national open science programme

Knowledge and strengths combined - citizen science in the Netherlands

Science and society in co-creation

Final Report of the Citizen Science Working Group

26 October 2020

NPOS (2020) Knowledge and strengths combined - citizen science in the Netherlands

Colophon

Title: NPOS (2020) Knowledge and strengths combined - citizen science in the Netherlands

Inhoud

1. Summary

Reader's Guide
In the original Dutch text of this guide, the Citizen Science Working Group decided to use the terms citizen science and citizen scientist in English. Whenever this guide refers to 'civic organisations', that term also includes government organisations.

In citizen science projects, professional scientists conduct research together with citizen scientists. The efforts, knowledge and experience of the latter are essential for the desired results in all phases of the research. The research can be initiated by researchers as well as by citizen scientists or civic organisations and often yields results that could not be achieved within the professional, scientific world[1] alone. Citizen science comes in many forms.
That is why it is important to give a broad description of what citizen science entails. Citizen science can be strongly related to transdisciplinary research[2]. The combination of multiple scientific disciplines and cooperation between scientific and social parties is essential to solving urgent and complex scientific and social problems - such as realising the Sustainable Development Goals[3]. Citizen science is also an important domain for open science because citizen science projects (among other things) make collected data, data analysis and other aspects of the scientific process public. Citizen science projects can also have a social impact, for example, by clarifying which action perspectives exist and by clarifying how policy adjustments can have an effect. Citizen scientists must also experience how science works, and scientists in turn, learn what is important to people from outside the fixed work environment and how you work with them.

Over the past decades, a great deal of inspiring pioneering work has been carried out in the Netherlands with numerous individual projects - in all shapes and sizes and within numerous scientific fields. These projects were initiated by scientists, as well as by citizen scientists or civic organisations. To anchor citizen science in the scientific domain and to promote cooperation between science and society, a next step is needed, with a double focus: on network development and promoting quality. A major challenge is to structurally connect science[4] with citizen scientists and civic organisations to identify shared goals. These lead to projects that yield both scientific and social results. Projects, where possible[5], must do justice to the diversity in society by also involving those groups that would otherwise end up on the sidelines.

[1] In this document, 'scientific world' covers the entire field: universities, higher professional education institutions, research institutions such as those of the Netherlands Organisation for Applied Scientific Research/TO2, governmental knowledge institutions and research institutes of the Royal Netherlands Academy of Arts and Sciences and the Dutch Research Council.
[2] see https://www.oecd-ilibrary.org/scienceand-technology/addressing-societal-challenges-using-transdisciplinary-research_0ca0ca45-en. More about the relationship with transdisciplinary research in Section 3.
[3] See publication Margaret Gold et al, July 2020
[4] In this document, science explicitly includes all fields of science, namely humanities, social sciences, science & technology and medical.
[5] Sometimes, projects are by their nature aimed at specific target groups.

In this proposal, the working group advocates setting up a **network structure** that embraces existing collaboration structures. New collaborations and forms of collaboration are developed and introduce a tool for all parties for successful citizen science: the **quality matrix**.

Citizen science is a programme line in the National Open Science Programme (NPOS). The Citizen Science Working Group has been set up to develop this line. With the present plan, the working group gives substance and direction to the Dutch ambitions in the field of citizen science and provides policymakers, initiators (both scientists and citizen scientists or civic organisations) and financial backers[6] with tools to promote citizen science. In doing so, the working group focuses on innovation in the domain, building on knowledge and expertise from the Netherlands and abroad.
The starting point was the 'Citizen science in the Netherlands' workshop that took place at the Royal Netherlands Academy of Arts and Sciences on 22 February 2019, on the initiative of The Young Academy. Policymakers and researchers, as well as representatives of civic organisations and funding institutions took part in this workshop. The participants concluded that network development and quality promotion should be a priority, which explains the focus of this report.

The working group makes proposals for the development of a national network that facilitates the sharing of knowledge and experience and stimulates cooperation and innovation, and for the formation of a simple but effective support structure. This organisation method must make it possible to link scientific initiatives with social initiatives and vice versa; to bring widely shared questions in society to science, connect disciplines, develop new disciplines, and develop new citizen science methods. Methods that involve citizen scientists in the various phases of the research process and meet the requirements for good quality scientific practice. The aim is to achieve true collaboration between citizen scientists and scientists.

The support structure envisaged by the working group makes optimal use of what is already happening in our country, connects initiatives and creates room for innovation.
The starting point is that the organisation has a flat, flexible and open network structure, with room for knowledge institutions and citizen scientists. This organisation consists of a board and some staff members. The staff positions (including support for the board) will be placed with a chairing organisation to be selected. The working group proposes to recruit members for this organisation through an open call. A broadly diverse and inclusive[7] board independent of the chairing organisation directs the staff office. The board is assisted by a scientific and civic advisory council and the activities are structured in a dynamic system of working groups -

[6] E.g. The Dutch Research Council)/the Netherlands Organisation for Health Research and Development, patient organisations, governments
[7] I.e., not only from the academic world.

analogous to a working method with which good experience has been gained in a European context (ECSA), but also in Flanders and Austria, for example. The National Open Science Programme steering group appoints the first board.

With a view to the desired innovation of the citizen science domain, the network thus created organises support for scientists, citizen scientists and civic organisations in the fields of citizen science projects, knowledge development (pilot projects, research), knowledge exchange (symposia, workshops, citizen science courses, etc.) and innovation, for example, by stimulating the development of new forms of transdisciplinary collaboration and new (co-creation) methods for citizen science. The new network organisation will also set up pilot projects as case studies for new collaborations and new forms of citizen science.

The aim of the working group is that the 'Citizen Science NL Network' (Network CS-NL - working title) will become operational in 2021.

To promote the quality and effectiveness of citizen science projects, the working group is introducing a quality matrix, which builds on the ten principles for citizen science of the *European Citizen Science Association (ECSA)*. The principles have been translated into success factors that provide guidance when designing and assessing citizen science projects. These success factors focus on both scientific and social quality.

In this way, the working group believes it has fulfilled the task of the steering group and does justice to the priorities identified by a large and varied number of actors during the workshop and the consultation round. This report should be regarded as a development document that needs to be regularly adjusted and supplemented given the dynamics in the citizen science domain.
Ultimately, citizen science should be part of the curriculum of scientific programmes and thus a 'normal' research practice. This also means that citizen science is included in the system of recognition and appreciation.

2. Introduction

Reader's Guide
In the original Dutch text of this guide, the Citizen Science Working Group decided to leave the terms citizen science and citizen scientist untranslated. Whenever this guide refers to 'civic organisations', that term also includes government organisations.

There are many definitions and manifestations of citizen science. In addition, many innovations are currently taking place in this domain. For these reasons, the working group defines the term citizen science as broadly as possible. Citizen science is the practice of science by people who do not (necessarily) work as professional scientists. Also, they often - and ideally - work together with professional scientists. The research questions can be submitted by citizen scientists or civic organisations as well as by scientists. Citizen science promotes the quality of research, contributes to the solution of complex issues, can provide new policy insights and instruments and has the potential to increase citizen scientists' involvement in and insight into scientific research.

Our country has proven to be a pioneer in several areas with high-profile citizen science projects, ranging from research into particulate matter, medieval texts and benthic animals to research into burial mounds. In recent years, interest in citizen science has increased, among professional scientists as well as citizen scientists and civic organisations; for strategic reasons or to strengthen the connection between science and society; to serve social purposes or to satisfy curiosity. Many of these types of projects are somewhat ad hoc in nature and are not structurally embedded. This brings us to one of the major challenges for the near future: structurally connecting actors from the professional scientific world with citizen scientists.

With the growth in the number of citizen science initiatives, it is also becoming increasingly clear how great the need is for the exchange of knowledge and experience. This was both the reason for and the most important outcome of the 'Citizen science in the Netherlands' workshop, held at the Royal Netherlands Academy of Arts and Sciences on 22 February 2019 on the initiative of The Young Academy. What is lacking is a platform for sharing knowledge and experience and a supporting toolkit for the development and assessment of projects: where do you start? What are the pitfalls? How do you set up effective communication between professional scientists and citizen scientists?
How do you guarantee the quality of the process and outcomes? How can the collaboration become sustainable? Ultimately, citizen science should be part of the curriculum of scientific programmes and thus a 'normal' research practice. This also means that citizen science is included in the system of recognition and appreciation.

With the current plan, the Citizen Science Working Group wants to give direction to the Dutch ambitions by stimulating learning from each other

and by providing tools to policymakers, initiators and financial backers[8]. The members of the working group are familiar with how other countries organise and promote citizen science, and believe that the Netherlands can (and should want to) be a pioneering country in the next phase as well. The members of the working group propose an - from an international perspective - innovative course based on two core themes: network development and quality promotion.

This report proposes a **network structure** that stimulates collaboration and the sharing of knowledge and experience and fills gaps by connecting new and existing networks. A structure that, moreover, lays fertile ground for innovation in the citizen science domain. To promote the quality and effectiveness (scientific and social success) of citizen science projects, a **quality matrix** is introduced, which builds on the ten principles for citizen science of the *European Citizen Science Association (ECSA)*. This tool also serves the assessment and evaluation of citizen science activities.

These two themes were identified during the workshop in 2019 as necessary conditions for the next step in the development of citizen science in the Netherlands.

In the next section, the subject of citizen science is clarified and we consider the position of the Netherlands and, briefly, several guiding countries. Section 4 provides the working group's vision, outlines the mission with a view to 2030 and specifies the goals and target groups of this proposal. Subsequently, the two tracks of the proposal are elaborated: the development of a network structure in which knowledge and experience are shared; that promotes the efficiency of citizen science and that provokes innovation (Sections 5 and 6). Section 7 provides guidelines for quality assessment. Lastly, Section 8 contains the timetable as envisaged by the working group. The appendices provide information about the consultation round, case studies and an explanation of the quality matrix.

While we are working on this document, the world is grappling with the COVID-19 virus. The relationship between scientific knowledge and the functioning of society is on everyone's mind. Scientists and policymakers are currently being reminded of the difference between being in the right and winning your case. Rarely has it been so evident which research questions society considers important. Rarely has it been so important to share knowledge, to give people an insight into how science works and to involve them in it. This form of co-creation can be well illustrated by the involvement of citizen scientists in projects in all phases of the research.

[8] For example, the Dutch Research Council/the Netherlands Organisation for Health Research and Development, patient organisations, governments

Skills, recognition & rewards and metrics
In the model for the transition to open science, as embraced by the National Open Science Programme steering group, three vertical themes have been identified, including citizen science. These themes are implicitly addressed in the present plan. Summarising, citizen science projects require special skills that need to be stimulated and trained[9]. Since these skills, as well as the time invested in organising and maintaining citizen science groups, cannot be compared to more common research methods, consideration should also be given to how this form of research is recognised and valued, as well as the way in which support is provided by the institution (both substantively and financially). This requires, among other things, good measures (quantitative or narrative), as well as financing mechanisms that fall outside the regular financing practice[10]. Several of these aspects, in particular skills and recognition, are addressed in this memorandum in the form of proposals for a network organisation and parameters for (among other things) the assessment of the quality of project applications. The other aspects have to do 1) with evaluation and appreciation of scientific and social performance - aspects that are partly covered by the latest Strategy Evaluation Protocol[11] and 2) opening existing funding systems for (additional) resources that fall outside the standard of the doctoral candidate and postgraduate researcher. In addition, employers must take into account, when assessing researchers in the various phases of their academic career, the fact that the organisation of citizen science projects requires its own form of commitment and generates different types of impact. Of a different order, but no less important: the recognition and appreciation of citizen scientists. See point 8 in the quality matrix on page 7 and in Appendix II about that matrix.

[9] See also: 'Doing it together Science (DITO), publication Citizen Science & Open Science: Synergies & Future Areas of Work
[10] See also: We Observe Policy Brief #2, July 2020: 'Mission Sustainable: Fostering an enabling environment for sustainable Citizen Observatories', Margaret Gold et al.
[11] The MICS-project, funded from Horizon 2020, develops a framework for measuring and evaluating the impact of citizen science projects.

3. Analysis

Science Europe[12] distinguishes four forms of citizen science, which mainly differ when it comes to the intensity of the involvement and motivation of citizen scientists:

- *Crowdsourcing* - collecting data using devices (such as sensors) managed by citizen scientists.
- Distributed intelligence - citizen scientists collect information and interpret research data.
- Participatory science - citizen scientists think along about the research design and contribute to the implementation.
- Extreme - citizen scientists (partly) take the initiative and work together with professional scientists on the basis of equivalence to the entire research process, from problem definition to analysis and interpretation of the results.

All four of these are valuable; the choice of one of them depends solely on the aim, nature and structure of the research project. Many projects combine multiple forms and diverse roles of citizen scientists[13].

Characteristics of citizen science

"Citizen science is a common name for a wide range of activities and practices. It is possible to understand it by considering the characteristics of those activities and practices […]. These are found in different scientific disciplines - from the natural sciences to the social sciences and the humanities - and within each discipline, the interpretation of citizen science can be slightly different. Yet despite these differences, citizen science is an emerging area of research and practice, with evolving standards on which different stakeholders are developing methodologies, theories and techniques. It is, therefore, useful to establish some level of shared understanding, across disciplines and practices, as to what to expect from an activity or a project that is set out to be a citizen science one."

(European Citizen Science Association, ECSA's characteristics of citizen science, 30 April 2020)

Citizen science is in full development and many methodological innovations will take place. The sustainable and successful collaboration between professional scientists and citizen scientists in particular presents a major challenge. A too restrictive definition of citizen science could have an inhibiting effect. But the fact that citizen science can play a role in all phases of the research and at varying intensities[14] makes it relevant to also explain what citizen science is *not*.
Citizen science interfaces with transdisciplinary research[15] but is not the same; it is part of open science, but it is also more than that (see figure below). Citizen science can include aspects of co-programming and co-

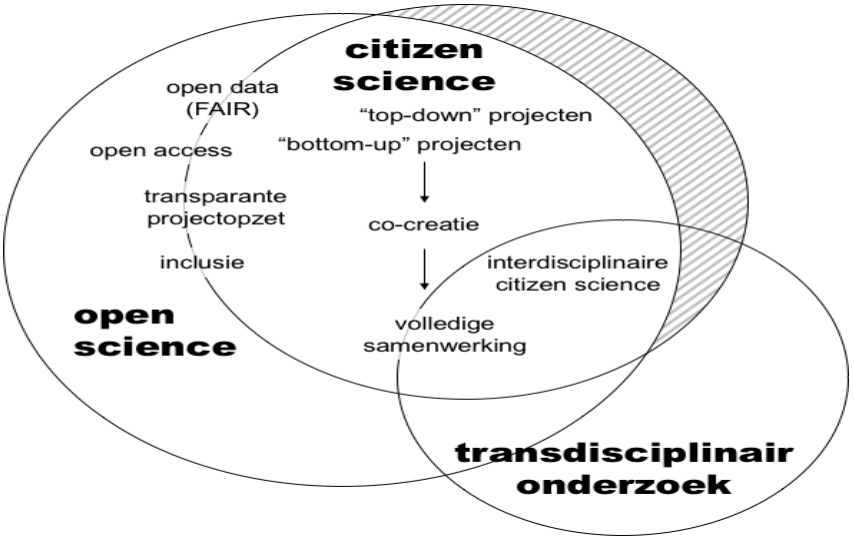
[12] Science Europe Briefing Paper on Citizen Science, June 2018

[13] See also www.participatiematrix.nl for a framework within healthcare.

[14] Kasperowski et al. 2018

[15] see https://www.oecd-ilibrary.org/scienceand-technology/addressing-societal-challenges-using-transdisciplinary-research_0ca0ca45-en. More about the relationship with transdisciplinary research in Section 3.

creation - but it goes beyond that. Several of these adjacent areas are briefly examined below.



Venn diagram for the concepts of citizen science, open science and transdisciplinary research, which makes it clear that there are many interfaces and overlap. Citizen science should by definition be open science. Reaching the centre of the cross-section (full transdisciplinary collaboration) is essential for addressing urgent but complex societal and scientific challenges.

Citizen science is applied in many scientific domains: from natural sciences, medical and technical sciences to social sciences and humanities. The characteristics of citizen science can differ within each domain.

Living labs

According to a study by the Rathenau Institute[16], living labs, mainly found in cities, co-creatively come up with innovative solutions for social challenges. Formulated like that, living labs would be a form of citizen science. But resident participation in living labs is often of a completely different order from that of citizen scientists in citizen science projects. Interest in living labs is also increasing in ecology[17], but it mainly means that socio-economic, legal and other non-ecological factors are taken into account to determine, for example, the effectiveness of biodiversity restoration or to promote a more sustainable form of food production. Citizen science and living labs can therefore be seen as partly overlapping research strategies with often diverging approaches.

The similarity between citizen science and living labs is that science and society are connected. In the case of citizen science, this can vary from filling in questionnaires to studying structures in (aerial) photos to actually measuring particulate matter or traffic noise yourself. An

[16] 'Living labs in Nederland: onderzoek en innovatie mét steden', May 2017
[17] Such as in the recently launched research programme on biodiversity restoration.

important advantage of the citizenship approach is that it makes it possible to collect results on a scale that the professional scientific community[18] alone could never realise. This does not mean that research is also cheaper as a result. Scientists invest a lot of time and energy in recruiting, educating, informing and guiding citizen scientists and in quality control. A lot of time and energy is also invested in connecting science and society, the sustainable financing of projects, the motivation of citizen scientists, the method of data storage, reporting, the dissemination of knowledge and questions about the ownership of results.

Transdisciplinary research

Within transdisciplinary research, different disciplines and/or scientific approaches are linked (interdisciplinarity) and the intensive collaboration with citizen scientists is also made explicit. Such collaborations are essential to address urgent and complex scientific and social challenges, such as achieving the Sustainable Development Goals[19]. Citizen science projects with an interdisciplinary character can therefore be called transdisciplinary and make unique contributions to these challenges. They also pose a challenge in themselves, in terms of organisation and sustainability of the implementation.

Practice-oriented research

Co-creation between education, research and professional practice is characteristic of the practice-oriented research of the universities of applied sciences. Practice-oriented research almost always takes place in networks, and it is often short-cycle in nature to meet the needs of practice. In this type of research, scientific knowledge is combined with the knowledge, skills and experience of practitioners. This involves working closely with the field (for example, with municipalities, provinces, or private landowners) to ensure that research results are understood and used[20]. For example, sometimes there may be an overlap between practice-oriented research and citizen science. An important difference, however, is that by definition, citizen scientists have an active role in citizen science, which is not necessarily the case in practice-oriented research.

Health research

Traditionally, research into care and welfare involves patients and (or: as) citizen scientists, for example, by having questionnaires completed. Such a form of cooperation and involvement does not (necessarily) make it

[18] In this document, 'scientific world' covers the entire field: universities, higher professional education institutions, research institutions such as those of the Netherlands Organisation for Applied Scientific Research/TO2, governmental knowledge institutions and research institutes of the Royal Netherlands Academy of Arts and Sciences and the Dutch Research Council.

[19] See publication Margaret Gold et al, July 2020

[20] Exploration of Practice-oriented research at Universities of Applied Sciences, Ministry of Education, Culture and Science, the Netherlands Association of Universities of Applied Sciences, SIA Steering Body, 2019

citizen science. Citizen science in healthcare is a relatively underexposed research domain, about which little scientific insights have been published. But the number of research projects is growing rapidly. Compared to other disciplines, citizen science for health research has its own dynamics. It often concerns personal (medical) data, privacy and ethics (therefore) play an important role, many stakeholders are involved in the process, and people themselves can also be the object of research. This form of citizen science therefore requires separate attention. In the case of self-examination, the patient is not a subject who needs to be protected, as is the case with the randomised controlled trials, the golden research standard in medicine, but co-researcher. This requires a different perspective for medical ethics assessment.

In health research, there is room for a thorough approach to citizenship: from determining the research question[21] together (co-creation) so that it better meets the needs of patients and healthcare professionals, collecting data, to sharing the acquired knowledge with patients. The Netherlands Organisation for Health Research and Development concluded that the qualities of patients are not being used[22]. Many patients are looking for ways to keep themselves healthy and employable for society. They can contribute to the development of scientific insights by means of self-examination. Self-examination is a combination of self-monitoring and patient-driven big data research using that monitoring data. Self-examination can be the start of citizen science in healthcare, where research is initiated by the patient in collaboration with scientists, a form of extreme citizen science. One example that is also referred to in the knowledge agenda is MyCardio: patients test their own cardiovascular interventions. Another example of citizen science in healthcare is the iconic regional citizen science project TOPFIT Citizen Lab, which is described as a case study in Appendix III.

In the coming years, it is important, together with parties such as the Netherlands Organisation for Health Research and Development, to develop citizen science methods specifically for health research and to explore how scientists and citizen scientists can be brought together in a responsible manner to arrive at new knowledge and insights in the field of care and welfare.

Next level

Our country has wonderful pioneer projects that provide a wealth of knowledge and expertise, but there is insufficient exchange between experts and projects and between scientific areas themselves. During the aforementioned 'Citizen science in the Netherlands' workshop, it became clear that the time truly has come to strengthen the way in which citizen science is supported in our country. An effort that is furthermore justified by the enormous increase in citizen science projects in recent years as a

[21] see, for instance https://www.jla.nihr.ac.uk/

[22] 'Onderzoek voor en door patiënten - Een kennisagenda voor hogere kwaliteit van leven en meer maatschappelijke participatie door patiënt-gedreven onderzoek in gezondheid', October 2019

result of the growing awareness of their value: the conviction among professional scientists that this research method not only strengthens the links between science and society, but can also really contribute to better and unique scientific research. Tailwind also provides the availability and accessibility of digital tools that enable people to participate in research from their living room. The motivation and willingness to actively participate in or initiate scientific research is also growing among people and civic organisations, to narrow the gap between science and society and sometimes from an activist starting point. It is of great importance to the scientific and social success of initiatives that scientists and citizen scientists do not remain side by side, but work together structurally.

Citizen Science Labs and Hubs
There is a great deal of enthusiasm for starting citizen science projects, especially among professional scientists in all kinds of disciplines, but above all, there is a great need for substantive support. At some universities, scientists who have experience with citizen science or who conduct research into citizen science develop initiatives whereby they make their expertise available to colleagues and challenge them to start new projects with citizen scientists. Examples include the Citizen Science Lab of Leiden University and the Citizen Science Hub of the University of Twente. This support can consist of advice, organising workshops, but also of a full 'incubation' in which care is taken of all aspects of citizen science, from co-creation to evaluation. Such central parties also play a crucial role in connecting local and national parties (including financial backers).

Reinforcement and professionalisation should primarily be aimed at removing two substantial bottlenecks: the lack of a well-functioning network structure for sharing knowledge and experiences and the lack of tools for developing and assessing projects and for assessing project applications.

International perspective

Within the European Union, more and more funds are being made available for citizen science projects, while only a few EU Member States have started to develop a citizen science policy. When formulating the plans for the Netherlands, the working group members took a good look around, especially when it comes to governance. For this report, Belgium (Flanders) and Austria have served as sources of inspiration in this area.

Flanders
The key player in Flanders is Scivil, the Flemish knowledge centre for citizen science. Scivil, founded partly on the advice of the Flemish Young Academy, is financed by the Flemish government and by RVO-Society (fund). The organisation operates independently of academic structures, financial backers and governments, which has advantages and disadvantages. It receives advice from a steering group with experts and representatives from various Flemish knowledge institutions (institutes and universities, EOS and RVO-Society). Within Scivil, various thematic working groups examine sub-aspects of citizen science and develop recommendations, guides or support for projects.

Austria
In Austria, Österreich forscht is the central platform. It is a website set up in 2017 by the Citizen Science Network Austria (CSNA), a network of scientific and education and training organisations. The main activities: the annual *Citizen Science Konferenz*; providing information about citizen science and citizen science projects and - just as in Flanders - exploring themes in working groups with representatives of the partner institutes. The network chair is the *Universität für Bodenkultur Wien*.

Europe and beyond

The Wikipedia lemma about citizen science provides a nice overview of projects outside Europe and the US, areas where citizen science already has older roots. In addition to the global citizen science organisation, The Citizen Science Association (CSA), the aforementioned European Citizen Science Association (ECSA) was founded in 2014. The ECSA is a membership and network organisation for practitioners and researchers in Europe. In the same year, the CSA started an (open access, peer-reviewed) publication: Citizen Science: Theory and Practice. There are two EU-funded projects affiliated with the ECSA: The Citizen Science Cost-Action and EU-Citizen-Science[23], which aim to share expertise on citizen science at European level, and to act as a network of networks.

[23] Both represented in the Netherlands by Citizen Science Lab Leiden

4. Vision, mission, goal and target groups

Vision
The Citizen Science Working Group is focusing its sights on further strengthening the already prominent position of the Netherlands in the field of citizen science, through innovation and collaboration. The pioneering role of our country, thanks to individual projects in individual disciplines and initiatives from society, creates an excellent starting position for this.

The working group does not formulate this ambition based on the urge to compete (the Netherlands versus other countries) but based on the conviction that citizen science has enormous potential for science and society. Citizen science can be initiated by both citizen scientists[24] and professional scientists. This concerns cooperation and dialogue - initiatives that are only aimed at proving the wrong of (institutional) science, the government or other parties, and initiatives with a biased activist approach are emphatically not included. Citizen science builds bridges between the scientific world and the rest of society and offers opportunities for all fields of science to be dynamically connected with each other. This is also a good reflection of practice, in which both groups often find each other step by step. It is important to note that large groups of people, such as people with a migrant background, are not yet reached, but it is often the higher educated people who participate in research and initiate research. All people in the Netherlands must have access to citizen science. Citizen science can improve scientific research, help answer complex scientific questions, and increase people's understanding of and involvement in the scientific process; it places social issues on the research agenda of a wide range of parties, offers action perspectives and provides inspiration for policy adjustments.

Mission
Given the rapid developments and the ambitions of both science and society, citizen science in 2030 will be a natural and often indispensable part of scientific research that is anchored in the curriculum of higher and scientific education and that is included in the system of recognition and appreciation. In 2030, citizen science will shape the collaboration between professional scientists and citizen scientists in all kinds of different ways. These collaborations are often transdisciplinary and are crucial to address and resolve urgent but complex scientific and social problems (such as reaching the Sustainable Development Goals). Successful citizen science projects are established on the basis of equal partnerships. Initiatives from the scientific world and from citizen scientists or civic organisations are sustainably linked through co-creation and sustainable financing options. In 2030, citizen science projects will meet the requirements of open science and will be 'inclusive': gender, migration background, educational level, etc. This inclusiveness - the ambition to involve and continue to involve *those* people who are difficult to reach while they can offer a valuable different perspective - is a major challenge for citizen science in the next ten to

[24] Such as the projects organised by Waag (see, for instance, Appendix III), or Amersfoort University

fifteen years.

New projects that innovate - for example, in terms of methodology or field of application - are supported in all phases by a national network of expertise consisting of scientific experts in the field of citizen science, and experts from both professional science and the rest of society. Furthermore, the network stimulates participation across society. The subsidy structures (including the method of assessing proposed projects) for scientific research and social projects are specifically geared to each other or even integrated to boost and financially support these new initiatives during all phases, while realising a high-quality research methodology.

Professional scientists who invest a lot of time in the many aspects of citizen science that are not part of their regular research work are supported and recognised by their employers and that appreciation is balanced in the academic assessment procedures. Citizen scientists who (whether or not on their own initiative) invest a lot of time in the many aspects of citizen science know that they are fully supported and involved, and recognised and appreciated.

Short-term goals
The proposals of the working group should mean that by 2022:
1. A **support structure** (network structure) has emerged which
    - Provides researchers with guidance
    - Connects initiatives and actors
    - Stimulates innovation (in particular connecting science and society)
    - Strengthens connections
    - Offers opportunities for new connections in the form of symposia, working groups, research into citizen science, and pilot projects (from science and society).
2. The **quality matrix** offers guidance to initiators from science and society and has given direction to a financing instrument for these initiatives.

Target groups
- Policymakers
- Financial backers
- Scientists and science organisations
- Citizen scientists and civic organisations

5. Network structure: roles and ambitions

There are many examples of citizen science networks in countries around us that fulfil different roles. All these roles come together in this proposal for a support structure. The working group defines ten roles that such a network can assume and illustrates them based on a number of core tasks. These roles are then linked to the ambition levels of the National Open Science Programme (NPOS) as determined by the NPOS steering group. Definition and number are in a sense arbitrary: many roles are interrelated and in practice can fall under one and the same denominator. The distinction made below serves the accuracy of the description. This description also provides guidance, in due course, for the evaluation of the CS-NL Network.

The Citizen Science Working Group has interpreted the ambition levels of the NPOS steering group as follows, from a low to a high ambition level:

- *Ambition level 1* - ***connection***: the CS-NL Network is based on what is currently being done and focuses on establishing connections and stimulating the exchange of knowledge and experience between people, organisations and initiatives.
- *Ambition level 2* - ***expansion***: the CS-NL Network is working on broadening the domain (especially in those disciplines where citizen science is used even less in the scientific process), provides direction and initiates.
- *Ambition level 3* - ***intensification***: the CS-NL Network also links all collected knowledge and expertise back to science, citizen scientists and realises innovation in the citizen science domain.

<u>Ambition level 1 - connection</u>

1) Gathering and exchanging expertise

- Collecting success factors, learning points and examples of projects in a central place (website, book)
- Organising symposia, webinars and workshops
- Realising internal communication channels
- Bringing together experts (also from different disciplines)
- Making knowledge available and sharing it (also from different disciplines)
- Connecting to international networks and conferences
- Communicating about and connecting results of research into the effectiveness of citizen science projects

2) Guaranteeing scientific quality

- Maintaining a quality standard (see Section 7)
- Organising data standards (FAIR, open)
- Advising financial backers (e.g. on criteria for the evaluation of proposals)
- Formalising peer review (including project proposals)

3) *Counter service*

- Analysing information supply (such as websites)
- Realising project portal for interested parties and initiators (for example, expanding www.iedereenwetenschapper.nl)
- Forwarding questions from scientists and citizen scientists or civic organisations

4) *Lobby*

- Putting it on the agenda with government, financial backers, etc.
- Facilitating national pilot programmes
- Advising on embedding project results in policy

Ambition level 2 - expansion

5) *Community building*

- Developing a portfolio of workshops and training courses
- Facilitating visits/exchanges
- Setting up working groups and joint pilot projects
- Developing guidelines for inclusive collaborations
- Connecting groups on both sides of all kinds of social gaps

6) *Establishing relationships with citizen scientists*

- Developing a school network (for example, in collaboration with GLOBE-NL, science hubs)
- Involving citizen scientists and civic organisations (NGOs, neighbourhood associations, patient associations, etc.)
- Involving policymakers (local, regional, provincial, national)
- Involving commercial partners
- Drawing up ethical guidelines (code of conduct)

7) *Directing and coordinating PR & marketing*

- Communicating about the added value of citizen science (in all kinds of areas and in all forms)
- Communicating about the added value of collaboration, interdisciplinarity, co-creation, combinations of questions from scientists or citizen scientists
- Showing diversity of projects, impact and types of success
- Provoking initiatives (new projects)
- Developing and maintaining external communication tools (website, newsletter, social media, etc.)
- Committing media partners

Ambition level 3 - intensification

8) Maximising social impact

- Elaborating and communicating best practices (quality, impact)
- Maintaining and expanding a network with policymakers, governments and financial backers

9) Aiming for innovation/co-creation

- Developing vision, strategy and methodology for citizen science 2.0
- Bringing together scientific and civic organisations, citizen scientists and other stakeholders in co-creation workshops
- Setting up and supporting a wide variety of pilot programmes with knowledge
- Strengthening research into effectiveness, incentives and barriers of/for citizen science projects with a national programme
- Supporting development and implementation of project evaluations
- Developing new scientific and social areas
- Experimenting with new working methods and manifestations

10) Funding agency support

- Acquiring seed funding for targeted investments in new projects from the network
- Financing citizen science research
- Realising cooperation with financial backers for selection and evaluation of projects

6. Network structure: support

In the case of citizen science, too, innovation arises at boundary lines and the collective benefits from the innovations that take place in the various places in the network. Hence our ambition to forge connections between projects, fields of science, citizen scientists and (other) initiators - and between science and society. The essence of the support structure envisaged by the working group is connecting existing initiatives and networks. Developing a database that provides an overview and insight into the citizen scene domain seems like a logical first step. This way, knowledge and expertise are exchanged and the field as a whole benefits from innovations that have been developed in sub-areas. The top-three challenges are:

1. Truly connecting the academic approach with social initiatives from all over society (including population groups that are less likely to turn to science)
2. Developing new disciplines
3. Developing new citizenship methods, e.g. using new technology[25] and co-creation methods

We propose a support structure with a high learning capacity, which is flexible, which makes optimal use of existing echelons and which also organises (informal) knowledge networks at the level of disciplines or within scientific and social institutions. Depending on preference and available resources, the proposed support structure can be transferred to existing organisations.

Building blocks of the support structure

I. <u>Board</u>

At the heart of the network structure are the board and the staff office. The board is multiform, is composed of (scientific and social) partner organisations and citizen scientists (see under II) and is appointed by them[26]. The composition of the board must take into account a balance between fields of science, experience with citizen science methods and projects, gender and migration background. At least two citizen scientists will also be added to the board (see below under 'Partners and members'). Board members are appointed for a period of three or four years, replacement takes place according to a predetermined schedule, to guarantee knowledge transfer. The board could itself choose its chairman and supervises the functioning of the whole process. The board is therefore not bound by the location of the organisation that is responsible for chairmanship. The first board of the CS-NL Network issues a call for the selection of a chair: the organisation that accommodates the support structure for a period of six years, at its own expense and/or with an annual financial contribution from, for example, the Dutch Research Council or central government.

[25] New sensors, artificial intelligence, etc.
[26] In our opinion, the first board is appointed by the NPOS steering group, as indicated earlier.

II. Chair

Many variants are conceivable for acting as chair, varying from the Royal Netherlands Academy of Arts and Sciences, the Dutch Research Council, the association of universities in the Netherlands; an individual university (analogous to the successful working method of the top research schools)[27]; an innovation stronghold such as Waag or a newly established organisation. In any case, the chairing organisation must be able to oversee the entire Dutch citizenship domain.

III. Staff office

The chairing organisation is responsible for the staff functions: secretariat, the accounts, coordinators to support the working groups and pilot projects, communication and event organisation (depending on the ambition level, between two and five FTEs). The staff office reports to the board. We believe it is important that the staff office is mandated to make implementation decisions and to operate strategically.

IV. Partners and members

Partner organisations are:
- (umbrella organisations or representatives of) universities, university medical centres, universities of applied science and research institutes.
- Civic organisations such as Waag, GLOBE-NL[28] patient organisations, non-governmental organisations (NGOs) and local organisations.
- Government (umbrella) organisations such as the Dutch Research Council, the Netherlands Organisation for Health Research and Development, ministries, the Association of Netherlands Municipalities, the Association of Provincial Authorities, the Association of Regional Water Authorities, National Knowledge Institutes (the National Institute for Public Health and the Environment, the Royal Netherlands Meteorological Institute, etc.) and public libraries.
- Science communication organisations such as the VSC, the sector organisation of science museums and science centres.

The board ensures that the partner organisations do justice to the breadth of science and the balance between science and society. Enthusiastic initiators of and participants in citizen science projects - individuals, but also schools, for example - are given the opportunity to become a member of a citizen scientist group ('association of friends') that nominates two board members.

V. Advisory council

The board is assisted by a (scientific and social) advisory council, including (prominent) representatives of partner and member organisations. The members of this advisory council are appointed for a maximum of three years. The advisory

[27] For example, Leiden University is ambitious with its Citizen Science Lab, which means a great deal of knowledge and expertise is already available; and the University of Twente is also investing heavily in citizen science. The Lorentz Center in Leiden may also serve as an inspiration example: locally organised national role.

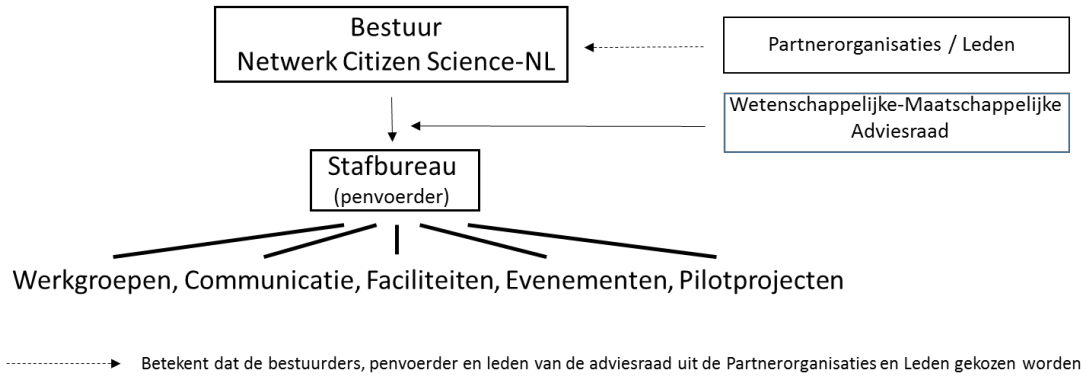
[28] GLOBE-NL has valuable knowledge of and experience with developing didactic strategies through the education system - from primary and secondary to higher education.

council advises the board, as well as partner organisations and financial backers, on their strategy and on setting up thematic working groups.

VI. Working groups

The knowledge and experience in the field of citizen science is drawn from - and shared in - working groups. These working groups can form - or have already been formed - around scientific or social themes (environment, biodiversity, etc.) or focus on horizontal themes such as ethics, scientific research in the fields of citizen science, communication (internal and external), facilities and activities, such as the annual CS-NL symposium[29]. It is recommended to set up a working group that advises initiators and financial backers on projects and that plays a role in the further development of quality standards, in advising and evaluating citizen science projects (for example, at the request of financial backers such as the Dutch Research Council and the Netherlands Organisation for Health Research and Development) and when peer reviewing articles. This working group method is inspired by the experiences within the ECSA, at Scivil and at *Österreich forscht*.

Organisation chart



Network structure for Citizen science Netherlands (CS-NL Network). The board consists of representatives of scientific and social institutions and citizen scientists and is assisted by a scientific-social advisory council. The staff office is placed with a chairing organisation and coordinates, organises, informs, connects and starts or supervises pilot projects.

Evaluation
The support structure will be evaluated after a term of four years.

Pilot projects
The board of the CS-NL Network manages and represents, but also stimulates innovation. Pilot projects are exploring new ways: new disciplines; interdisciplinary or transdisciplinary collaboration; radical experiments (e.g. with new forms of citizen science), etc. These pilot projects validate the quality matrix (Section 7), as well as new co-creation methods. The pilot projects ideally link up with research into citizen science and nurture communication about citizen science.

[29] he Citizen Science Lab at Leiden University will start with monthly e-seminars in October 2020.

Supervision
Until further notice, the NPOS steering group fulfils the role of supervisor.

Cost estimate
The realisation of this support structure involves costs. These costs can be borne by the chairing organisation and/or the partner organisations, the government and science financiers. Depending on the ambition level and the available resources, investments can also be made in the TBD items.

Staff	
Secretariat (1 FTE)	€ 100,000
Accounts department (0.2 FTEs)	€ 20,000
Communications department	(0.5 FTEs) € 50,000
Events organisation	(0.2 FTEs) € 20,000
Other personnel costs	
Pilot project coordinator	TBD
Attendance fees	€ 10,000
Expenses	€ 5,000
Out-of-pocket costs	
Scientific research[30]	TBD
Pilot projects[31]	TBD
Innovation facilities[32]	TBD
Means of communication (website, etc.)	€ 10,000
NL-CS symposium	€ 30,000
Subtotal	*€ 245,000*
Unforeseen (5%)	€ 12,250
Total	**€ 257,250**

[30] This involves developing your own knowledge about citizen science in addition to existing research. The budget can, of course, be used for matching.
[31] Term (indicative) two years
[32] Workshops, co-creation sessions; incubator sessions, etc.

7. Promotion of quality

Experiments are increasingly being conducted with a wide range of forms of citizen science, and collaboration with citizen scientists and civic organisations is also increasingly becoming part of scientific project applications. For the assessment of such projects or sub-projects in applications, we so far lack a tool that makes it possible to assess the form, approach and chances of success of citizen science as objectively as possible. The enormous variety in citizen science projects means a wealth of possibilities to bring scientists and citizen scientists together, but does not make it easier to assess projects. Also, initiators of new citizen science projects have an explicit need for tools for setting up such a project. The working group has developed a tool for this that is based on[33] the Ten Principles of Citizen Science of the ECSA. It used scientific knowledge about the development and implementation of citizen science projects and the expertise and experience of the working group members[34].

The working group transformed the ECSA principles into success factors to be taken into account when designing and assessing projects. It indicates in which phase of the scientific process these factors can mainly play a role, and in each case, it describes several criteria that must be taken into account in each project. It is important to note that not all success factors are relevant or of equal importance for all projects. It is important that each of the principles is considered in order to arrive at a substantiated decision about the design and implementation of the project.

The working group believes this tool simplifies the assessment of applications - it is in line with the approach used by the Dutch Research Council and an assessment method for science communication that was developed for the Rathenau Institute. The Dutch Research Council, the Netherlands Organisation for Health Research and Development, patient organisations, ministries and others can make use of it - also in the development of new funding instruments[35].

The tool also offers points of reference to scientists, organisations or individuals with the ambition to set up a citizen science project - they can think in advance about the various components, points for attention and pitfalls, and about the criteria that can help to give the project the best chance of success. The working group members want to emphasise that this matrix is a 'living' thing, which will develop and - it may be assumed - provides inspiration for the CS-NL Network to build on - for example, by formulating criteria in the form of rubrics.

[33] The first principle has been split and the list has been supplemented with an eleventh principle.
[34] With the explicit footnote that both the ECSA and the working group rely mainly on expertise from academia, a fact the authors of this paper are well aware of.
[35] There is currently no funding instrument specifically for citizen science projects.

Success factors for citizen science

		Project phase			
	Principle	**Planning phase**	**Start of the project (recruiting)**	**Term of the project**	**Completion phase (dissemination)**
1a	Actively involving citizen scientists.[36]	Definition and inventory of: target project, target group (type of citizen scientists and their motivations), media channels, citizen scientists (other platforms, organisations).	Efforts are made to involve people from different backgrounds in the project.[37] Attention is paid to training and supervision.	During the project, the needs of citizen scientists with regard to their role in the project are monitored and, where possible, justice is done to those needs.	The communication plan contains minimal actions to be taken to shape interaction and communication between citizen scientists and scientists.
1b	Citizen scientists and scientists (interaction) contribute to the project.	A clear definition of roles expected of citizen scientists and scientists and possible opportunities for citizen scientists to formulate new roles.	When recruiting participants, it is clearly communicated what role and activity are expected of them and what they can expect from the scientists.	Citizen scientists actively contribute to the scientific process. They play a role as fellow scientist, critic or otherwise.	Citizen scientists are also involved where possible in the dissemination of information/results of the project.
2	Projects lead to scientific and/or social results.	The project plan includes at least a literature review that embeds the research in the current scientific field and identifies the expected contribution of the research to scientific knowledge.	When recruiting participants, it is clearly communicated how the project will acquire new knowledge and insights.	Protocols contain clear instructions for citizen scientists and measures to guarantee (scientific) quality and reliability of results.	Can be in the form of scientific publication, report, available data.
3	Scientists (research result), as well as citizen scientists and civic organisations (social result), benefit from participation.	Identify wishes and benefits on both sides; reward and/or reputation mechanisms.	In communications to citizen scientists, it is clear how the project contributes to science and to society. Expectations are clearly described.	Organising activities, mechanisms through which both citizen scientists and scientists benefit from participation.	Evaluation of the impact of the project for scientists and citizen scientists.

[36] The Rathenau Instituut says (consultation round): *"[We] point out [...] the pitfall that more involvement is not necessarily better – it is not so much that citizens need to be involved more often, or in greater numbers, but that their involvement needs to have value and meaning. Sometimes scientists involve the public primarily for form's sake. Citizen scientists, for example, are then only allowed to have a say on topics that are not really important to the researchers. Thus, they do not get the chance to make a substantial contribution, and the researchers subsequently fail to see the point of their involvement (Ives et al., 2013). In other cases, citizens or social actors do contribute meaningful points, but their contribution is sidetracked if it is not in line with the wishes and interests of the researchers (Abelson et al., 2003)."*

[37] Gender, educational level, location, age, ethnicity, socio-economic status, etc. Unless, of course, that goes against the goal of a project that actually concerns a specific target group.

4	Citizen scientists can participate in different phases of the scientific process as much as possible.	A clear description of phases in which citizen scientists are actively involved, which tasks they perform and which roles they fulfil.	Ask citizen scientists how they can contribute.	Monitoring the needs and possibilities of citizen scientists to be involved in different phases of the project.	Possibly involving citizen scientists in the dissemination of the results of the project, e.g. towards (local) authorities, or within their own environment.
5	Citizen scientists receive and provide feedback.	The communication plan describes how the citizen scientists will receive feedback during the project and what opportunities there are for exchange.	Clear communication about the project during recruitment.	Periodic discussion of results with citizen scientists and the general public, even when results do not meet expectations (e.g. too little data, not usable).	Outcomes of the project are appropriately communicated with citizen scientists and the general public (public report, fact sheet, publication in newspapers, popular science journals).
6	Citizen science is a research approach like any other: with limitations and risks that must be taken into account.	Listing risks and approach to prevent risks aimed at: reliability of scientific results, recruitment and interaction/involvement of citizen scientists. Among other things, taking care of a diverse group of citizen scientists.	Monitoring risks and application of corrective actions.	Monitoring risks and application of corrective actions.	Evaluation approach as outlined in the risk plan.
7	Research data, insights and metadata are publicly accessible (FAIR).	Data protocols are available; there is a plan for sharing data/outcomes with and by the citizen scientists and others.	Data protocols are available.	Where possible, data is available in accordance with the FAIR principle, also during the project; well-considered choices are made for community versus public sharing.	FAIR data.
8	Citizen scientists are recognised in terms of results and publications.	The communication plan states how citizen scientists receive recognition for their contribution.	In communications to the outside world, the contribution of citizen scientists is specifically mentioned.	In communications to the outside world, the contribution of citizen scientists is specifically mentioned.	Publications/reports always acknowledge the cooperation of the citizen scientists; possibly as co-author, or in acknowledgements.
9	Projects are evaluated (scientific output, quality of data, experience of citizen scientists, broader impact on society and policy).	An evaluation plan states how and when the project will be evaluated with regard to both scientific and social goals.	Possible baseline measurement of the situation at citizen scientists, in society, in the environment for impact measurement afterwards.	Evaluation during the project; adapt project based on interim evaluations; link with risk analysis (6) and feedback (5)	Evaluation after the project on impact with regard to scientific and social goals.

10	Project teams consider ethical and legal aspects (copyright, intellectual property, confidentiality, recognition).	Ethics and/or legal committee's approval if necessary.	Efforts are made to involve as many citizen scientists as possible from different backgrounds (gender, educational level, location, age, ethnicity, socio-economic status) in the project.	Monitoring ethical and legal aspects throughout the project.	Monitoring ethical and legal aspects throughout the project.
11	All the above factors are taken into account in the distribution of financial resources, including through the use of expertise. Efforts are also made to ensure continuity of the project.	The project team has relevant expertise (knowledge of target groups and group processes; communication, data management, evaluation, etc.) or has a plan to deploy that expertise where necessary. Plans for how a project can be continued, or where it can be placed for continuity.	The project team has expertise in communication, data management, evaluation, etc.; or it has a plan to call in that expertise when needed.	Plans for how a project can be continued, or where it can be placed for continuity.	Plans for how a project can be continued, or where it can be placed for continuity.

The success factors are explained in more detail in Appendix II.

8. Timetable

What?	**When?**	**Who?**	**Explanation**
Online seminar citizen science	*October and beyond*	*Leiden University*	*Monthly*
Adopting plan	26 October 2020	NPOS steering group	
Adopting budget CS-NL Network	26 October 2020	NPOS steering group	Budget 2021 for CS-NL Network
Appointing coordinator CS-NL Network	26 October 2020	NPOS steering group	
Adopting first board CS-NL Network	18 December 2020	NPOS steering group	Working group likes to contribute ideas
First board meeting CS-NL Network	January 2021	Board	
Issue call for chairmanship	January 2021	Board	
Adopting work plan 2021	January 2021	Board	
Selection of chair	January 2021	Board	
Start CS-NL Network	February	Chair	
CS-NL symposium	May	Chair	Official start CS-NL Network

Appendix I Consultation round

Phase 1
On 8 July, the draft document of the Citizen Science Working Group (without timetable and appendices) was sent to thirty-four people. The text of the accompanying e-mail reads:

Dear Sir, Madam,

In recent months, work has been carried out under the banner of the National Open Science Programme (NPOS) on a proposal for the Citizen Science programme line, one of the three programme lines within the NPOS. The Citizen Science Working Group has tried to give direction and content to the Dutch ambitions for this wonderful subject.

This message is accompanied by the draft text of the plan (minus the appendices). We would appreciate it if you would and could answer the following questions before 1 August:

1. *How do you assess the problem definition (Section 3, Analysis): that there is a primary need for:*
    a. *A network structure and*
    b. *guidance for the development and assessment of citizen science projects?*
2. *How do you assess the proposed solution direction (Sections 6 and 7)?*
3. *Do you have any other suggestions?*

With thanks and kind regards,
On behalf of the Citizen Science Working Group,
Wim van der Putten, chairman
Hugo van Bergen, secretary

Phase 2
After the deadline had passed but a few trendsetters had not yet responded, the decision was made to send a reminder to these people. They were given the opportunity to respond before 1 September. Most have made use of it. That brought the total number of respondents to twenty. Almost all suggestions have been incorporated in the text.

Phase 3
The request for advice to the NPOS Advisory Council formed part of the consultation round. As agreed in the steering committee meeting of 18 June, the individual council members were also invited to respond - themselves or someone from their organisation. The council discussed the document on 3 September and 9 October. Its suggestions have been incorporated in the text.

Appendix II Explanation of the success factors

Below is a brief explanation of each of the eleven success factors in the matrix.

1a- Actively involving citizen scientists

Citizen science offers an opportunity to be actively involved in scientific research. More and more people are finding their way to citizen science projects, but these are often mainly people who already come into contact with science. That is why it is important to approach other target groups to involve them in citizen science (inclusiveness[38]). This not only provides a broader group that comes into contact with science, but also provides a more diverse input for projects. When it comes to bottom-up projects, this applies in the opposite direction: scientists must be involved (and open to this). In the original list of ten principles, it says *"Citizen science projects actively involve citizens in scientific research that yields new knowledge or insights"*. We have split this principle into two parts:

1. actively involving citizen scientists (or scientists by citizen scientists) and
2. ensuring that all citizen scientists actively contribute to the project. It is advisable to think in advance about who you want to involve and why; to make a trade-off between the quality and quantity of citizen scientists[39].

1b - Citizen scientists and scientists (interaction) contribute to the project

This means that citizen scientists play an active role as co-researchers in the project, and/or as initiators of it. They perform tasks in which they actively formulate research questions, formulate hypotheses, collect data, analyse data, draw conclusions and/or report and disseminate results. This does not mean that every participant has to take part in all these parts, or that every project involves participants in all these phases, but that more is asked than just filling out a questionnaire. Making an active contribution to scientific research is an important motivation for many people[40]. It is also an important prerequisite for the acquisition of knowledge that cannot be acquired in a traditional academic way. In addition, actively participating in scientific research can have an impact on the understanding that citizen scientists have of the scientific process. Obviously, it may mean that scientists have to make substantive compromises in order to meet the wishes of the citizen scientists.

2 - Projects lead to scientific and/or social results

Citizen science differs from purely educational or outreach projects because it involves genuinely new knowledge for science and/or society. Educational and outreach projects can, of course, be part of a citizen science project. The number of scientific publications based on citizen science is growing every year. Projects also have an impact on new knowledge, for example, with regard to air quality or perception of health in a particular district. It is important, also for citizen scientists, that it is clear how the project yields new scientific or knowledge.

3 - Both scientists and citizen scientists benefit from participation

For a good relationship between all parties within a project - scientists, non-scientists and other organisations or groups - it is important that all those involved benefit from the project in some way. This is not about material or financial benefit, but it can mean that citizen scientists learn more about a certain topic, that scientists obtain new results, that

[38] Unless the research focuses on very specific target or sub-target groups.
[39] See also the book 'Citizen Science - hoe burgers de wetenschap uitdagen' (Liesbeth Gijsel, Tine Huyse and Ine van Hoyweghen)
[40] But the motivation may also be different: personal development, getting to know people, achieving a social goal, etc. When striving for diversity and inclusiveness, it is important to keep these factors in mind.

organisations acquire insights that help their public cause further, or that initiatives are strengthened by scientific research. Whether people benefit from participating in a citizen science project is related to the motivation for that participation, which may lie in wanting to contribute to science, tackling a social problem (e.g. air quality, plastic pollution), enjoying a certain activity, and all kinds of other motivations. Finding out the motivations of the different parties involved helps to respond to the different needs.

4 - Citizen scientists can initiate and participate in different phases of the scientific process
As mentioned earlier, there is an enormous variety of citizen science projects and the way in which people are involved in the scientific process or initiate that process themselves differs. In most citizen science projects, citizen scientists are mainly involved in either collecting and sending data or analysing data. These are certainly legitimate forms of citizen science and many of these projects are very successful. Still, it is a good idea to facilitate citizen scientists' initiatives and strive for their involvement in multiple stages of the scientific process. This can lead to a better use of local knowledge (e.g. when analysing the context of different data points or interpreting the data) and to a greater sense of ownership among citizen scientists, which means they remain involved in a project longer and more intensively.

5 - Citizen scientists receive and provide feedback
The aim is to create meaningful interaction between citizen scientists and scientists. This includes feedback: provide citizen scientists with information about the results of the project - it shows what they are doing - and create room for feedback to the scientists[41]. This creates a bond between scientists and citizen scientists. Sufficient (room for) feedback - in combination with expectations management[42] - ensures that citizen scientists remain motivated and involved. In some cases, people are disappointed or even stop participating if they do not get enough feedback. You can give feedback, for example, in the form of newsletters, e-mails, social media, events, activities, blogs, and meetings; you can receive feedback via e-mail, social media and meetings.

6 - Citizen science is a research approach with limitations and risks that must be taken into account
Citizen science can be applied in both qualitative and quantitative research and must in both cases meet the applicable quality requirements for scientific research.
Ultimately, it should be a natural addition to the toolbox for 'regular' scientific research. For quantitative research, citizen scientists appear to be perfectly capable of performing reliable measurements and analyses. Even in cases where the quality of individual measurements lags behind that of professional measurements, the collected data still plays an important complementary role. There are all kinds of ways to improve the reliability and quality of data (e.g. through expert checks, statistical analysis of outliers or having it analysed by several citizen scientists). Also, data collected by professional scientists is not always error-free. That is why it is important that project organisers report on reliability, validity and any bias within the project in the same way as with any other form of science. It is also good to realise that perhaps not every research question is suitable to be answered reliably by means of citizen science.

7 - Data and metadata are publicly accessible
Since citizen science is strongly linked to open science, it is important that data and metadata are as publicly accessible and FAIR[43] as possible - for the citizen scientists in the project, but also for the general public. It is also important that metadata is clearly reported

[41] Citizen scientists in particular can be experts in their local environment or have out-of-the-box insights that a professional scientist does not have.
[42] For example: can I sue my neighbour for the results of the air quality measurement?
[43] FAIR: Findable, Accessible, Interoperable, Reusable

so datasets and databases can be connected to each other. There is a difference between sharing the data and results internally, i.e. with the group of citizen scientists, and sharing data with the general public. The first can already be done during the project, the second usually happens afterwards. Challenges in disclosing citizen science data include the privacy, time and money needed to clean up databases and make them suitable for public sharing, and ensuring the proper use of public data. When setting up the research, it is important to take into account the potential value of data for citizen scientists and society. How do you organise governance in such a way that data has added value for citizen scientists, for example, who want to get involved, for influencing policy, increasing awareness, etc.?

8 - Citizen scientists are recognised in terms of results and publications
Although citizen scientists often receive recognition during the project in internal and external communications, this recognition is not always reflected in the final publications. Nevertheless, it is important to also recognise in academic output, such as articles and presentations, that the outcomes have been made possible by the contribution of citizen scientists. This can be done in the acknowledgements of an article, at least, but in some cases, citizen scientists become co-authors of an article. In other cases, all citizen scientists together are one of the 'co-authors' and a list of citizen scientists who want to be mentioned by name can be found on the project website. Recognition is also possible in other types of publications, for example by/for policymakers. There are several ways to achieve recognition, but it contributes to a greater sense of appreciation and ownership among citizen scientists. In addition to recognition, appreciation is also important, for example in the form of considerations such as courses, lectures and meetings that offer citizen scientists the opportunity to delve further into a subject.

9 - Projects are evaluated (scientific output, quality of data, experience of citizen scientists, broader impact on society and policy)
Since in principle, citizen science has both scientific and policy-related goals, it is important these goals are evaluated. Also, the citizen science field is still fairly new, which makes it very important to substantiate all kinds of assumptions about the usefulness of citizen science. Both during and after the project, it should be evaluated whether the set goals are being achieved in all these areas. If it is indicated that a project will change the attitudes of participants towards nature, then it is important to measure this as well. A baseline measurement and a measurement afterwards of the attitude, knowledge and action perspective of participants can be of added value in this case.

10 - Project teams consider ethical and legal aspects (copyright, intellectual property, confidentiality, recognition)
As with any scientific research, ethical and legal aspects will have to be taken into account. In addition, involving citizen scientists in the research provides an extra dimension in which safety, well-being, privacy and other rights play an important role. It is important to reflect on this and to do everything possible to take ethical and legal aspects seriously. In the field of social sciences and medicine, much is known about the ethics of working on research with citizen scientists. This is particularly important for citizen science projects related to health, where people share their own medical data, for example.

11 - When allocating financial resources, all the above factors must be taken into account and the continuity of the project must be ensured
We have added an extra success factor to the above principles, relating to the distribution of

financial resources within the project in order to do justice to all the above success factors. The interaction and communication with citizen scientists, guaranteeing data quality, evaluating the project, gaining insight into the experiences and needs of citizen scientists - all these aspects of a citizen science project, in addition to collecting or analysing data, require time, money and expertise. This should become visible in the distribution of financial resources and in the composition of the organisation team. It means, for example, that the target group is represented in the team and that there is someone with knowledge of science communication or community management (whether that budget is reserved for means of communication). In addition, it is important that consideration is given to and a budget has been made available for the continuation of the project after the term of the financing. With which organisations can the project be placed, or which other steps can be taken to ensure continuity?

NOTE: it is emphatically not the intention that every project is fully committed to all principles, but that every project team has thought about every success factor and made a well-considered and substantiated choice. The project teams do not have to reinvent the wheel. Although every citizen science project is unique, much has been written and developed worldwide to support the design and implementation of citizen science projects.
A platform has been set up within Europe that collects and makes these types of materials accessible: EU-citizen.science. The network to be established will play a key role in this respect as well.

The project plan

The optimal citizen science project plan includes:

1. Project description:
    a. Purpose of the project
    b. Nature of the involvement of the citizen scientists
    c. Knowledge expected from the citizen scientists
    d. Reward and recognition of the citizen scientists
2. Communication plan
3. Risk plan
4. Data management plan
5. Evaluation plan

All success factors from the matrix can be classified in this format.

Appendix III Case studies

1. Waag: citizen sensing in the Province of Noord-Holland

As a public research organisation, Waag | Technology & Society has been active in the field of citizen science since 2014. In the Smart Citizens Lab, Waag is working on initiatives in which residents use open hardware technology to map the quality of the living environment. This is done in areas in connection with liveability and sustainability, such as air quality, noise pollution, water quality and gamma radiation.

An important aspect of Waag's approach is that based on a social urgency, via a bottom-up approach, residents are involved as equal co-researchers in all phases of the process: from the social challenge, the research question, the scope of the research, the planning, the building of a measurement community, the design of a measurement strategy, the actual measurement and collection of data, then analyse and interpret this data to finally take action or design solutions. Waag refers to this variant of citizen science as citizen sensing and explicitly focuses on achieving social impact with the help of science.
Also, the process of measuring with citizen scientists results in a democratisation of knowledge and technology and there is room for them to get a seat at the table so that they can participate in discussions and make decisions about the social challenges in the fields of air, noise, water and gamma rays.

The basis for this approach has been laid in the European Making Sense research project, where hundreds of local residents, spread all over Europe, gained experience with citizen science. During Making Sense, people in Pristina (Kosovo), Barcelona and Amsterdam are linked to air quality experts and Fab Labs where the open hardware sensors were prototyped. By working together with different disciplines, measurement results improved and the impact increased. The methods used, lessons learned and best practices are described in Citizen Sensing, a toolkit (PDF). The toolkit forms a blueprint for policymakers, city makers and other stakeholders to facilitate locally driven data collection. The toolkit can be downloaded and used by everyone, free of charge.

Waag's citizen sensing approach is further tested and refined in the programme Hollandse Luchten. With Hollandse Luchten, Waag, on the instruction of the Province of Noord-Holland, and a large number of partner organisations are working on a citizen scientist platform for measuring the living environment in the province. Measurement communities have been built up in the IJmond region, Amsterdam-Noord and Zaanstad-Kogerveld, with active and involved residents who feel they are co-owners of the measurement network of almost two hundred air quality sensors. From 2018 onwards, a lot of experience has been gained in making the technical infrastructure of a measurement network more sustainable: the sensors, the LoRa network[44], data platform and the visualisation and analysis tools that enable real-time monitoring. Important lessons have also been learned about how to build local measurement communities, make people co-owners of the measurement network and the data that is collected. This way, we explore how we can connect residents' measurements to official measuring stations of the Municipal Health Service and the National Institute for Public Health and the Environment and how both data streams can reinforce each other. Lastly, we explore how the local expertise, urgency and involvement of the

[44] See: https://nl.wikipedia.org/wiki/LoRaWAN

measurement communities can be used in a sustainable way for science and policy making.

2. University of Twente: TOPFIT Citizen Lab

In the near future, we face major challenges to keep healthcare affordable and to ensure sufficient staff is available. This requires a new type of solution that can prevent, replace or relocate care. Because more is known about the role of behaviour, lifestyle and living environment on our health, there is a greater emphasis on prevention and health promotion. In the Netherlands, the aim is to keep the population healthy for five more years. Whilst working towards better health and the focus on prevention, the individual person increasingly becomes the key element. This is also in line with the trend of self-management and self-control in healthcare, in which people want more insight into and autonomy over their own health. This requires more involvement in researching, testing, adapting and implementing innovations.

The TOPFIT Citizen Lab, for and by people, is working on a citizen science methodology that is suitable for and can be used in healthcare. This involves various stages of health, according to the principle of 'positive health': confidence in people's ability to cope with life challenges and take control of their own. The situation of the individual is always the starting point: health situation, work environment and role of new technology. People are involved in the TOPFIT Citizen Lab in various ways. For example, by opening up experimental spaces for research ('Citizenlab Locations'), by actively involving people ('Citizenlab Mobile') and creating an open platform they can use to collect, analyse and share their data themselves ('Citizenlab Digital').

3. National Institute for Public Health and the Environment: Gezond Slotermeer and Kijk! A healthy community.

The living environment in a community influences the chances of residents to feel and live healthily. The systematic research of the community into characteristics that promote or hinder health is usually done by professionals. It provides reliable data, but residents' perspectives are little or not discussed. Conversely, in the case of a participatory 'community review' with residents and other stakeholders, the approach is not systematic and scientifically robust. In the Slotermeer community, in Amsterdam's Nieuw-West district, an approach has been developed in two successive projects to connect participation and a systematic approach through citizen science.

In the first project, 'Gezond Slotermeer' ('Healthy Slotermeer'), residents were trained to interview fellow residents about their perspectives on the healthy community. The training included personal competences and interview skills as well as knowledge about health and its determinants. With the help of supporting materials such as a checklist and a report form, these residents together interviewed 350 fellow residents. This provided partly new and different information than what was already known from conventional community research. The results ended up in a report as well as in a leaflet for the residents. In addition, the effects on these 'health ambassadors' were measured in focus groups, with pre and post-questionnaires, and in interviews. This showed that participating in this form of citizen science had an effect on health literacy, perspectives for action, social networks and norms and values of this group. Their research work also led to the development of health activism, committed to addressing health challenges identified by them in the community. Examples include the indoor environment in homes and parenting problems.

In the second project, 'Kijk! Een gezonde wijk' (Look! A healthy community'), a community audit app as a follow-up to this was developed to involve more residents. The indicators in the app as well as the form and application were developed with local residents. A range of participatory research methods have been applied, such as Structured Interview Matrix, cognitive interviews and Place Games. The research was critically followed by an expert group of local residents who provided solicited and unsolicited advice.
The app was applied on two occasions. An evaluation showed that the use of the app appealed to residents more if they did this in groups. Moreover, installing and using a community audit app appears to be a high barrier for people with a lower level of education. In contrast, other non-technological participatory forms of research have been very successful. We have established that technology can only be promising for low-educated groups if it is embedded in a broader social process. An important success factor is a broad and existing network of residents who are willing and able to involve others in the research.

Recommendations:
- Know and engage the target group
- Meet the questions and priorities of the residents themselves
- Ensure continuity, i.e. integrate research into ongoing processes
- Put process and encounter above technology
- 'Simple' technology is also often difficult to apply for low-educated groups
- Give the networking of citizens themselves a prominent place in the research
- Give recognition to the participants
- When evaluating: look not only at the scientific value, but also at the meaning for and effect on the participants themselves

4. Leiden University: Citizen Science Lab

Since 2018, the Citizen Science Lab (CSLab) of Leiden University supports and connects scientists and citizens in setting up and implementing citizen science projects. A lot of experience has been gained for this during projects such as iSPEX, in which thousands of citizens collected data about particulate matter using an attachment on their telephone. Not only does the CSLab supervise the setting up of projects, it also conducts research into the motivation of participants and the impact of citizen science on science, society and policy. To reach researchers and the public, the lab has a good network, both locally from the humanities, social sciences, science & technology and medical sciences, and internationally through EU-Citizen. Science, ECSA, the Citizen Science COST-Action and Globe-NL. In order to use the knowledge available at CSLab, it offers initiators support in setting up and maintaining new citizen science projects. Top-down (from the academic world) and bottom-up (from the rest of society) are linked by means of co-creation in citizen science initiatives. For example, Leiden University celebrated its 444th anniversary in 2019 and thanks to funding from the University and the Municipality of Leiden, it was possible to set up a pilot project.
To this end, a call for questions was issued among residents of Leiden and The Hague.

Ultimately, the lab received more than fifty questions from residents, scientists and civic organisations. A jury with representatives from the municipality, university and scientists outside the university ultimately chose two projects: 'Plastic Spotter' and 'Psychologielab op Wielen' ('Psychology Lab on Wheels'). The first arose from questions from residents and the second from questions from scientists.

In the first project, participants and scientists will jointly investigate plastic pollution in canals and rivers to find out where the plastic comes from and where it goes, using an existing citizen science app, further developed for this project.
Since residents are already intensively involved with the topic, cooperation is sought with existing initiatives during the project. During various events, people were able to contribute ideas about the project and share their perspective on the topic, approach and target group. For this purpose, use was also made of existing platforms, such as the 'Groene Ideecafé' ('Green Idea Café'), which already reached many people. For this project, data is collected using an existing app that could be expanded.

The second project, 'Psychologielab op Wielen' makes psychology research accessible by taking it to the market, to schools, community centres and other public places, using a mobile laboratory. This way, participants are reached for projects from psychology.

Recommendations:
- By involving various stakeholders from the start, both financially and in terms of content, you make them jointly responsible for the success and continuity of the project.
- Take into account the expectations of participants, scientists and stakeholders with regard to time commitment, accessibility and responsibilities.
- Find out which relevant projects, platforms and networks already exist, among participants and scientists, and make use of them.
- By actively involving people from the start of the project, you get to know your target group in time - which you can use in the further development of your project.
- Be aware of the added value of involving the audience. In that case, it is not just about data collection. Participants often also provide new perspectives, ideas and questions. Make sure these are heard.
- Connect active people and initiatives to increase collaboration and involvement. Make some participants ambassadors of the project, for example, by including them in the project team.
- Interaction with citizen scientists can be uncomfortable for scientists. They come up with different ideas and questions than scientists. Always look for a synthesis of this. There are many different personalities from very different backgrounds that you will interact with and you do not know in advance how that will turn out. There is therefore no one way or guideline for this. Dare to learn by just doing it, practice makes perfect. As long as you are open to other people's opinions and ideas and are flexible.
- Consider the relevance to the participants, why should they participate? What do they want to happen with the data?

5. 'Bodemdierendagen' (the Netherlands Institute of Ecology and the Centre for Soil Ecology)

In the International Year of Soils (2015), the Netherlands Institute of Ecology, together with the Centre for Soil Ecology, launched the 'Bodemdierendagen' ('Benthic Animal Days') citizen science project. Experts from Wageningen University & Research and Vrije Universiteit Amsterdam also contributed. It was the first citizen science project on soil biodiversity of its kind. Previously, we have seen bird counts, national garden counts, etc. The 'Bodemdierendagen' will be held on 4 October (World Animal Day) and the week after. Using a search card, participants register the number of benthic animals they find during a set time, for example, twenty minutes. There are two levels of identification. The data can be entered at the 'Bodemdierendagen' website. Feedback will then be sent by e-mail and the garden is given a score. 'Bodemdierendagen' focus on a range of participants, from primary school students to adults. The data is shown and discussed on the website[45]. A brochure has now also been published ('Ondersteboven' ('Upside Down')) and series have been made about researchers who talk about their favourite benthic animal ('Bodemdier van de maand' ('Benthic animal of the month')).

Recommendations:

- 'Bodemdierendagen' are very successful from a publicity point of view (radio, TV, websites), but participation is nevertheless limited. In that case, collect data spanning a number of years, so ultimately, the data can be statistically analysed with more weight.
- Intensifying cooperation with outreach-oriented organisations, such as BNNVARA's 'Vroege Vogels' and IVN Nature Education, can increase participation. Currently, there is a Postcode lottery project ('Onder Het Maaiveld' ('Below Ground Level') together with the Dutch national committee of the International Union for Conservation of Nature and the Butterfly Foundation, which also provides support for the 'Bodemdierendagen'.
- Linking with other garden counts can also lead to an increase in the number of participants.
- The reach and awareness achieved with 'Bodemdierendagen' are already relatively large.
- The scientific potential of 'Bodemdierendagen' is considerable and in the coming years, it will become clear whether the 'Onder het Maaiveld' project can take the 'Bodemdierendagen' into a new phase.
- A citizen science network structure would be very welcome to learn from the experiences of others: especially identifying who the most important participants can be and where they are, can play an important role in better reaching these participants and approaching new participants.

[45] https://www.bodemdierendagen.nl/resultaten

Appendix IV Composition of the Citizen Science Working Group

Chairman

- Wim van der Putten, the Netherlands Institute of Ecology, Wageningen University & Research, the Royal Netherlands Academy of Arts and Sciences(chairman)

Members (in alphabetical order)

- Quentin Bourgeois, Leiden University
- Lea den Broeder, RIVM, endowed lector at Amsterdam University of Applied Sciences
- Nanna Hilton, Groningen University
- Rolf Hut, Delft University of Technology
- Anne Land-Zandstra, Leiden University
- Tine de Moor, Erasmus University Rotterdam
- Daniel Oberski, Utrecht University
- Montserrat Prats-López, Open University
- Frans Snik, Leiden University
- Judith Veenkamp, Waag Society
- Sabine Wildevuur, University of Twente

Secretary

- Erik van de Linde, the Royal Netherlands Academy of Arts and Sciences (until 21 April 2020)
- Hugo van Bergen (since 21 April 2020)