Addressing the Challenges of Awareness, Acceptability, and Sustainability*. Zenodo. https://doi.org/10.5281/zenodo.4472670 pg.44
[15] European Commission, Joint Research Centre (JRC) (2018): *An inventory of citizen science activities for environmental policies.* European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/jrc-citsci-10004

national Citizen Science platform) has the additional advantage of aiding knowledge exchange, discovery and networking amongst the practitioner community.

The secondary purpose of this process should be to **identify success stories to raise awareness of the impacts of Citizen Science** amongst actors in the national science and policy landscape, and further support and scale them up such that their impacts can be sustained over time, over larger geographic regions, with a higher diversity of participants. These then contribute to the development of the 'Creative Solutions' towards filling those gaps and achieving the strategic aims.

The scaling-up of successful Citizen Science projects remains a relatively under-addressed subject, despite the stated ambition to scale impactful initiatives, and the increasing number of Citizen Science projects, practices and initiatives developed successfully across Europe in the past years. The Discussion Paper and Thematic Report '*Scaling up Citizen Science*[16]' address this topic in more detail and describe a range of action areas for policymakers.

2.3. Identifying Actions towards the Strategic Aims (Step C)

In order to co-creatively design actions to address these gaps and needs (**C = Creative Solutions**), and devise a plan to address them (**D = Decide on Priorities**), we draw on the framework of the 'Enabling Environment' and 'Enabling Factors'[17] that have been explored throughout the MLE, namely:

1. National Legal & Policy Frameworks,
2. Institutional Internal Policies & Culture,
3. Capacity Building & Networks,
4. Supporting (Data) Infrastructures, and
5. Societal Dialogue.

An environment that enables Citizen Science should achieve most or all of the five key strategic aims described in Step A above. The enabling factors are inter-relatedly needed to achieve those key strategic aims, and describe the various forms of support that are necessary to encourage, enable, support, and sustain Citizen Science as a participatory research practice,

For a deeper understanding of these factors and best practice examples, the Topic 4 Thematic Report '*Enabling Environments and Sustaining Citizen Science*[18]' describes the enabling environments and the institutional and governance arrangements that can support Citizen Science, with a particular focus on the role of different stakeholders, including

[16] European Commission, Directorate-General for Research and Innovation, Mutual learning exercise on citizen science initiatives: policy and practice. Fifth Thematic Report, Scaling up citizen science, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2777/527361

[17] See: the Topic 4 Discussion Paper on Enabling Environments https://ec.europa.eu/research-and-innovation/sites/default/files/rio/report/Discussion%20Paper%20Topic%204%20Enabling%20Environments%20FINAL_BT.pdf ; and Topic 4 Thematic Report on Enabling Environments and Sustaining Citizen Science https://op.europa.eu/en/publication-detail/-/publication/28235058-6646-11ed-b14f-01aa75ed71a1/language-en/format-PDF/source-275091694

[18] European Commission, Directorate-General for Research and Innovation, Mutual learning exercise on citizen science initiatives: policy and practice. Fourth Thematic Report, *Enabling environments and sustaining citizen science*, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/305248

research institutes, funding bodies, public authorities, businesses and industry, and civil society organisations in promoting Citizen Science.

Throughout the thematic topics explored across the MLE, information, experiences and lessons learned were shared amongst the participants to identify best practice and innovative actions that can contribute to achieving these aims. Of all of these recommendations for action, the four most impactful recommendations that have been supported across all of the thematic topics are to:

1. Ensure that Citizen Science practitioners - in academia (top-down), in society (bottom-up), in policy (collaborative) and in the private sector (collaborative) - are supported by a **national network of practitioners** to share knowledge, form partnerships, and further develop best practice.

2. Ensure that **dedicated funding instruments** can provide financial support to the places where it is most needed (especially to societal partners) in order to enable new initiatives to get off the ground and to provide ongoing funding or scaling-up funding for successful initiatives. These instruments should allow sufficient flexibility for co-creational approaches to be implemented.

3. Enable the **culture change** required to open up science and the scientific process more fully to the participation of citizens, societal actors, and civil society organisations for the benefit of research quality, policy impact, and improved societal welfare.

4. Enable the establishment and ongoing iterative development of key **supportive infrastructure** such as data-gathering tools and platforms, data analysis and visualisation tools, data hosting and archiving, and domain-specific research infrastructures.

As in the first step (A = Aims & Vision), agreement on the details of the actions required to address the needs of the practitioner community and fill gaps within the enabling environment should also be reached via a co-creative co-design process with key members of both the national science landscape and the Citizen Science community. For an example of such a process in action, Box 2 below describes the recent extensive consultative process conducted in Germany throughout 2021, which led to 94 recommendations for action for the further development of Citizen Science in Germany.

The German Citizen Science community recently undertook a major consultation exercise

to produce a White Paper Citizen Science Strategy 2030 for Germany[19] with the support of the Federal Ministry of Education and Research (BMBF) and the German Federal Environmental Foundation, which was compiled with the participation of 219 people from 136 organisations - from scientific institutions and research libraries to science shops, societies and private individuals - with a total of 1,343 contributions, 119 comments and 31 position papers from organisations and institutions.

The Citizen Science White Paper produced in 2020 is the natural successor to the Green Paper for Citizen Science in Germany[20] that was produced in 2016 by the 'GEWISS' capacity building programme (standing for: BürGEr schaffen WISSen – Wissen schafft Bürger, i.e., Citizens Create Knowledge – Knowledge Creates Citizens), which aimed at strengthening Citizen Science in Germany. One it its 52 recommendations for action was the establishment of a national platform for Citizen Science in Germany, thus resulting in the launch of 'Bürger schaffen Wissen'[21].

Funding provided by BMBF in 2014, 2018, 2021 and 2023 helped to increase the number of projects profiled on and supported by the platform from year to year and to support the national community of practitioners. In order to strengthen the capacity building of Citizen Science actors, training workshops were successfully implemented. Since 2021, the platform has been offering training workshops on topics such as communication, legal issues, evaluation and volunteer management.

The survey found that the most effective support instruments for gaining expertise in Citizen Science were the knowledge-exchange with colleagues from other organisations facilitated by the network, knowledge-exchange with colleagues from one's own organisation, the experience gained from participating in a Citizen Science project, and the experience gained from organising or leading a Citizen Science initiative. Most respondents reported that what Citizen Scientists gain the most from participating in Citizen Science projects is new knowledge about the topic being investigated within the project content, and the feeling of making a difference together with others in the field of that topic. These inputs led to the development of the 94 recommendations for action made in the White Paper, across 15 thematic priority areas for further supporting, sustaining and developing Citizen Science in Germany.

In 2021, Citizen Science was anchored in the German coalition agreement, stating ''we will use Citizen Science to integrate perspectives from civil society more strongly into research''.

In addition to the current Citizen Science funding guideline BMBF has created a Citizen Science competition for cities and municipalities in order to strengthen local networks. The funding of the national Citizen Science platform will be continued (2023-2025). Among others, a Citizen Science prize for excellent research will be launched and there will be increased focus on integrating Citizen Science multipliers and civil society organisations into mainstream Citizen Science.

More Information:
https://www.buergerschaffenwissen.de/sites/default/files/grid/2022/10/17/White_Paper_Citizen_Science_Strategy_2030_for_Germany.pdf

[19] Bonn, A. et al. (2021). White Paper Citizen Science Strategy 2030 for Germany. Helmholtz Association, Leibniz Association, Fraunhofer Society, universities and non-academic institutions, Leipzig, Berlin. SocArXiv http://osf.io/preprints/socarxiv/ew4uk

[20] Bonn, A. Green Paper. Citizen Science Strategy 2020 for Germany. Projekt" Bürger schaffen Wissen-Wissen schafft Bürger"(GEWISS), 2016. https://www.buergerschaffenwissen.de/sites/default/files/assets/dokumente/gewiss_cs_strategy_englisch_0.pdf

[21] https://www.buergerschaffenwissen.de/

The specific action areas that require attention in order to grow and sustain Citizen Science are presented in greater detail in the underlying Discussion Papers and Thematic Reports on the topics of the MLE, which also summarise the insights and recommendations that emerged during the dedicated workshop sessions on those topics[22], but there are a number of cross-cutting requirements to all of them:

Firstly, **dedicated funding** to support, sustain and scale Citizen Science is needed across all of the categories of enabling factors, not just within research funding programmes. Investment is needed in the research infrastructures and technical tools & platforms that support Citizen Science, and also in human resources, training, education, and other forms of capacity building and knowledge exchange. Opportunities should be taken to also engage key stakeholders in the co-creation of these funding programmes and mechanisms.

Secondly, the system of **rewards and recognition** within the career pathways for academics, scientists, researchers, and other knowledge experts must be updated to include participatory and collaborative research practices, such that they are recognised as having value to both the quality of the science and to society, and thus need to be rewarded within the normal progression of a research career. This culture change goes hand in hand with reforming research assessment and the concept of excellence[23].

And thirdly, **knowledge sharing** of methods and best practice, and **awareness raising** of the impacts of Citizen Science should be supported within institutions and across the entire research landscape, such that the silos between research groups, departments, faculties, and external stakeholder groups can be bridged and brought more closely together in collaborative partnerships. This should include the establishment of and support for internal Working Groups, societal knowledge hubs such as Citizen Science in Public Libraries, and national Citizen Science Practitioner networks.

2.4. Identifying the Actors and the 'Spheres of Influence' towards the Strategic Aims (Step C)

During the explorations of the factors that contribute to an enabling environment for Citizen Science, the MLE participants discussed which of these they themselves could play a role in putting into place, either at the institutional level, or within their own department. By considering their own 'Spheres of Influence', they could express where they had an ability to create or implement these factors from their formal role or mandate or encourage their creation and implementation as advisors or facilitators.

This forms an important part of 'backcasting' **Step C (Creative Solutions)** and the development of actions and action lines towards achieving the national strategic vision, according to each actor's role within the scientific landscape, as shown in Table 1 below.

Actors may include the National Ministries for Science and Education, (but also Environment, Transport, Agriculture, Food, Health, and others), regional, local and other sectoral policy makers, Research Funding Organisations (RFOs), Research Performing Organisations (RPOs), Research Supporting Organisations (RSOs) such as eScience Centres and computing infrastructure providers, and Higher Education Institutions (HEIs), and Research and Technology Organisations (RTOs) who are operating closer to market needs.

[22] See the MLE Repository: https://ec.europa.eu/research-and-innovation/en/statistics/policy-support-facility/psf-challenge/mutual-learning-exercise-citizen-science-initiatives-policy-and-practice
[23] See for example the work of the Coalition for Advancing Research Assessment https://coara.eu/, and the Agreement on Reforming Research Assessment https://coara.eu/agreement/the-agreement-full-text/.

Spheres of Influence → / Strategic Aims ↓	Ministries	RFOs	RPOs	RSOs	HEIs
1 (a) Embed Citizen Science as part of mainstream research and innovation processes	✓	✓	✓✓	✓	✓
1 (b) Embed Citizen Science as part of mainstream funding	✓	✓✓			
1 (c) Embed Citizen Science as part of mainstream education	✓	✓	✓		✓✓
2 (a) Integrate Citizen Science Data into mainstream processes for research, policy making and decision making.	✓✓	✓		✓	
2 (b) Build Citizen Science data and technology infrastructure	✓	✓	✓	✓	
3 Support Citizen Science Practices	✓	✓	✓✓	✓✓	✓
4 Strengthen Citizen Science Networks	✓	✓✓	✓	✓	✓
5 Make Knowledge Production Inclusive	✓	✓	✓	✓	✓

Table 1: Areas of recommended actions within the Strategic Aims, and the key actors within the national science landscape (with double checkmarks indicating the stronger sphere of influence where several actors play a role)

2.5. Deciding on the Priorities (Step D)

The priorities for action in any given country will depend on the unique context of the scientific and policy landscape, and the stage of development of Citizen Science as a practice - they should therefore be set in collaboration with the relevant actors and the field of practice. These decisions form **Step D - Decide on Priorities** in the backcasting process.

Despite this emphasis on local context, a number of needs have clearly emerged throughout the MLE process as cross-cutting requirements, which form a clear place to start in setting the national priorities for action. Dedicated funding is particularly important for addressing the three aspects of sustainability that are particular to Citizen Science practices, namely: sustaining Citizen Science projects and initiatives over the mid to long-term, sustaining the wider uptake of Citizen Science data and multi-stakeholder engagement practices, and sustaining Citizen Science as a research practice within RPOs and HEIs (a topic that is covered in the Horizon 2020 projects TIME4CS and INCENTIVE).

3. Step-by-Step through the Backcasting approach

Step A = Aims & Vision

The first step of the backcasting approach for any country wishing to strengthen the ties between Science, Policy and Society, and realise the full potential of Citizen Science practices, is to develop and define the national strategic aims and vision for Citizen Science in collaboration with key stakeholders from both Science & Society.

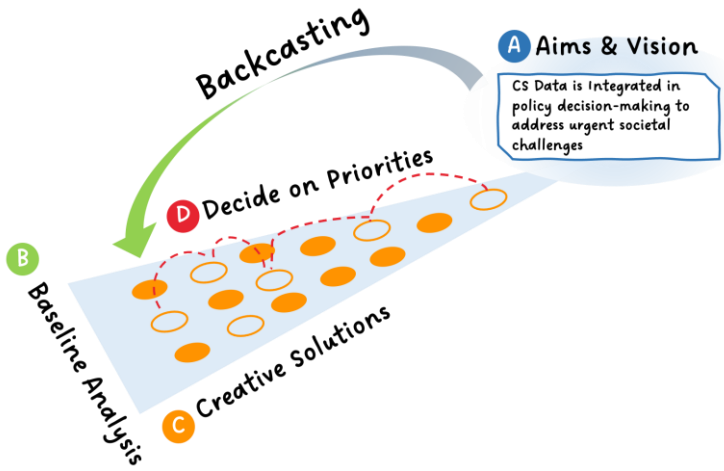
To aid this process, launch and maintain an ongoing dialogue with as wide-ranging a group of actors from across the quadruple helix as possible, who are stakeholders in the scientific processes and societal outcomes of Citizen Science approaches, to come to a common

understanding of the locally relevant definition of Citizen Science (or similar term), the values that are important to guard and protect, and how quality should be defined / monitored / evaluated.

Come to a shared understanding of what you understand by the term Citizen Science and be explicit about the range of activities being encouraged and supported, giving consideration to your own national cultural, scientific and socio-political context.

"*… the definition of Citizen Science should be instrumental. It must reflect the objectives of the actors, its use, and the extent of the engagement of citizens at different levels. This means that a definition of Citizen Science needs to encompass and promote an open and broad understanding of manifold research practices and participation. This comprehensiveness is essential to both, producing meaningful research on Citizen Science, as well as providing support to the development of Citizen Science on the national and European level. …*[24]."

If for example, the strategic vision is to close the gap between Science, Society & Policy, such that societal actors have a strong participatory role in addressing urgent societal challenges, then the stated aim might be to integrate citizen-generated data into policy decision-making processes related to those issues - as shown in Step A below.



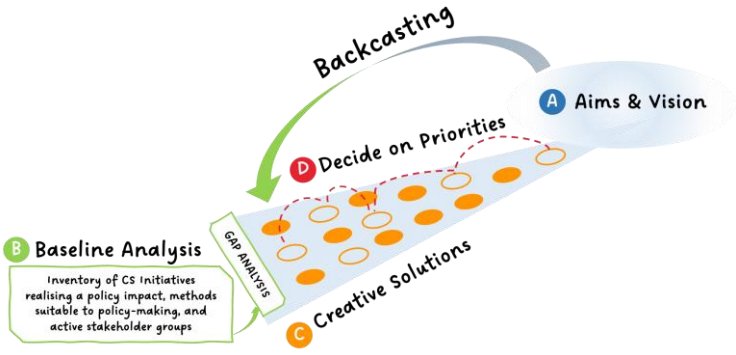
Step B = Baseline Analysis

The second step is to investigate and build an inventory or landscape report of the range of Citizen Science initiatives taking place – also taking "Invisible Citizen Science[25]" into account – that is, the participatory initiatives that might not be using the term Citizen Science but certainly fall within the range of practices described by that umbrella term. This is especially relevant when using local languages, and when considering grassroots Citizen Science that is initiated bottom-up – these are the most common 'invisible' cases.

[24] Manzoni, M., Vohland K., Schade, S, Survey on Citizen Science Strategies and Initiatives: Report on outcomes in Europe: Technical Report on Outcomes, European Commission, Ispra, 2021
[25] Term coined by Bálint Balázs at the Citizen Science COST Action workshop 'Invisible Citizen Science', June 4th, 2019. Event Report: https://web.archive.org/web/20220625105050/https://cs-eu.net/news/cs-strategies-europe-event-report-cesis-latvia-june-4th-2019; Presentation Blog Post: https://cs-eu.net/blog/b%C3%A1lint-bal%C3%A1zs-%E2%80%9Ccitizen-science-much-more-public-engagement-or-informal-learning%E2%80%9D. See also: Balázs, B., Mooney, P., Nováková, E., Bastin, L., Jokar Arsanjani, J. (2021). Data Quality in Citizen Science. In: , et al. The Science of Citizen Science. Springer, Cham. https://doi.org/10.1007/978-3-030-58278-4_8

During the inventory process, make note of the support mechanisms that are already present (e.g., in the European Citizen Science platform[26], or in the national one when it exists), and of success stories that can be scaled up to extend their impact. Showcase these initiatives and raise awareness of their impacts amongst decision makers in the areas those impacts have been realised (for example policy vs publications). This should be followed by a gap analysis of what enabling factors and mechanisms are still needed.

Continuing the example of integrating citizen-generated data into policy decision-making processes for urgent societal issues, this inventory might focus on examples of initiatives already realising a policy impact, the Citizen Science methods and protocols well-suited to gathering data that is relevant to policy decision-making, and the range of actors and stakeholders who are already active in this way - as shown in Step B below.



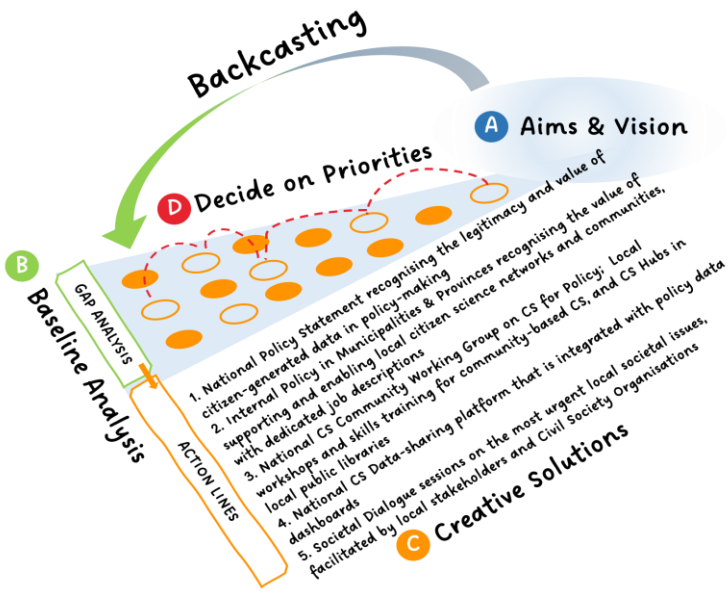
Step C = Creative Solutions

To start taking action on addressing the gaps it is important to form multi-stakeholder groups as broadly as possible, to co-design the strategic actions needed to address the gaps and needs identified in the baseline analysis, including the key actors needed to achieve the ultimate strategic vision.

Examine the structures for providing research support (in terms of skills acquisition and knowledge exchange) and operational support (in terms of community building, communications, ethical guidance, legal support and other success factors outside the research itself), and invest in building those further, and expanding them broadly across the national scientific ecosystem.

The Enabling Factors framework described in Section 2.4 is useful for this step. For example, integrating citizen-generated data into policy decision-making processes for urgent societal issues, might result in the following action lines- as shown in Step C below.

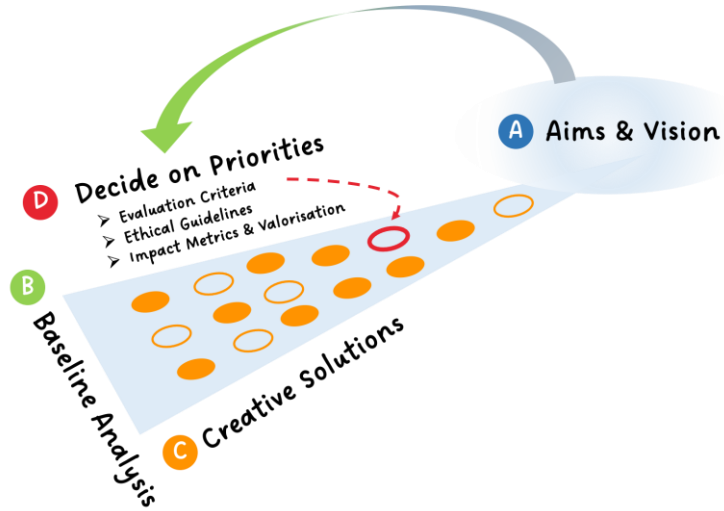
[26] See https://eu-citizen.science/, where +240 projects, + 200 resources, +60 training resources, +230 organisations, + 16 platforms, + 2,850 users can be found (on January 5, 2023).



Step D = Decide on Priorities

This final step in setting the national strategic aims into action is best enabled via a strong and robust network of stakeholders - researchers, funders and civil society – who have coordination support from a national associative body that can hold events and enable knowledge exchange. Such a network will be best equipped to prioritise the actions which will have the most impact, either by addressing an urgent need of the Citizen Science community of practice or strengthening existing initiatives to more effectively achieve their desired impacts.

It will also be necessary to agree upon how these priorities should be set, in terms of evaluation criteria, ethical guidelines, and impact metrics and valorisation, as shown in Step D below. The establishment of such guidance can itself form one of the first actions with the national community of Citizen Science actors and stakeholders.



4. Recommended Enabling Factors and Creative Solutions from the Topical Themes of the MLE

Topic 1 - Introduction and overview of Citizen Science

Topic 1 provided **an introduction to the activities and practices of Citizen Science**, looked in detail at the response of the public to engagement in science in general, and with Citizen Science in particular, examined the principles and characteristics of Citizen Science, and finally, looked at current funding mechanisms of Citizen Science at the European and national levels.

Thematic Report 1 emphasised that it is important to maintain a wide definition of Citizen Science. Especially in the context of research and innovation support systems, both in terms of policy and funding, to enable support of participatory research activities as they emerge in different areas of research. While Citizen Science is well established in the natural sciences, it continues to evolve with adoption of such activities in biomedical research, social sciences, and the humanities.

The Report introduced several typologies of Citizen Science, and especially looked at the potential for participation in Citizen Science activities. In particular, it highlighted the insights that were provided by the Eurobarometer 516 study. The combination of increased level of education (and higher education) across Europe, with a declared interest in participation in research projects, mean that there is a significant potential for growing Citizen Science in Europe.

The main recommendations contained in this Thematic Report are:

1. Citizen Science should be approached in a pluralistic way, allowing different practices to be included.

2. The growth in education across Europe opens up the potential of many more people to participate in Citizen Science projects

3. Funding schemes that are dedicated to Citizen Science are emerging at different levels - from the Horizon programmes to local funding.

4. The ECSA principles of Citizen Science and ECSA characteristics of Citizen Science provide a basis to define best practices in Citizen Science.

Topic 2 - Ensuring good practices and impacts

The overall goal of Topic 2 was to **identify and discuss practical examples and best practices of Citizen Science and its related impacts**. Different visions on how to do "good" Citizen Science were shared, while also discussing what good Citizen Science means.

As discussed in Topic 1, the overall landscape of different practices makes it difficult to come up with a unique definition of Citizen Science. The range of activities, levels of engagement, different goals, and specific cultural issues make the practice of Citizen Science a multidimensional and complex one; and as a result, difficult to define in specific terms. In order to identify good practices, successful Citizen Science projects were selected by the 11 countries participating in the MLE and a set of variables were defined against which the projects were analysed, including:

1. Variable 1: Participation, Engagement, Inclusivity & Diversity in Citizen Science across all phases of the research project

2. Variable 2: Data Quality and Openness

3. Variable 3: Science Communication in Citizen Science projects

4. Variable 4: Demonstrating Impacts

5. Variable 5: Fostering Sustainability

The wide range of the sample selection of Citizen Science best practices demonstrated that a so-called “successful” Citizen Science project depends on many aspects, such as the project objectives, the resources available, and the definition of the variables and its measurement to evaluate the extent to which the expected objectives and impacts are achieved.

In addition, there is still a lot of room for public authorities to make use of this source of information and for Citizen Science projects to have a greater impact on policies. Nevertheless, challenges and barriers such as data quality and validation, scientific recognition, demonstrated impact and sustainability, among others, seem to hold back the whole potential of Citizen Science. More capacity building and training, new funding opportunities and schemes, clustering and networking, and institutional changes to recognise the practices are still needed to further support new and ongoing Citizen Science initiatives and their practitioners to open-up science to society.

Finally, existing Citizen Science national networks and funding schemes were analysed to identify commonalities and recommendations to better implement and support Citizen Science initiatives and projects at the national level and overcome the detected barriers. Participants were asked to vote on the most promising national support mechanisms and strategies to strengthen Citizen Science.

The main recommendations contained in this Thematic Report are:

1. Work on recognition and institutional barriers.

2. Facilitate training and capacity building.

3. Launch specific Citizen Science calls.

4. Include specific evaluation criteria in general calls.

5. Build common repositories, observatories or platforms.

6. Launch calls for replication/upscaling of ongoing projects.

7. Increase or enrich new or existing networks.

8. Use cascade funding schemes.

9. Promote common data infrastructures.

10. Support Citizen Science practices through incubator models.

Topic 3 - Maximising the relevance and excellence of Citizen Science

Topic 3 addressed the key factors identified as **ensuring the relevance and excellence of Citizen Science**. Relevance generally refers to the importance of research in addressing matters that are of significance to society. Excellence meanwhile is often applied to the scientific quality of research: undertaking research with rigour and producing reliable, robust and reproducible results.

The Thematic Report on this topic gave particular attention to three key factors that can ensure high relevance and excellence across Citizen Science activities.

1. Alignment and support for the UN's Sustainable Development Goals (SDGs).

2. Consideration of novel ethical issues raised by Citizen Science.

3. The management of data in line with the FAIR principles (Findability, Accessibility, Interoperability and Reusability) in order to strengthen policy uptake.

For each factor, key challenges were raised and questions asked.

Discussions over the three key factors of excellence and relevance were conducted with MLE experts and participants.

Several key recommendations are highlighted in this Third Thematic Report:

- All of the three factors of excellence and relevance of Citizen Science are highly interdependent, thus any strategy or action aiming to maximise relevance and excellence of Citizen Science should take all these factors into account.

- Beyond the need to ensure high data quality or good ethical conduct in Citizen Science, policymakers need to believe that Citizen Science projects can be sustainable, which requires innovative funding schemes to ensure a continuous contribution to the SDGs or national/local goals.

- Regulations need to be adopted, but most importantly, technical support needs to be provided in order to foster the recognition and legitimacy of citizen-generated data for decision making, particularly regarding ethics and data management for local Citizen Science projects.

- There is a need to showcase further Citizen Science uses in policy.

- The MLE identified that a specific effort is required to change the perspectives of national actors towards citizen-generated data and Citizen Science.

- The area of ethics of Citizen Science represents specific challenges that need to be recognised and supported by policymakers. The MLE participants and experts also identified practical challenges that small RPOs and actors such as SMEs and NGOs encounter in Citizen Science and societal engagement. In both cases, capacity building is needed, for example in the form of templates or "how to" guides to involve as much R&I actors in Citizen Science practices as possible.

- Finally, appropriate consideration and clarifications are required to explain how the ethical practices of Citizen Science interact with European and national policies (e.g., GDPR).

Topic 4 - Enabling environments and sustaining Citizen Science

Topic 4 addressed the theme of **Enabling Environments and Sustaining Citizen Science.** Many European Member States are increasingly aware of the importance and value of societal engagement within future science policy and practice, and the value of participatory knowledge production that includes the insights and local knowledge of societal actors. Topic 4 focused on enabling environments and the institutional and governance arrangements that can support Citizen Science, with a particular focus on the role of different stakeholders, including research institutes, funding bodies, public authorities, businesses and civil society organisations in promoting Citizen Science.

Topic 4 identified three aspects of sustainability within the context of this MLE:

1. Sustaining Citizen Science projects and initiatives over the mid to long-term, in terms of their ability to secure financial support for ongoing operations and the continued engagement of participants, the provision of supportive technical infrastructure, and enabling knowledge sharing and best practice development in national networks.

2. Sustaining the wider uptake of Citizen Science data and multi-stakeholder engagement practices, such that the broader aimed-for impacts of Citizen Science approaches can be achieved.

3. Sustaining Citizen Science as a research practice within RPOs and HEIs.

The term '**Enabling Environment**' encompasses the various forms of support that encourage, enable, support, and sustain Citizen Science practices, researchers and participants. UNESCO has highlighted seven priority areas of action in its Recommendations on Open Science, which form a useful framework for understanding the types of activities that are crucial for building an enabling environment for Open Science at the individual, institutional, national, regional, and international levels. Given the key role of Citizen Science practices to achieve societal engagement within the movement towards Open Science, these recommendations similarly provide a relevant framework for the discussion of the enabling environments for Citizen Science.

The Topic 4 Discussion Paper introduced a framework for the enabling factor discussions that is based on the work of the International Labour Organisation. The five categories of enabling factors within this framework are:

1. National Legal & Policy Frameworks,

2. Institutional Internal Policies & Culture,

3. Capacity Building & Networks,

4. Supporting (Data) Infrastructures, and

5. Societal Dialogue.

The main recommendations contained in the Thematic Report are:

1. **Create Dedicated Funding.** Dedicated Funding is an overarching requirement for each of the subsequent recommendations. Ensuring the availability of dedicated funding will require both funding instrument innovation and explicit attention for participatory practices in research policy, in order to enable the close collaboration of knowledge institutions with

societal actors for the production of new knowledge and insights and sustaining these over the longer term.

2. **Explicitly support Citizen Science in National Legal and Policy Frameworks** are showing a wide range of options. This is not surprising when considering the wide range of research and innovation systems across Europe. Therefore, the policies need to be tailored to the appropriate local context and consider all phases of a Citizen Science Project journey, including initiation, recruitment, maintenance and outcomes.

3. **Explicitly support Citizen Science in the Institutional Culture and Policies** such as a) 'Rewards and Recognition' for Citizen Science in scientific career paths and b) Dedicated Support Centres for Citizen Science within RPOs, as specific points of attention for institutional transformative change.

4. **Build Capacity Building and Supportive Networks** in terms of skills training and ongoing education of all stakeholders and to the systems of support for collaboration, networking, and securing the resources (both financial and operational) that are key to the success of Citizen Science.

5. **Build supportive and dedicated Technological and Data Infrastructures** focusing on (i) the technical platforms and tools for data gathering and analysis in Citizen Science initiatives, (ii) the data infrastructures for data aggregation and data sharing that are needed to ensure that Citizen Science data are findable, accessible, interoperable, and reusable (FAIR), (iii) the integration of Citizen Science data with official data systems and frameworks, and (iv) research infrastructures that are inclusive of societal actors and support participatory and collaborative research initiatives in any given domain.

Topic 5 - Scaling up Citizen Science

Topic 5 addresses meanings, dimensions, models and approaches/strategies of **scalability in Citizen Science** as well as drivers, success factors and challenges of (up)scaling Citizen Science projects and initiatives across Europe.

Due to limited knowledge available in literature about scaling up in Citizen Science, both the Topic 5 Discussion Paper and the Thematic Report draw on original content generated through a mixed methods approach which combined findings from i) a literature review, ii) a survey distributed among the MLE CSI-PP country representatives, iii) interviews conducted by the Topic 5 Expert with seven experts in Citizen Science and cognate disciplines, and iv) three working sessions held during the Berlin meeting on 7-8 November 2022.

The main outcomes of Topic 5 consist of a multi-dimension qualitative definition of scaling up in Citizen Science, the MLE CSI-PP Responsible and Inclusive Scalability Framework, nine exemplary Citizen Science projects and initiatives, and eight key areas of action for policymakers aimed at supporting the (up)scaling of Citizen Science projects and initiatives across Europe.

Firstly, the Thematic Report[27] acknowledges that scaling up is a value/ambition that suits some unique types of Citizen Science projects and initiatives but not all. Hence it suggests that scaling up should be i) a 'responsible' and inclusive process, ii) context- and domain-dependent, iii) sustained by a sound logic consistent with the project/initiative, iv) driven by common scientific questions and common social challenges, and v) built on proven impact,

[27] Avaialble at https://ec.europa.eu/research-and-innovation/en/statistics/policy-support-facility/psf-challenge/mutual-learning-exercise-citizen-science-initiatives-policy-and-practice.

related to science and scientific literacy, inclusion, regulatory frameworks, matters of concern (e.g., environmental, societal).

Secondly, drawing on this multi-dimension qualitative definition of scaling up, it introduces the MLE CSI-PP Responsible and Inclusive Scalability Framework composed of four models of scalability (scaling up-out-deep-down) and two approaches/strategies (top-down/deliberate and bottom-up/accidental).

Thirdly, it presents five Citizen Science projects and initiatives exemplary of the four models and the two approaches/strategies of the MLE CSI-PP Responsible and Inclusive Scalability Framework, namely: Plastic Pirates – Go Europe![28], OpenStreetMap, CurieuzeNeuzen, Hush City and Roadkill. Furthermore, four exemplary upscaled Citizen Science projects are illustrated in the Topic 5 Discussion Paper[29], i.e., FotoQuest GO, The Star Spotting Experiment, Tea Bag Index, Dugnad for Havet (in English: Marine Citizen Science).

Finally, the Thematic Report proposes eight key areas of action for policymakers:

1. **Rethink the meaning of innovation in Citizen Science** acknowledging that the next innovation steps for the field of Citizen Science lie in the processes for reproducing, sustaining, and upscaling successful Citizen Science projects and initiatives[30].

2. **Adopt and promote a multidimensional, qualitative definition of scalability** which stems from the triangulation of proof of value, matter of concern and social/legal alignment and define specific evaluation criteria for selecting Citizen Science projects and initiatives to be scaled**.**

3. **Ensure responsible scaling-up** addresses the RRI dimensions[31] and ensure they are accounted for in the design and development of the projects/initiatives to align outcomes with the values of society.

4. **Commit to 'People First' (up)scaling processes**, acknowledging the importance of keeping people central and connected in the process of scaling Citizen Science projects and initiatives, and taking action to remove the systemic barriers impeding people from actively participating in science producing 'contextualised knowledge' at any level[32].

5. **Support a Responsible Scaling Ambition[33] in Citizen Science** by designing specific funding programs and mechanisms, diversifying the sources/types of funding, and ensuring the funding lines and sources can be visible to Citizen Science grassroots movements and bottom-up projects/initiatives.

6. **Support the implementation of different models (up-out-deep-down) and approaches/strategies (top-down/deliberate, bottom-up/accidental) of scalability**,

[28] Plastic Pirates – Go Europe! | Plastic Pirates (plastic-pirates.eu)
[29] See Section 4 of the Discussion Paper available at https://ec.europa.eu/research-and-innovation/en/statistics/policy-support-facility/psf-challenge/mutual-learning-exercise-citizen-science-initiatives-policy-and-practice.
[30] Schade, S. 2022. Interview with Antonella Radicchi, June 29 2022 (via Zoom).
[31] The RRI dimensions are: public engagement, open access, gender equality, science education, ethics, and governance. Source: https://rri-tools.eu/about-rri
[32] See also Irwin, A., 1995. Citizen Science. A Study of People, Expertise and Sustainable Development. Routledge; Skarlatidou, A., Haklay, M. (eds), 2021. Geographic Citizen Science Design: No One Left Behind, UCL Press. https://www.uclpress.co.uk/products/125702
[33] Adapted from the term "Scaling Ambition" from Maturano, J. M. 2020. Responsible Scaling of Citizen Science projects for farmers: developing a SDGs-guided Toolkit. Technical Report. IIASA.

acknowledging scalability in Citizen Science is context- and domain-dependent and should be responsible, inclusive and aligned with the logics of the projects/initiatives.

7. **Develop local/regional/national/European networks** to foster collaboration and initiate discussions about the cultural transformation/s and implications expected via the scaled projects, with an emphasis on the language issue and its cultural and scientific implications.

8. **Support the exploitation of citizen-generated data from (up)scaled Citizen Science projects/initiatives** integrating them in policies and policy making programs at the local/regional/national/EU level.

Summary of Recommendations towards achieving the 5 strategic aims for Citizen Science

Recommended Actions
1 (a) Embed Citizen Science in mainstream research practices:
Raise awareness of Citizen Science research practices and increase their acceptance
Recognise and reward Citizen Science practices in career trajectories & remove institutional barriers
Include Citizen Science practices in the qualitative evaluation and assessment of research excellence
Provide a central online repository of consolidated research and best practice
Facilitate knowledge exchange amongst researchers
Facilitate inter- and transdisciplinary collaborations
1(b) Embed Citizen Science in mainstream funding:
Provide dedicated funding programmes for Citizen Science approaches in research and innovation
Include specific evaluation criteria in general calls
Launch calls for scaling up (or down, or out, or deep) ongoing projects
Support Citizen Science practices through incubator models, with graduated funding levels
Provide cascade funding models that can rapidly respond to local needs
Diversify the variety of funding models to also support grassroots participation and initiation
1(c) Embed Citizen Science in mainstream education
Develop and deliver participatory Citizen Science lesson modules for hands-on STEM teaching
Develop and deliver Citizen Science as a research method module in higher education
Include Citizen Science methods in the provision of research training for PhDs and Postdocs
Systematically integrate community-engaged learning in higher education

Recommended Actions

2(a) Integrate Citizen Science Data in policymaking

- Integrate Citizen Science data within formal data monitoring platforms (environment, public health, mobility, urban planning, climate change, etc.)
- Embed Citizen Science initiatives and citizen observatories into local and regional policy-making processes
- Integrate citizen-generated data in national policy-making processes
- Build common open (FAIR) data repositories and data platforms

2(b) Build Citizen Science data and technology infrastructure

- Provide and maintain Citizen Science data hosting, data analysis and data sharing platforms
- Fund and support the ongoing iterative development of Citizen Science data gathering and analysing tools
- Integrate Citizen Science methods and data into domain-specific research infrastructures

3. Support Citizen Science Practices

- Identify different actors with a stake in research processes and/or outcomes, and address their needs in context
- Provide skills development, training and research support across stakeholder groups
- Provide centralised communications and community outreach support for researchers
- Invest in the production of high-quality guidance and resources for the innovative application of new approaches and new domains of application

4. Strengthen Citizen Science Networks

- Provide structural coordination and operations funding, including communications and community management for a national Citizen Science practitioner network
- Facilitate knowledge-exchange, networking and partnership formation across the national community of practitioners
- Facilitate the further development of best practice at the national level
- Bring multiple stakeholder groups together, including civil society organisations, societal actors and citizens
- Facilitate collaboration between Open Science networks, Science Communication & Public Engagement networks, and Citizen Science networks

5. Make Knowledge Production Inclusive

- Provide opportunities to participate in open and collaborative processes of scientific knowledge creation, evaluation, and communication to the benefit of society and its members, in all domains of research.
- Support societal dialogue to engage diverse stakeholder groups in discussions of research questions that impact them
- Remove barriers to participation of non-traditional participants in research and innovation
- Develop specific funding criteria for societal actors such as NGOs, local community organisations, faith-based organisations, etc.
- Implement Responsible research and innovation (RRI) practices with particular attention for diversity & inclusion

Recommended Actions

Develop funding and project evaluation criteria that address diversity and inclusion

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The policy brief offers ‘How To’ guide to the Final Report describes the backcasting approach in more detail and provides an example of how it can be applied in practice.

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