Public Involvement in Knowledge Generation

Citizen Science Opportunities in the Dutch Water Sector

Stijn Brouwer, Timo Maas

Bridging Science to Practice

Report

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Contents

1 Knowledge in a changing society

1.1 Introduction

Although the vital importance of drinking water provision, and with this the core task of drinking water organisations, has essentially been stable for the past few decades, the challenges water companies meet, the way they operate, and certainly also the citizens they serve, have undergone significant changes (Geldof et al. 2000; Tonkens 2008). For instance, over the past few decades the water sector has become ever more technological and technocratic, among other things, due to the ever growing complexity of challenges drinking water organisations face (Geldof et al. 2000). One could argue that, as a result, water has increasingly turned into something dealt with by experts, and that in relation to this, an even bigger "gap" or "distance" between water (organisations) and citizens can be witnessed. And, indeed, according to a recent OECD (2014) assessment of Dutch water governance, including drinking water, this is especially true for the Netherlands. Despite the country's unique history and connection with water (Borger & Ligtendag 1998), the assessment concludes that Dutch citizens are mostly ignorant of water related risks and (potential) threats to fresh water security, including water pollution. At the same time, and separate from the question whether this should be perceived as a reaction to or merely societal development in the opposite direction, a shift towards active citizenship can be witnessed. Indeed, according to various authors (Kearns 1995; Roberts 2004; Tonkens 2008), in modern society the average citizen has become more active and increasingly is eager or at least expected to participate.

Perhaps one of the most interesting and challenging manifestations of this changing citizenship – especially with regard to the present challenges and call for more combined and multidisciplinary solutions in the water domain – is the role and meaning of knowledge. Indeed, through fast evolving developments in the field of information and communication technology and the ever growing presence of the internet, nowadays citizens are able to retrieve detailed information about almost every imaginable subject at any time of the day. One of the key challenges stemming from the fact that internet can open up more and more information, lies in the development that citizens not only "consume", but increasingly also require information, transparency, and open data, a development that not only results from, but also contributes to the growing empowerment of citizens (Borgman 2000; Pahl-Wostl 2005).

1.2 Open data and the "right to know"

The call for, and direction to, a high degree of transparency cannot be understood simply as a spontaneous process, but (in part) also stems from deliberate policy, or even legislation, among others motivated by the idea that the availability of information may facilitate empowerment (Borgman 2000) and further enables society (including politicians, industry, NGOs, citizens, etc.) to take better decisions (Krämer 2012). Indeed, over the past few decades there has been a significant growth in information disclosure regulations and so-called freedom of information legislation. Examples include regulation that requires companies to disclose financial information, as well as rules on food safety and nutrition labelling (Bennear & Olmstead 2008). Because of the on the one hand self-reinforcing character of these processes, and on the other hand, the growth of regulation on information disclosure, it can be envisaged that expectations regarding transparency, and demands for insight, will only continue to grow.

With regard to government-held information on environmental matters the Aarhus Convention (UNECE 1998) on Access to Information, Participation, and Justice in Environmental Matters has had significant impact in terms of information disclosure (Krämer 2012; Etemire 2014).[1] In the domain of potable water, an appealing example in this respect is the 1996 Amendments to the Safe Drinking Water Act in the United States. This act, which is one amid many of the countries' ''right to know'' provisions, obliges US drinking water companies to annually report to their customers on drinking water quality, including the provision of information regarding the source of drinking water, detected contaminants, violations of health-based drinking water regulations, and procedural regulations (Blette 2008; Brennear & Olmstead 2008). Additionally, the US Environmental Protection Agency, in charge of enforcing this act, hosts a platform containing

[1] The Convention was negotiated under the auspices of the United Nations Economic Council for Europe (UNECE), and although it allows for any UN member to accede, its current parties are all UNECE members.

quality and inspection information on all public water systems (US EPA, 2015).[2] An interesting example of transparency in the Dutch water management sector is the benchmarking exercise of the water boards. , This benchmark is published every two years, and serves various objectives: providing greater transparency to interested parties, giving account, learning, and gaining insights of how to improve.

The increase in the availability of open data has many implications and consequences in various areas. For one, it means that knowledge (creation), innovation, and creativity has been strongly democratised over the past decades (Fischer 2007). In part, this brings challenges in the field of legitimacy and transparency, but what it mostly does is opening up opportunities in the field of public participation in the form of co-creating knowledge and innovation. Indeed, besides the increase in open data from governmental organisations, also citizens increasingly play an important role in collecting (crowd-sourcing) and disseminating such data (Buytaert et al. 2014). For example, in the Netherlands, the voluntary group "Groninger Soil-movement" collects (publicly-available) information relating to natural gas extraction and earthquakes, enabling citizens to see the connection between the two, and hereby challenging the government to take action to mitigate the negative side-effects. Another consequence, or rather a challenge, related to this democratisation of knowledge is that the previous linear model of the relationship between science and policy is increasingly under siege.

Although the suggestion of a growing mistrust towards science in general would be unjustified – especially studies regarding the very large (e.g. the galaxy) or the very small (e.g. quarks) are usually still awed – the Dutch Advisory Council of Science and Technology Policy (Corbey & Janssen 2010) reports that in relation to specific topics trust in science indeed has decreased. Recent examples are the controversy following the "Climategate" affair and discussions revolving around biotechnology and genetically modified organisms.[3] Particularly where science reports about topics that directly relate to our daily lives trust in science has decreased. According to Bäckstrand (2003), both what she calls the inflationary use of expert advice, as well as the politicization of scientific knowledge, have contributed to a "legitimacy crisis" of science, i.e. the erosion of the authority and legitimacy of science. In relation to these developments, citizens increasingly question why his or her knowledge would be inferior to that of "the expert".

Although science at times may have the image of standing apart from the rest of society, it is clear that also science itself is by no means stationary in its development, (methodological) knowledge, attitude, and quest for social relevance. Manifestation of this are the call for open access publishing (Suber 2012) or the sharing of data used in scientific studies, usually referred to as open data (Molloy 2011). The next section describes how, apart from changes in dissemination practises, several related developments in scientific practice can be observed in the light of the search for scientific legitimacy and new relationships between science and the public.

1.3 Changes in scientific practice

A number of attempts have been made to either describe or prescribe changes in scientific practice, the creation of a more democratic form of science, and consequently, a re-assessment of the classical expert-lay divide (Lidskog 2008). One of the most well-known proposals claiming that science has become more inclusive, is presented in Gibbons et al.'s (1994) book *"The New Production of Knowledge – The Dynamics of Science and Research in Contemporary Society"*. This work sketches the emergence of a new form of, so-called 'Mode-2', knowledge production. Unlike the traditional (Mode-1) form, that is, knowledge generated in an academic context and characterised by homogeneity, autonomy, and disciplinary borders – this new mode refers to knowledge generated in a context of application by so-called transdisciplinary collaborations (Hessels 2010). In this new kind of knowledge production, which is believed to supplement rather than replace Mode-1, knowledge is no longer created within disciplinary borders, or even scientific institutions alone; it is open to other forms of knowledge than that of science. It is a new way of producing knowledge where different groups of people, be they professional scientists, bureaucrats, or the general public, have their own contribution to make (Edelenbos et al. 2011). The two generations of mass higher education and the related shift towards the knowledge society are considered key driving forces of this transformation; in this knowledge society so-called knowledgeable actors are no longer exclusively located in the traditional bulwarks of academia but can also be found within places like research institutes, think-tanks, and industrial laboratories (Lidskog 2008).

[2] When focusing on the provision of drinking water in the Netherlands, the demand for insight and transparency seems rather limited. Websites, such as www.rechtopveiligwater.nl, which are characterized by a highly distrustful discourse, and argue for openness on for instance chemical contaminants in drinking water, have so far not resulted in remarkable societal commotion.

[3] The Climategate affair refers to the hacking and subsequent publishing of emails from the Climatic Research Unit at the University of East Anglia, leading to a series of allegations of fraud towards prominent climate scientists, all of which were cleared in a number of subsequent independent investigations.

The result of this new production of knowledge is science that is highly contextualised, which is considered to be more socially robust and eclectic (Gibbons 2000; Nowotny et al. 2001; Lidskog 2008).

A second influential proposal, or rather a prescription, for more inclusive science has been proposed by Funtowicz and Ravetz (1993) and is known as “post-normal science”. Unlike Mode-2 knowledge production, where the transition to the knowledge society is considered to be the foundation for change, post-normal science has emerged as a response to new (industrial) risks. Given the uncertainties and complexity accompanying such risks, it argues that the traditional form of knowledge creation, which according to Funtowicz and Ravetz (1993), among other things, assumes that problems can be handled without questioning the broader paradigm, is no longer adequate. Indeed, proponents of post-normal science hold that there is a need for a scientific practise that can deal with the uncertainties and ambiguity that accompanies complex risks, requiring not only a better cooperation between disciplines, but foremost additional knowledge from non-traditional actors including citizens (Lidskog 2008; Renn et al. 2011). This call for public participation may indeed be considered the most striking characteristic of post-normal science (Hessels 2010).

Whereas in Mode-2 knowledge production participation only referrers to highly articulate, well-educated people and the democratisation of science is more of a spatial (including different kinds of knowledge sites) than of a substantive kind, post-normal science explicitly welcomes the input from groups other than scientists, including citizens, environmental movements, and political organisations (Lidskog 2008). The reason for including the public and other stakeholders primarily relates to the need to understand the contextual character of problems and solutions, rather than seeing them as universal and context-independent. Although post-normal science makes a plea for the involvement of a much broader group of participants, the role of non-academics in this form of knowledge production is relatively restricted; it primarily serves to enrich, evaluate and correct the traditional production of scientific research by the traditional scientific community. In Mode-2 knowledge production, although it only welcomes a small, and according to some even elitist part of the public, the role of non-academics is much more a leading one; they are not only invited to act in addition to, but also alongside traditional scientists (Lidskog 2008).

In the spirit of the transition towards Mode-2 knowledge production and post-normal science, it is interesting to note that to date more and more members of the public are in practice indeed participating in scientific research (Cooper et al. 2007; Cohn 2008; Silvertown 2009; Shirk et al. 2012; Gura 2013).[4] In fact, the involvement of the public in scientific research, in this study referred to as citizen science, could be viewed as a promising development where the search of science for ways to include knowledge from non-traditional actors and strategies to deal with the legitimacy crisis, converges with developments in society including the rapid advancements in the field of information and communication technology. This development towards the inclusion and recognition of the value of the brain- and innovation power of the general public cannot only be witnessed within the academic context, but also within the public sector, and, last but not least, within the private sector. Examples of the latter include toy company Lego’s inclusion of user-designed sets in both the adult and children segment following a period of little innovation and difficulty maintaining its market position (Antorini et al. 2012), but also a website like InnoCentive, where companies like DuPont and Proctor & Gamble pose problems for others to solve in exchange for a reward (Howe, 2006), or the Google Vulnerability Rewards Program, in which the internet giant pays citizens up to $20,000 for discoveries of security vulnerabilities in its products (“Google VRP”).

1.4 Objective, Method and Outline of the report

Building on the rapidly changing society and (the role of) new forms of knowledge generation, this explorative study aims to provide more insight into possibilities of how water companies can connect with citizens by involving them in the generation of knowledge. This work is primarily based on literature research centered on publications specifically related to citizen science, as well as literature on participation, philosophy of science, and water governance. In addition, 6 semi structured face-to-face interviews were conducted with experts and practitioners in the field of citizen science and open data to explore their views on the value, meaning and potential of citizen science, particularly within the domain of Dutch drinking water organisations. Last but not least, a focus group with citizens was organised to discuss their perspectives on and motivations for participation options and data sharing in relation to drinking water. All

[4] In the European context, the concept of Responsible Research and Innovation has become the new “buzzword” in recent years, especially with regard to science policy and the determination of the research agenda. Like mode-2 and post-normal science it aims to supplant a linear approach to science. By involving a wide range of stakeholders early in the process a certain degree of “co-responsibility” is created, which in turns results in “science for society, with society” (Owen et al. 2012).

interviews were conducted between August and September 2015, were transcribed, and sent back to the interviewees for review. The full transcripts of the interviews as well as a summary of the focus group are reproduced in an separate (and confidential) report. [5]

The report is structured as follows: after this introductory chapter, which set out the background for the study by discussing developments in society, philosophy of science debates and data (generation), Chapter 2 explicitly focusses on citizen science, successively detailing what this concept entails, why it is promoted, and in what forms it exists. Last but not least, this chapter discusses the potential for citizen science, specifically in the domain of drinking water. When and how the various forms of citizen science are effective is discussed in Chapter 3. Chapter 4 focusses on the citizen scientists themselves, and elaborates on their motivations and expectations. The final chapter, Chapter 5, presents a brief summary and conclusions. The report ends with four appendices, including one on the degrees and methods of traditional (power-based) participation, and one containing a set of practical tips and questions for setting up a citizen science project.

The report is part of a larger exploratory study on citizen science. Besides this report on citizen science (opportunities), this study included a technical assessment (Kronemeijer 2015), an exploration of citizen involvement case studies around the world (Büscher et al. 2016), and a multi-disciplinary citizen science pilot study on the microbiological stability of drinking water in Amsterdam, entitled the "freshness of drinking water".

[5] For questions regarding this report please contact the authors directly.

2 Citizen Science

2.1 Introduction

Nowadays, more and more members of the public are participating in scientific research (Cooper et al. 2007; Cohn 2008; Silvertown 2009; Shirk et al. 2012; Gura 2013). Examples of interesting citizen science projects include studies such as the Galaxy Zoo project, in which by classifying the shape of galaxies from the Sloan Digital Sky Survey, more than 200,000 citizen scientists have greatly enlarged the number of (reliably) classified galaxies (Lintott et al. 2008). The eBird project run by the Cornell Lab of Ornithology now receives 25 million observations of bird presences a month to track bird species across the United States (Gura 2013). And in the FoldIt game people fold complex proteins to predict their structure, which is hoped to contribute to the development of new drugs (Cooper et al. 2010). Other fields of study with appealing citizen science projects include hydrology (Buytaert et al. 2014), climate science (e.g. Old Weather, n.d.) and, rather prominently, ecology (e.g. Dickinson et al. 2012), as well as many others. A large number of diverse projects is for instance hosted by the Zooniverse platform; the volunteers active on this platform are estimated to deliver the equivalent of 50 years of work every year (Simpson et al. 2014). Furthermore, to increase public awareness of citizen science and to recruit participants, websites of popular science magazines such as Scientific American (2015) or in the Netherlands “Eos Wetenschap” (2015) have sections dedicated to listing projects their readers might have an interest in.

The recent advances in communication technology, and specifically the rapid developments in online and mobile interaction, have enabled citizen science to become more widely practiced than ever before (Rotman et al. 2012; Kronemeijer 2015). Still, it is important to realise that the engagement of ‘amateurs’ in scientific exploration and research is by no means a new phenomenon, as amateur scientists have studied the world for centuries (Bonney et al. 2014; Haywood 2015). Indeed, until the mid-19th century professional scientists were a rare sight, most scientists were what we would now consider amateurs (Miller-Rushing et al. 2012) and had some alternate primary source of income (Silvertown 2009). That having said, the recent surge of new technologies, especially the widespread availability of computers and the internet (enabling for instance easier use of remote sensing techniques), as well as the more recent rise of smartphones and their advanced sensors and easy-to-use “apps”, have undoubtedly allowed for a “new dawn” of citizen science (Silvertown 2009; Dickinson et al. 2012; Rotman et al. 2012; Raddick et al. 2013). Moreover, whereas previously ‘citizen science’ was often practiced informally as a leisure activity, at current the engagement of citizens in scientific research exploration has become a much more formalized process (Haywood 2015).

2.2 Concept of Citizen Science

Simply speaking, citizen science refers to the participation of the general public (i.e., non-scientists) in the generation of new scientific knowledge (Buytaert et al. 2014). As a term, it was coined by Bonney (1996) to refer to projects run by the Cornell Lab of Ornithology involving data gathered by citizens, whereas, independently, Irwin (1995) had just defined citizen science in the realm of philosophy of science, describing the concept as an “arena where different knowledge claims can meet and cross-fertilize” (Lidskog 2008: 78). Today, there is a plethora of terms relating to citizen science; terms used in the literature include civic science (Kruger & Shannon 2000), community-based management/monitoring (Whitelaw et al. 2003; Palmer Fry 2011), and somewhat more influentially, public participation in scientific research, often abbreviated to its acronym "PPSR" (Bonney et al. 2009; Shirk et al. 2012). Wiggins and Crowston (2011) distinguish citizen science from other public participation in research on the ground of *active* participation by citizens in the research process, making it fundamentally different than for instance much psychology research where individuals are mostly a subject to be studied rather than active participants in the research itself. Grounded in the work of, among others, Bonney et al. (2009), Wiggins and Crowston (2011), Shirk et al. (2012), and Buytaert et al. (2014), in this study we define citizen science as any form of active public participation in the process of research to generate science-based knowledge, from setting the research agenda by asking research questions, to collecting data, and/or analysing the results.

2.3 Motivations for involving citizens in science

Apart from changes in society and the possibilities created by innovations in the field of communication technology (Silvertown 2009), the recent surge in the number of citizen science projects can, to some extent, also be explained by the outcomes that such projects may have. For example, for many scientists, the possibility of greatly increasing the quantity of data available for their analyses has been a key reason to promote citizen science (Cohn 2008). Other authors particularly stress the educational value citizen science projects may have, allowing participants to increase their knowledge of the object of study, as well as to gain a better understanding of the scientific process more generally (Shirk et al. 2012; Cornell et al. 2013). The latter claims closely mirror the so-called "deficit model", i.e. the idea that the public needs to be educated on the results generated in the closed realm of science (Irwin & Wynne 1996) by assuming that an educated public is more likely to accept evidence presented by professional scientists (Lewenstein 1992). In short, public participation in knowledge generation is believed to offer a wide range of advantages. On an abstract level, and analogous to rationales for participation in general (e.g. participation in decision-making), the motivations for citizen science cited in the literature can roughly be classified as either substantive, instrumental, or normative.[6,7,8]

The first important citizen science rationale cited in the literature is that it has a substantive value, i.e. that it may increase the quality of research or the final product. Public participation in research may not just result in more information on the research topic itself, scholars report that it can also spark more alternative or specific solutions (Irvin & Stansbury 2004; Reed 2008). Together these characteristics are thought to be able to help not only in finding answers to regular problems, but also in dealing with highly complex problems that do not have one single solution that is right or wrong, good or bad, true or false; problems also known as so-called wicked problems. Especially in the light of new (industrial) risks that have emerged according to post-normal science scholars, "new" sources of knowledge may help to deal with these risks (Lidskog 2008; Renn et al. 2011). Furthermore, the public may come up with entirely new research questions that the scientific community had not considered yet (Gibbons et al. 1994; Seijger et al. 2013). Finally, this substantive motive also rests on the idea that all (scientific) knowledge is subjective, and that with a broader set of participants more perspectives can be integrated (Griffin 1999; Connelly & Richardson 2005).

The second, so-called instrumental motive for citizen science cited in the literature starts from the idea that the process of participation will increase the legitimacy of the final product (Junker et al. 2007; Reed 2008). Just as participation in decision-making may increase the "ownership" of the decision (Glucker et al. 2013), which is said to lead to smoother implementation of that same decision (Koninsky & Beierle 2001; Irvin & Stansbury 2004), cooperation between scientists and the public is believed to reinforce mutual trust (Bäckstrand 2003; Fernandez-Gimenez 2008) and a higher acceptance of the research outcomes, making citizen science itself a response to the "legitimacy crisis" facing science (Bäckstrand 2003: 29). Citizen science may then also be expected to increase the uptake of research results (Boon et al. 2011). This can have important implications, for instance, Buytaert et al. (2014) describe how citizen science can contribute to more resilient communities. Another part of the instrumental motive rests on the fact that data collection can be a tedious and expensive undertaking. Citizen scientists have the potential to make large contributions to the quantity of data available to professionals (Hage et al. 2010; Miller-Rushing et al. 2012). The before-mentioned eBird project averages 25 million contributions a month (Gura 2013); by 2008, the Galaxy Zoo project had over 100,000 participants, who had classified the shape of more than 40 million galaxies (Lintott et al. 2008). Data collection on such a scale would be impossible if the collectors would have to be paid (Cohn 2008).

The third, normative motive for citizen science postulates that there is intrinsic value to participation (O'Faircheallaigh 2010). Especially in situations where the product of participation will directly affect those who (potentially) participate, there is claimed to be a strong moral ought for participation (Glucker et al. 2013). In relation to citizen science as a specific form of participation, the complex risks thought to be facing society would give the public the right to partake in research thereof (Rip et al. 1995). Indeed, scholars such as Buytaert et al. (2014) and Haywood (2015) suggest that citizen science may not only lead to increased science literacy and scientific thinking and herewith to a growth in 'understanding' and appreciation of science, but also argue that the engagement of the public in the research process makes science more democratic and 'legitimate', regardless of its effects on trust or the implementation of research results discussed in relation to the instrumental motive. This goes for both the legitimacy of the content of the science, as well as the legitimacy of the kind of issues on the research agenda (Buytaert et al. 2014). Further, participation is expected to have a positive influence because people will have increased contact with others with a different perspective on the world (Connelly & Richardson 2005; Dietz & Stern 2008; Wechsler 2014). Within the normative motive, "emancipating" can be discerned as a separate sub-category.

[6] Next to the substantive, instrumental, and normative rationales, Wesselink et al. (2011) identify for participation in decision-making a fourth, legalistic, consideration for decision-makers to include participation-processes in project designs. In this version options for participation are purely included to comply with legal requirements, and it is probable that the results obtained in the process remain unused (Wesselink et al. 2011).

[7] Attachment I elaborates on the meaning and significance of participation in decision-making.

[8] The motivations of participants will be addressed in Chapter 4.

The emancipating motive states that groups who otherwise have little to no voice in the public debate will be better heard (Glucker 2013). However, the question is raised whether these groups will indeed find such processes, and to what extent they will be able and/or willing to participate (O'Faircheallaigh 2010).

In practice, Hessels (2015, pers. comm., 20 July) suggests that this normative motive, combined with the idea that participation increases the legitimacy of the product, will likely especially be favoured by politicians, whereas others (scientists, bureaucrats) might be more interested in the substantive and/or instrumental benefits of citizen science. Some confirmation of this proposition is given by both the project leader of a citizen science project named "Meet je Stad" in the city of Amersfoort on creating a climate-proof city, as well as the project leader of a citizen science project "Crowdsourcing in Reeuwijkse Plassen" at the Water Authority Rijnland. For the city of Amersfoort, the possibility to build public awareness, which is hoped to ultimately lead to higher acceptance of new policy measures, and to a lesser extent, the data collected by the volunteers, is an important motive for initiating and facilitating this citizen science project (Sijbrandij 2015, pers. comm. 4 August).[9] For the Water Authority Rijnland, apart from the collection of the data itself, key motivations to involve citizens include creating a support base for their new water level, showing the environment that they are willing to listen and want to work together with citizens, and eventually, reducing misperceptions on the water system, and eventually turning distrust into trust (Van den Berg 2015, pers. comm. 18 September).[10]

Critical notes as to whether citizen science can live up to above mentioned expectations have been placed as well, in this study summarized together with the postulated benefits in Table 1 below. One of the often mentioned disadvantages of citizen science is that these projects can be a costly undertaking, both for the public, of whom it should not be forgotten that participation takes place in their free time (Lidskog 2008), as well as for scientists leading and coordinating such projects (Gura 2013). Further, studies investigating postulated benefits of citizen science obtain mixed results in confirming links towards for instance public education, knowledge of the scientific process, or public attitudes and/or behaviour towards the environment (Moss et al. 1998; Overdevest et al. 2004; Brossard et al. 2005; Haywood 2014). One reason given for these negative results is project designs in which participants solely collect data, but are not able to reflect on the results (Haywood 2014). Opposition can also come from the other side, with scientists not always being eager to let untrained people challenge the hierarchical academic structure or use the data collected by non-professionals (Slovic 1999; Rotman et al. 2012). Although a number of studies suggest that citizen scientists can collect reliable data, for instance, Delaney et al. (2008) find that 12/13 year olds had a 95% accuracy rate in classifying crabs, scientists may fear that the quality of data collected by non-professionals is of poor quality, especially in projects with a strong contributory aspect (Riesch & Potter 2014; Paul et al. 2014). To overcome this barrier, in the Galaxy Zoo project, for instance, repeated classification by participants, combined with an algorithm to check for anomalies to validate the data contributed by participants is used (Lintott et al. 2008). More generally, Cohn (2008) suggests that a balance must be found between asking participants for either too vague or too complex contributions, neither of which are valuable to scientists (Cohn 2008; Tregidgo et al. 2013).

[9] A key motivation to initiate the *'Meet je Stad'* project is the idea that citizens may experience different problems/find other solutions than those suggested by professionals. By explicitly involving their perspectives, the city of Amersfoort hopes to achieve a better and more complete understanding of the issue, and ultimately to design better solutions. The project is especially interesting since the precise research questions are to be determined by the participants themselves (Sijbrandij 2015, pers. comm. 4 August).

[10] In the '*Crowdsourcing Reeuwijkse Plassen*' project 10 citizens monitor groundwater water levels in their backyards and monitoring surface water levels in their surroundings as to increase knowledge about the relation between groundwater and surface water levels(Van den Berg 2015, pers. comm. 18 September).

Table 1: Potential (dis)advantages of citizen science

Advantages	Disadvantages
• More data available for analysis • Less contested knowledge • Trust between public and scientists • Education / Social learning • Better quality science • Easier implementation of research results	• Time and resource intensive • Loss of control of the process by scientists • Reliance on volunteer effort • Quality of data may vary • Retention of participants may be challenging

Note: table based on literature discussing citizen science as well as participation more broadly (Functowicz & Ravetz 1993; Gibbons et al. 1994; Rip et al. 1995; Bäckstrand 2003; Irvin & Stansbury 2004; Reed 2008; Hage et al. 2010; Conrad & Hilchey 2011; Miller-Rushing et al. 2012; Rotman et al. 2012; Glucker et al. 2013; Gura 2013; Haywood 2014; Riesch & Potter 2014)

2.4 Different types of Citizen Science

Scholars differentiate between types of citizen science based on the variety of forms in which it is practised (Buytaert et al. 2014). Such typologies are typically based on varying degrees of participation in the research project, which, for instance, can be defined by the effort or duration of involvement by participants, the number or types of participants, or, most influentially, the power that participants have with regard to the research steps in which they participate (Bonney et al. 2009), the latter reflecting the prominent position that power has in discussions on participation. In fact, models such as Arnstein's ladder (1969; revised by e.g. Pretty 1995) which centre around, and conflate power as a degree of participation, are an important reference point of typologies of participation.[11] In line with critique on Arnstein's general participation ladder (as detailed in Attachment I), various scholars, including Collins & Ison (2006) and Cornwall (2008), however, signal several problems in relation to the use of this traditional power approach with regard to citizen science. In the first place, they regard the hierarchical structure of this power approach, assuming that more power is better, problematic. In fact, they suggest that this certainly does not always reflect public perception, and in connection to that, argue that more power is not necessarily beneficial for citizens (Saldivar-Tanaka & Krasny 2004; Cornwall 2008). Furthermore, they argue that not all citizens necessarily want to be involved in every step of the research process (Lawrence, 2006).

Arguably the most influential categorisation of types of citizen science projects is that of Bonney et al. (2009), which itself resembles categorisations by for instance Lawrence (2006). They classify citizen science projects based on the degree of involvement, and distinguish between so-called *contributory*, *collaborative*, and *co-created* citizen science projects (Bonney et al. 2009). *Contributory* projects are those in which members of the public merely collect data for scientists to use in their research, in *collaborative* projects the public actively helps scientists with the analysis of this data as well, whereas *co-created* projects are characterised by the fact that the study is entirely designed and executed by the two parties working together (Bonney et al. 2009). In an expansion of this framework, Shirk et al. (2012) add two new typologies on either side of the spectrum. In the *contractual* form, the public asks scientists to answer specific research questions, but is not involved in any of the data collection or the analysis that follows. On the other side of the spectrum, members of the public are fully in charge of a study in the *collegial* type (Shirk et al. 2012).

In relation to the discussion of Mode-2 knowledge and post-normal science in Section 1.3, the forms discussed by Bonney et al. (2009) remain most prominent, because these are the forms in which one can actually speak of public involvement in the research process (which is not the case in the *contractual* form), whereas the role of scientific experts is also not completely neglected (as seems to be the case in the *collegial* type). Still, the contractual form allows for citizens to set the research agenda, and citizen scientists working along the collegial type may make valuable contributions to science, with a famous example of the latter being Benjamin Franklin (Silvertown 2009), who made a number of scientific discoveries, including a method to prove that lighting is a form of electricity by flying a kite in a thunderstorm. Table 2 provides an overview of the different types of citizen science projects, highlighting the

[11] Arnstein describes eight forms of "participation", reaching from a form which she describes as essentially manipulating the public, to informing the public, and ending at a form where citizens have full control over the decision-making process, equating participation and power (Arnstein 1969). A more detailed discussion of power and participation is provided in Attachment I.

involvement of the public in the various research steps. It should be noted that the dissemination step as shown in the table only covers the way the public participates in the process itself.

Table 2: Typology and description of (the involvement of the public in) citizen science projects (based on Shirk et al. 2012). The letter 'P' indicates that the public participates in this step of the research process,(P) that the public may participate, whereas the letter 'I' indicates that the public executes this step independently

Type of project	Contractual	Contributory	Collaborative	Co-created	Collegial
Role of citizens	*Pose research questions to the scientific community*	*Contribute samples or data to a research project*	*Collect data and analyse results together with scientists*	*Work together with scientists to develop and execute a research project*	*Independently set-up and execute a research project*
Choose/define research question	I/P			P	I
Develop hypotheses				P	I
Design methods for data collection			(P)	P	I
Data collection		I/P	P	P	I
Data analysis		(P)	P	P	I
Interpret data & draw conclusions	(P)		(P)	P	I
Dissemination & Implementation	(P)		(P)	P	I
Evaluation	P			P	I

Of course, in practice, the distinction between the various types of citizen science are often far from clear-cut and more subtle (Cornwall 2008). For instance, primarily contributory projects may still allow for analysis by participants (Tomasek 2006), and many co-created projects only have a small set of participants being involved in the project as a whole, while others keep their role limited to certain tasks (Shirk et al. 2012). This final points relates to the second primary characteristic of citizen science types discerned by Shirk et al. (2012), namely what they refer to as the *quality* of participation. In their work, the quality of participation indicates to what extent the project meets the "needs and interests of the public" (Shirk et al. 2012: 4). This means that a project with a very low degree of public participation (e.g. the public only contributes data) may still classify as high-quality, whereas a project in which the public is involved in all research steps can be low-quality if the research question is not relevant to the public. Still, it is generally likely that a more collaborative approach is better at ensuring quality (Lawrence, 2006; Luyet et al. 2012) as there will be more input from the public on what type of research question to pursue.

2.5 Opportunities in (drinking) water research

Whereas the involvement of non-scientists is widely practised and highly successful in many domains and for many tasks, the involvement of non-scientists in the field of water management is so far rather limited. Indeed, because of the specialized knowledge and/or equipment needed for more advanced analysis, citizen participation in this domain is often limited to the collection of data in the form of water samples, basic hydro-chemical parameters, turbidity, conductivity/salinity, pressure, redox potential, and pH (Buytaert et al. 2014). When specifically looking at the domain of drinking water, the involvement of non-scientists is even more limited.

Does this mean that the potential for citizen science projects in the field of water management is low by definition? For various reasons we think this would be the wrong conclusion, meaning that the full potential for the involvement of citizens in the various research phases in the field of water management is not yet realised. Apart from the developments of a changing society and the role of knowledge as discussed in Chapter 1, an international literature study on participation and citizen science initiatives in the field of (drinking) water shows that appealing examples of public involvement do exist, including groups monitoring surface- and groundwater in shale gas regions in the United States to fill knowledge gaps and better protect drinking water sources (Brantley et al. 2013) (the results of the international analysis will be presented in a separate report entitled “Citizen involvement in water issues: an exploration of case studies around the world”). Moreover, helped by the fact that smartphones form a widely owned tool which as new sensing technologies emerge increasingly used in the determination of more and more water-related parameters, new perspectives for a wider range of data collection are opening up quickly (see Kronemeijer 2015 for an extensive discussion on the topic of smartphone-based drinking water monitoring).

3 Choosing the right type of Citizen Science

3.1 Introduction

Although a number of scholars have attempted to translate the scholarly discussion on participation to guidance for practitioners, literature on the subject of when to employ which form of participation or citizen science is scarce. A clear exception to this overall pattern, at least in relation to participation in decision-making, is the work of Lawrence and Deagen (2001). Building on the Vroom-Yetton model, originally designed to guide private business managers about employee input on decision-making, they provide a tool to give guidance for natural resource managers as to when and how to structure public participation. Based on a series of six yes or no questions, including questions such as *'is public acceptance of the decision critical to effective implementation'* and *'are the relevant publics willing to engage in an integrative dialogue in order to improve the situation'*, the responsible manager is guided through a decision tree, resulting in a suggestion for the most appropriate participatory form, ranging from no input whatsoever to the co-production of a solution between the public and manager.

Even if the clear and unequivocal structure of Lawrence and Deagen's decision tree (2001) may seem attractive for practitioners, various scholars (cf. Kangas et al. 2008) consider the approach too simple, if only because not all people are willing to commit themselves to very intensive planning, and/or would like to be able to choose the level of participation suitable to them. Hence, most authors are more modest in their recommendations, highlighting that the appropriate form of participation is context-sensitive (e.g. Tuler and Webler 2010), and may therefore not be something that can be based exclusively on a number of questions to be answered by the executive authority.

3.2 Contextual effectiveness

Fully acknowledging the idea that the most effective or appropriate degree of public involvement is context specific, Smiley et al. (2010) suggest five broad characteristics that shape the context for public involvement, hereby providing an important basis for determining the appropriate level of public involvement. These five characteristics include the planning goals of a decision-making process, the nature (complexity) of the planning problems, the size of the group required to represent the diversity of perspectives, the potential for participant learning, and finally, the integrity, willingness, and commitment of potential participants.

Also for citizen science specifically, it has been observed that in determining the most appropriate degree of participation, it is essential to consider the context and desired outcomes first (Wesselink et al. 2011; Shirk et al. 2012). The outcomes of citizen science projects have been categorized by Shirk et al. (2012) into outcomes for science, the system under study, and outcomes for individual participants, i.e. the citizen scientists themselves. The latter outcomes, among others, may relate to the development of new skills, new content knowledge, deepened relationships with the natural world and/or the community, and very important, increased scientific literacy (Shirk et al. 2012; Buytaert et al. 2014; Haywood & Besley 2014).

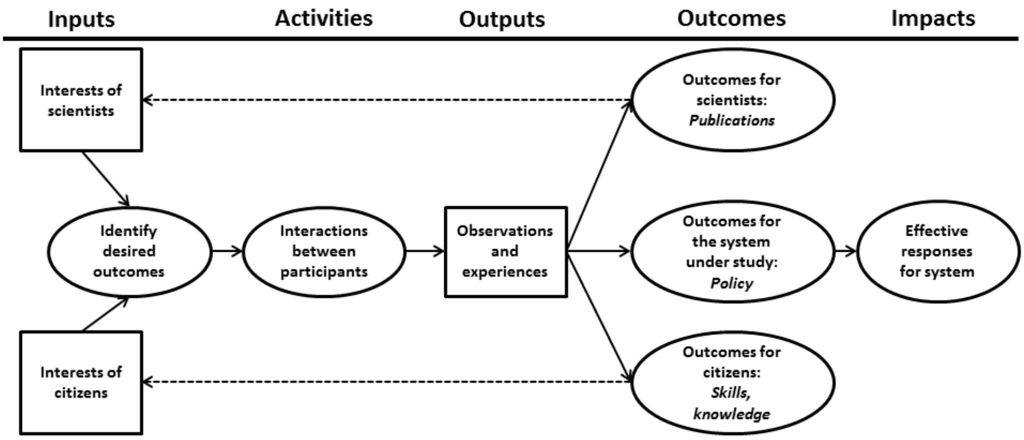

Figure 1: Overview of the citizen science process (adapted from Shirk et al. 2012)

Figure 1 shows how these outcomes and the differing interests of participants relate to the overall citizen science process, starting with the interests (hopes, desires, goals and expectations), skills, experiences and resources available to both scientists and citizens (input), the tasks involved in the project design (activities), resulting in outputs (the initial products or results of activities, including observations), outcomes (direct measurable elements), and ultimately impacts (sustained changes in the system). As a consequence of the importance of these contextual characteristics, projects that, for instance, aim for an explicit educational factor require a different set-up than projects simply aimed at creating larger databases, which again differ from projects in which entirely new research questions are being sought based on non-expert knowledge. According to Whitelaw et al. (2003), it is important that the outcomes will benefit the common good, so that the results will be more likely to be published or used by policy-makers. However, according to authors such as Bradbury and Reason (2008) none of this means that the project design can be unilaterally determined by a team of researchers. Instead, they argue that a participatory method should be used during early project planning phases to ensure that whatever degree of participation is chosen, (potential) participants agree (Bradbury & Reason 2008). In relation to this, Buytaert et al. (2014) warn that a participatory problem definition does not mean it is unbiased, and care should be taken to ensure that the process does not reinforce existing biases. Finally, Shirk et al. (2012) advise to take the time available to- and knowledge of prospective participants into account, especially in the project design phase.

Given the importance of the contextual variables, once more, including the interests of the public/(potential) citizen scientists themselves, the design of a new decision-tree for deciding the most appropriate form of citizen science seems little fruitful. Nevertheless, the various pros and cons that have been suggested for the different types of citizen science projects (see Table 3) may provide some guidance in deciding which type of citizen science is potentially most fruitful within a given context.[12]

[12] Attachment II provides a more practical guide to setting up citizen science projects, in the form of a number of questions to consider for the various stages of a project.

Table 3: Overview of pros and cons for different degrees of citizen science. (Compiled from Lawrence 2006; Fernandez-Giminez et al. 2008; Bonney et al. 2009; Danielsen et al. 2009; Conrad & Hilchey 2011; Shirk et al. 2012)

Type of project	Contractual	Contributory	Collaborative	Co-created	Collegial
Pros	Comfortable for scientists More societally-relevant research questions Little extra time or resources required May promote interdisciplinary research	May create long-term data sets Large quantity of data Access to local knowledge Technical skills for individuals Increased knowledge of system for individuals	Some learning opportunities for all partners, both for skills and knowledge High data quality Increased trust among partners May change attitudes of participants	Most responsive Diverse and profound learning opportunities for scientists and individuals Increased trust among partners Contacts with other viewpoints may change attitudes of participants No external funding may be needed More societally-relevant research questions	Diverse learning opportunities for individuals, building both skills and knowledge Wider body of researchers
Cons	No mutual learning No generation of trust between scientists and the public Public does not always know what is relevant in a given field	Decisions may be slow Low participant diversity Limited learning opportunities Medium time investment from all partners Lower generation of trust between partners Retention of participants most difficult	Difficult to replicate Decisions may be slow Medium time investment from partners (Partial) choice between scientific progress and science education	Medium data quality High time investment from individuals, low for scientists after set-up involving extensive training Difficult to replicate Commitment to intensive consensus model required Slow process Mostly aimed at social outcomes rather than scientific May have non-diverse participants	Little mutual learning Results may have difficulty reaching scientists Little generation of trust between scientists and the public

Irrespective of the exact form of citizen science performed, it is held to be important to ensure frequent evaluation of the project so that the project design can be adapted if necessary (Bradbury & Reason 2008; Tuler & Webler 2010; Shirk et al. 2012). More specifically, Carr et al. (2012) suggest that in evaluating participation projects three elements are important to consider: (1) the quality of the participation process, (2) project outcomes, both substantive and relational (e.g. trust), and (3) the impacts of the project (cf. Shirk et al. 2012), i.e. whether the project helps in achieving the overarching objectives. Successful projects should be beneficial for both scientists and the public (Silvertown 2009). Taking the entire evaluation process to a higher level, some argue that when evaluating a participatory project, the evaluation itself should be participatory as well (e.g. Blackstock et al. 2007), meaning that the indicators and evaluation criteria should be determined by the projects' participants as well as their respective ratings.

3.3 Best practice in participation and citizen science

A number of authors explored the driving factors behind successful participation projects, and in relation to this investigated what can be constituted as "best practices". Some of these best practices are directly applicable to citizen science, including early stage clarity on the rules and goals regarding the type of participation (Sabatier et al. 2005), reflecting Lynam et al. (2007) who state that *"well-formulated questions are more likely to generate robust answers"*. In the case of citizen science, this relates to the focus on the outcomes in the planning stage discussed in the previous section. Indeed, it has been suggested that clarity on the project objectives is fundamental to successful citizen science programs (Fernandez-Giminez et al. 2008; Shirk et al. 2012). Other factors that are considered important are skilled organizers (Griffin 1999; Leach et al. 2002; Reed 2008) and an appropriate (time) investment (Kenney et al. 2000; Leach & Pelkey 2001). Reed (2008) further recommends the institutionalization of participation, although this may be less relevant for citizen science. Indeed, according to Hessels (2015, pers. comm., 20 July) the differences between scientific disciplines form a limiting factor here; although he acknowledges that more involvement of the specific knowledge and experience of direct stakeholders such as industry representatives or civil servants may further help in increasing societal relevance of research questions, speaking of an overall institutionalisation of citizen science ignores these disciplinary differences.

In the discussion on best practises there are some more distinctions to be made between citizen science and public participation in decision-making as at least two key elements with regard to the latter do not seem to universally apply to citizen science. Firstly, the assertion in the literature that participation should be started as early as possible to be effective (Leach et al. 2002; Russell & Hampton 2006; Reed 2008; Renn et al. 2011), and secondly the argument that care should be given to ensure a representative group of participants (Duram & Brown 1999; Smith Korfmacher 2001; Reed 2008; Luyet et al. 2012). Particularly in contributory projects the main objective will usually be to obtain a larger quantity of observations, with the quality of those data being the main concern. Project managers might then perhaps prefer to mostly focus on what incentives may promote broad and continued participation by people who aim to provide quality data. However, care should be taken in projects that touch upon subjects closer to the public and that contain more contested values, as for such projects a more representative group of participants may be advisable (Renn et al. 2011; Haywood & Besley 2014).

More focused on citizen science specifically, Buytaert et al. (2014) warn for taking the participation of citizens for granted, which may severely impact the willingness of the public to participate. In relation to this, Shirk et al. (2012) highlight how the social aspect, including interactions between all partners (including scientists), is an important element of successful citizen science projects. Again, specific guidelines are difficult in this regard, as in any case the project will have to be tailored to the context in which it is to take place (Reed 2008; Wiggins & Crowston 2010). Finally, as discussed before, careful evaluation and adaptation of citizen science projects is considered an important element of good projects (Bradbury & Reason 2008; Tuler & Webler 2010; Shirk et al. 2012).

4 Motivation of participants

4.1 Introduction

An important question that relates to the desired structure of citizen science projects is what motivates citizens to participate in such projects. Why do participants choose to volunteer and contribute their time and energy to citizen science? What do they get out of it? Knowledge on the motivations of participants is important as, obviously, having motivated participants is essential for the project's success (Jennet et al. 2014). A carefully designed project will have to consider what type of participants it hopes to involve, but also the expectations that these participants may have in relation to the project. A number of scholars deal with categories that describe what motivates volunteers in general. For instance, Batson et al. (2002) recognise egoistic, altruistic, collectivistic, and principalistic motives for community involvement. The egoistic motive rests on the idea that involvement is only a side-result or means to an end of someone striving to benefit themselves; in the altruistic motive one actively tries to make other(s) better-off, although this group may be limited to one's direct surroundings; the collectivistic motive closely relates to the altruistic one, but is more explicitly focused on a single group; finally, someone acting according to a principalistic motive does so because s/he believes it is the right thing to do, but may thereby be vulnerable to rationalisation, leading to loss of motivation (Batson et al. 2002). This classification is similar to other recurring motivations in the literature, including that the goals pursued may relate to one's career, self-esteem, social motives, protective value, understanding/learning, values, religion, team-building, and enjoyment (Clary et al. 1998; Allison et al. 2002). The question that remains is how these categories translate to citizen science; as up to today, there has been relatively little empirical research carried out to map the motivations for volunteering for citizen science activities specifically (Raddick et al. 2010, 2013; Haywood 2015). To complicate matters further, it has to be remarked that someone's motivation may also be subject to change, i.e. that the motivation to continue participation in the project may be different than what sparked participation in the first place (Rotman et al. 2012, 2014).

4.2 From learning to social relations

Even if the significance, deeper value, and correlations between the different motivations for participating in citizen science projects may not yet be entirely clear, it is evident that people are motivated to participate in citizen science projects for many different reasons (Rotman et al. 2012; Jennett et al. 2014). In interviews with participants in COASST, a project in which volunteers survey deceased birds and marine debris on Pacific beaches in the United States, Haywood (2015) investigates what motivates the projects' participants. Some of the most important reasons that are mentioned include a "greater awareness and appreciation for the coast", a "sense of satisfaction and contribution", and "learning and gaining knowledge", the last being supported by the trainings that are given to participants (Haywood 2015). On the basis of these interviews, Haywood postulates that more than just the collection of data and contributing to research is important to the participants, something that is supported by Price and Lee's (2013) claim that especially the social aspects of projects are appreciated. In relation to the before-mentioned Galaxy Zoo project, Raddick et al. (2013), come to a somewhat different conclusion. Although they indeed do find that some of the project volunteers are largely motivated by the prospect of fun and participating in a social community, in their study, the feeling of contributing to science is the most mentioned (~40%) primary motivation for participants, followed by an interest in astronomy or the possibility to make new discoveries (Raddick et al. 2013).[13] Luckily for other, perhaps less sexy research projects, Raddick et al. (2013) stress that the success of the Galaxy Zoo project cannot be explained by specific features of the project itself such as the beautiful galaxy images or the fun of classifying galaxies, but mainly relates to the actual contribution to science that participants feel they can make.

Meanwhile, the impression does exist that participants expect something in exchange for their contribution. Acknowledgement of the contribution of citizen scientists is named by Rotman et al. (2014) as one of the main factors causing long-term commitment to citizen science projects. Besides general remarks in the acknowledgement sections of scientific papers this can even be extended to for instance co-authorship. An example is the Stardust@home project, where participants looking for cosmic dust have the opportunity to

[13] That there is a real possibility to make new discoveries is illustrated by "Hanny's Voorwerp", an unknown cosmic object discovered by a Dutch elementary school teacher, which has since been studied by the Hubble Telescope (Wiggins & Crowston 2010).

name a new discovery and appear as a co-author on the publication describing it (Méndez 2008). In Amersfoort, reports on biodiversity in the city that make use of ecological data collected by volunteers are presented to the responsible alderman in a small ceremony, again creating a sense of appreciation among participants (Sijbrandij 2015, pers. comm. 4 August). Other yet unnamed factors that are important in keeping participants motivated are the building of trust between participants and scientists, which is related to the hierarchical structure of the project, and to what extent a personal relation between the two groups is developed (Rotman et al. 2014). Table 4 provides a summary of the key motivations for volunteers to participate in citizen science.

Table 4: motivations for participating in virtual citizen science (Based on Jennet et al. 2014)

Key motivations for participating in citizen science
Interest in the research topic
Learning new information
Contributing to original research
Enjoying the research task
Sharing the same goals and values as the project
Helping others and feeling part of a team
Receiving recognition and feedback

There are also some factors that may actively demotivate participants. For instance, participants feeling that they should be committing more time to the project than they are able to (Rotman et al. 2014), which indicates that excessive expectations work counterproductive. Also a time-shortage amongst the scientists involved in the project can demotivate participants, as it may cause a lack of training for participants or poor coordination of the project (Buytaert et al. 2014). A lack of training can also (further) contribute to a lack of know-how regarding the technique used in the project, which again may be an important reason for people to stop participating in a project (Rotman et al. 2014). Finally, a feeling of being “patronized” or being “undervalued” by the professional scientists may be highly detrimental (Buytaert et al. 2014), which of course directly relates to the idea that participants expect something (appreciation) in exchange for their participation.

4.3 Motivation of citizens: empirical evidence

Because research into the motivation of citizens in participating in citizen science projects is still very scarce – and moreover is usually limited to citizens who are actually involved in such projects – in this research we opted for a much broader approach. We decided not to focus on those citizens who already participate in projects; instead, we decided to explore the average citizen’s ideas, desires and motivations with respect to becoming better informed about and/or involved with drinking water matters and companies, be it by means of participating in citizen science projects or not.

We conducted this exploration by putting together a focus group consisting of a group of 12 citizens, differing in age, gender, education. Extensive discussions were held with this group on the forms of connection, if any, that they, as citizens and drinking water consumers, would wish to have with drinking water matters and their drinking water company. To begin with, we addressed the question as to whether there is a need for more information and the degree to which there is a desire for more say on their part. Only then did the discussion zoom in specifically on the question of whether the participants would (hypothetically) be interested in participating, as citizen scientists, in research programmes related to drinking water. These themes stimulated lively and fascinating discussions during which a number of matters came to the fore, for example, the desire for a greater awareness and the interest in citizen science initiatives. At the same time, there appeared a variety of dilemmas and paradoxical elements, which the water companies, in their quest for connections with citizens, will certainly have to take into account.

Water-awareness and the need for information: an accumulation of dilemmas

One interesting initial observation arising from the exploration is that many participants made it quite clear that feel they actually know very little about drinking water; including, for instance, where it comes from, how it is treated, and who supervises its quality. A number of them weren’t even familiar with the name of their water company. At the same time, the participants indicated that they think it important that they, and society in general, become more aware of tap water. One participant put it this way: *‘Actually, when you think about it, it’s crazy . . . water is one of the most important things there is, but nobody pays attention to it. We simply assume that our tap water is good, and when we say to ourselves “hmmm, this tap water is looking pretty brown”, then we head over to the supermarket to* *pick up some bottles.'* The participants feel that one of the reasons for this lack of awareness is the fact that drinking water is considered to be very cheap. For example, one participant said: *'If you were to ask me who my water supplier is, I couldn't tell you. But take gas or electricity, for example. These cost you a couple of hundred euros per month: that hits your pocket. But when it comes to water, every few months you get a bill, and that's that; you think no more of it.'*

That water is perceived as being cheap and, perhaps more important, that people evidently have great confidence in the quality of their water, to the point that hardly anyone feels the desire or even the need to become informed, can naturally be seen as a compliment for the drinking water companies. One possibly significant downside of this ignorance, however, is that, when problems arise, not everybody knows who to turn to with his or her complaints or questions. One participant, for instance, noted: *'At my place, for example, when I turn on the hot water, white water flows out of the tap. I ask myself "What's going on?" . . . "What's wrong with my water?" . . . and "Where can I go for help?"'* Once again, if the confidence in the Dutch water provision weren't as high as it is today, one would have expected this woman to have taken action; something she didn't do in this case. Nevertheless, and regardless of her confidence, she continued to wonder and was left with a somewhat uneasy feeling: *'They did some maintenance work recently, so I thought that the issue would be resolved, but the water is still white. So I thought, what the hell: if something was wrong I would have been notified. So I do use the water, but I still wonder about it in the back of my mind.'*

Although the participants were practically unanimous about the idea that more information – and especially more awareness – concerning drinking water was desirable, there were significant variations from one person to another when it came to content, even though most attention focused on the themes of quality and health, costs, and lastly on consumption and the associated issues of wastage and possible future water shortages. Several participants indicated that they would appreciate having more insight into the price of water, and made frequent reference to the smart energy meters that many people have in their homes. Several participants for instance expressed their interest in having a sense of their consumption at the appliance level: *'If you installed small water meters [within the household's piping], for example, specifically for the shower, then you would be able to ask yourself "hey, how much have I wasted in the shower?"'* Some participants would not only desire information on their own usage, but also see it set against the usage of other households: *'Of course you might well be able to say that "I have used this much", but what is the standard? If someone else uses less, you'll realise that perhaps you're wasting a little.'*

The desire for more insight into water consumption data is related to the theme of water wastage. Using water economically and wastage is a theme about which a large number of the participants clearly had feelings and opinions: it's something that touches many people. For example, many of them believe that it is a shame to use a lot of water in taking long showers or in watering the garden, while others find it particularly lamentable to use drinking-water quality water for instance to scrub the floor or flush the toilet. For example, one participant said: *'When you look at how we deal with our water compared to people in very poor countries. While we stand under the shower for ten minutes washing ourselves, people somewhere else have to walk two hours to fetch their water . . . . I really hate it when my daughter stands under the shower for twenty minutes.'* Other participants related 'wastage' primarily to the notion that water will possibly become increasingly scarce in the future. One participant put it this way: *'Recently I read an article that said that we consumed something like 20% more water last summer, just because of the hotter weather. Maybe in a hundred years we won't be fighting wars over oil but over water.'* However, for other participants it is questionable whether one can say that there are actually shortages today in the Netherlands as well, or that they might occur in the future. If this is not the case, then another group of people see absolutely no reason to be economical with water. One participant articulated this position like this: *'If the water supply is so large and is being constantly replenished, so that there's absolutely no lack of water or threat of a shortage, then we don't have to be economical with it.'* The dominant discourse surrounding this theme was somewhat paradoxical. On the one hand, it was clear that people would like to know more in order to better understand whether shortages or problems lie in the future but, on the other, they indicated that they don't actively look for this information.

Although the participants thus indicated a need for more information, only a few of them had actively sought information about tap water: one participant did so to convince his girlfriend that tap water was better than bottled water, another to find out more about costs and, lastly, a number of participants searched for information in connection with the safety of tap water in holiday destinations. So, even though pretty well everybody said that it would be good if people were to become more aware of tap water, they very rarely actively seek out information themselves. Moreover, the information that drinking water companies sometimes include with their invoices is not often read – at least, that is what emerged from this focus group. When asked how they thought the drinking water companies should raise awareness, most participants saw a television programme as the answer. *'TV seems to be the easiest way. Internet means I have to do a search; that won't happen. Flyers? I have a "No-Junk-Mail" sticker, so I wouldn't get one in any case. Someone comes to the door? Door-to-door doesn't work.'* Another participant expressed the idea like this: *'In general I think it would be great if the national government or some water entity produced an information programme about it'* At the same time, some participants questioned this solution, wondering: Can you actually trust the media? *'Many things you see on TV aren't right at all. I wonder a little whether we can always believe what we see.'* This participant's scepticism about television's reliability is not unique. Indeed, apart from the question concerning the manner and content of the communication, the matter of *who* could convey the best information about drinking water was a very important one. It was striking for instance that several participants argued that information about drinking water safety and quality, for example, should not come from the drinking water companies but from an independent source. *'What's an independent source? If Dunea says that Dunea's water is good . . . yeah, sure it is . . .'* Also KWR itself, following the short introduction about the institute that we gave at the beginning of the session, would, because of its connection with the drinking water companies, not be the appropriate source either in the eyes of some participants.

One key conclusion from the focus group was however that when people take more time to think about the actual need for information, a large number of them conclude that information is only really relevant when there is actually something amiss. Thus one participant said that *'there is no need for information. It's only when there's something wrong going that we need it.'* In short, people don't so much say that they have a need for information, but that they would like to be more aware. How the drinking water companies should bring about this extra awareness desired by the participants is a tough question. One of the participants suggested beginning with the young: *'You can start with the young, with kids . . . I think that you can also raise some awareness in the schools, as part of the curriculum; like explaining where a glass of water actually comes from.'* Quite apart from the dilemmas around the question about how much people today really want information and who should provide it, there is also the associated challenge of how to respond to the evident need for awareness and the fact that several participants also indicated that, even though they consider the price of tap water very low, they would not be willing to pay for information campaigns to this end. One of the participants said: *'After all, we're talking about public money; it should be managed frugally.'* Another participant added: *'Whoever finances it [the information campaign], I only hope that it won't come from my taxes.'*

Leaving the control to the professionals

Whereas a large proportion of the participants indicated they would like to receive more information about their drinking water and, as discussed below, several among them reacted enthusiastically to their possible participation as citizen scientists in drinking water research projects, the group's interest in having more say on drinking water matters was remarkably low. Only a few of the participants said they wanted more say in how their money is invested, but nobody had a deeply cherished wish to have more say in the field of drinking water. However, a number of participants did say that they would appreciate it if the water companies were occasionally to ask them informally for their opinion. One participant for instance said: *'It would be nice, when it's time to pay a bill, to receive an email with information and a short questionnaire – which, by the way, you would not be obligated to fill in.'* At the same time, there was scepticism as to whether the drinking water companies genuinely want to listen to people, particularly when citizens propose views that perhaps don't fit in with the picture envisioned by the drinking water companies. One of those present recalled a descaling campaign in which the consumers were to be asked beforehand whether this would interest them, even if it meant that their water would become a little more expensive. Even if the answer had been negative, the drinking water company would have gone ahead with its plan, with a consequent damage to its image: *'At the time the respective water company wondered whether it was possible. The idea was attacked from all sides, because the price of water would go up by a couple of percentage points! . . . . To say they got a "no thanks" answer, is putting it mildly. It was more like: "The greedy guys just want to make more money".'*

Although all the participants found increased awareness to be important – and several of them openly expressed their doubts about the objectivity of the drinking water companies themselves – it is striking that many of them showed little interest in increased citizen say. In general, one could state that the focus group's participants felt that control should be left to the professionals. The reasons behind this position are twofold. There were those participants who indicated they had absolutely no need for more say or involvement with their drinking water supplier because they didn't want to be burdened. They 'simply' wanted to keep on being supplied with good water, and otherwise be left in peace. One participant, for example, stated: *'What people need is simply safe drinking water at a good price. Who provides if for us? Who cares?! People couldn't care less whether it's Dunea, Oasen or Evides . . . . We just want it to be safe and reasonably priced. Then we're very happy; and we don't all have to have an opinion about how the water is produced.'* Another participant articulated his lack of interest in becoming actively involved or having a say as follows: *'To us, the tap is our supplier . . . as long as it flows from my tap at home at about a constant pressure, I couldn't care less.'* The reasoning of a second group of participants was centred less on the need for a say, but on the conviction that only experts and skilled people should be the ones at the controls. In particular the idea that poorly informed citizens, including themselves, could have an influence on the quality of drinking water even seemed to be a bad idea to all the participants. This scepticism was expressed by one participant thus: *'I'd be scared to death if my tap water were subject to the influence of sentiments. I'd rather it were left to an agency.'* Another person asserted: *'I don't think you should let people make choices about this kind of thing; you should simply let the choices be made by some independent body.'* The view of the focus group participants was that people should only be allowed a say if they are knowledgeable. One individual said for instance: *'We* *can only have an opinion about the matter if we know more about it.'* The importance, but also the difficulty, of sharing knowledge and creating awareness was thus once again underlined.

Interest in citizen science projects

Although certainly not all citizens have an interest in collaborating, as citizen scientists, with their water company's research projects, there were a few individuals in the focus group who did signal their willingness to do so. Several of them for instance gave a convincingly affirmative answer when asked whether they would be open to helping their drinking water company with a research programme, for example, by holding a test strip under the tap first thing in the morning. In their willingness to participate in such projects, people would be motivated primarily by self-interest; in this hypothetical case, their interest would be to learn more about drinking water or, more specifically, to gain more insight into the quality of the tap water in their own homes. Thus one of the participants who expressed an interest in taking part in research programmes (hereinafter: 'candidate citizen scientists') stated: *'I drink water all day long; so it's actually really important to know what you're swallowing. I always assume that it's healthy . . . but who knows?'* Moreover, when the participants were asked whether they would be willing to take part in a citizen science project that didn't involve a personal benefit (such as gaining information about the quality of their own tap water at home), if they were asked or invited to, a large proportion of them said they would be open to it, especially if such a project would, for instance, benefit the environment. At the same time, clearly not everyone was keen about actively contributing to knowledge in the field of tap water. One participant for instance felt that research is really the task and responsibility of the drinking water company itself, and expressed no personal interest in it: *'I'm much too lazy for that . . . . I think that it's the water company's responsibility; I pay for my water and expect it to be of good quality. Just install a sensor, so that an alarm goes off whenever something strange happens; it's their problem.'*

An important related key conclusion about citizens' possible interest in collaborating with research projects is that the candidate citizen scientists all indicated that they felt that it would be very important, in the case of an actual project, that they be given feedback about both the collected data and what is done with the information. One possible candidate citizen scientist said: *'If you don't get any feedback, you'll take part the first time; the second time you might hesitate a little; but after that you'll think, what the heck, nothing will come of it anyway.'* At the same time, a dilemma also arose in relation to this theme, namely, the point was made that people would probably not be able to deal at all with certain types of data – for instance, concerning the quality and safety of drinking water. Thus for instance one of the participants said: *'Yeah, it could create a commotion . . . already when you think that there's something in the water you'll fall ill immediately . . . . People have no idea.'* Another participant expressed a similar point of view as follows: *'You'll stoke up your own fear; if there's a little too much of something in the water, you'll have no idea what it might mean.'* The discussion on this subject did not arrive at the conclusion that drinking water companies should therefore not share what they learn and inform people – for instance, about the water-quality data generated – but that this information sharing should be done very carefully. It is thus definitely not the case that all the participants were worried about possibly panicking about misinterpreting the data. One of them said: *'If you can see that a little too much of something is in the water, you can always quickly consult the water company and ask them what can be done about it.'* One clear finding is therefore that at the moment when people are asked to participate in a research project, they will want to know why and to what end the research project was set up, that is, to understand its background and objectives. Furthermore, the participants made it very clear that if they were to participate in citizen science projects, it would also be very important for them to be informed of the results. Whether this sort of data should be shared in raw or contextualised form is less clear. What *is* very clear is that a good many citizens seem to be open to having closer connections with their tap water and their tap water company, and that, for a proportion of them, citizen science-type projects could possibly be part of it. At the same time, it is evident that the effort to establish these connections faces a path full of dilemmas, challenges and open questions.

5 Summary and Conclusion

Building on the rapidly changing society and (the role of) new forms of knowledge generation, this explorative study has provided better insight into possibilities of how water companies may connect with citizens by involving them in the generation of knowledge. Based on a combination of literature research and expert interviews, we have demonstrated that, among other things due to a shift towards active citizenship, a changing role and meaning of knowledge, and fast evolving developments in the field of information and communication technology, citizens not only require transparency and open data, but also participate in scientific research. Indeed, even if the engagement of 'amateurs' in scientific exploration and research is by no means a new phenomenon, this study suggests that we nowadays face a "new dawn" in the participation of the general public (i.e., non-scientists) in the generation of new scientific knowledge, i.e. citizen science, in this study defined as any form of active public participation in the process of research to generate science-based knowledge, from setting the research agenda by asking research questions, to collecting data, and/or analysing the results.

In our efforts to provide a better insight into citizen science, this report not only provides a clear definition of this form of knowledge generation, but, based on the degree of involvement of citizen, also distinguish between five types of citizen science projects. Contributory projects are those in which members of the public merely collect data for scientists to use in their research, in collaborative projects the public actively helps scientists with the analysis of this data as well, whereas co-created projects are characterised by the fact that the study is entirely designed and executed by the two parties working together. In the contractual form, the public asks scientists to answer specific research questions, but is not involved in any of the data collection or the analysis that follows. On the other side of the spectrum, members of the public are fully in charge of a study in the collegial type. Besides that this study analysed the various pros and cons for the different types of citizen science projects, this study investigated what can be constituted as "best practices", and provides guidance in deciding which type of citizen science is potentially most fruitful within a given context. In determining the most appropriate degree of participation, our study suggests, among other things, that it is essential to first consider the context and desired outcomes, including outcomes for science, the system under study, and outcomes for individual participants, i.e. the citizen scientists themselves.

The development towards the inclusion and recognition of the value of the brain- and innovation power of the general public cannot only be witnessed within the academic context, but also within the public sector, and, last but not least, within the private sector. This is not without a reason. Indeed, our research shows that public participation in knowledge generation is believed to offer a wide range of advantages. On an abstract level, and analogous to rationales for participation in general (e.g. participation in decision-making), the motivations for citizen science cited in the literature can roughly be classified as either substantive (i.e. a better final product.), instrumental (i.e. a more legitimate final product), or normative (i.e. the idea that there is intrinsic value to participation). Interestingly, and despite the fact that involvement of non-scientists is widely practised and highly successful in many domains and for many tasks, the involvement of non-scientists in the field of water management is so far rather limited, especially in the domain of drinking water. This, however, does not mean that the potential for citizen science projects in the field of water management is low by definition. In fact, our research suggests that the full potential for the involvement of citizens in the various research phases in the field of water management is not yet realised, and identifies various potential promising citizen science opportunities in the drinking water domain.

Last but not least, based on the analysis of extensive discussions that were held during specially organised focus group, our study suggests that a good many citizens seem to be open to having closer connections with their drinking water and their drinking water company, and that, for a proportion of them, citizen science-type projects could possibly be part of it. At the same time, it is evident that the effort to establish these connections faces a path full of dilemmas, challenges and open questions. Despite these challenges and uncertainties, our study made it very clear that if citizens were to participate in citizen science projects, it would also be very important for them to be informed of the results. In fact, a clear conclusion of this study is that the candidate citizen scientists all indicated that, in the case of an actual project, it would be very important that they receive information and feedback about both the collected data and what is done with the information.

Although this study has clearly shown the potential for public participation in knowledge generation in the Dutch water sector, additional, and most importantly, empirically - generated, data are needed to establish the real value and meaning of citizen science projects in the Dutch drinking water sector. The development of a pilot study has the potential to yield valuable information on the opportunities and the challenges associated with involving citizens in conducting research. Admittedly, the development of such a drinking water citizen science pilot study may be a path full of open questions and challenges. But inaction, and the ignorance of our fast changing society and evolving developments in the field of information and communication technology, may not only be a lost opportunity to work on a closer connection between water and citizens, but also be a missed change to learn about what it means when citizens start to monitor parameters within their personal environment, including their drinking water. Now, and certainly in the future.

6 References

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Attachment I

Degrees and methods of participation

Given the close and clear associations between regular or power-based participation and citizen science, this attachment elaborates on the meaning and significance of participation in a broader sense than citizen science, focusing on the more traditional forms of stakeholder participation, that is, participation in decision-making. Despite the fact that the merits of stakeholder participation, including in the domain of water governance (e.g. OECD 2015) have been increasingly recognized at EU, national, and local level (Collins & Ison 2006), and the number of participatory activities has grown significantly, the notion of stakeholder participation is still rather ambiguous. Among other things, scholars disagree on whether stakeholders are always organised groups or if individuals – in this study referred to as citizens - can or should also be regarded as stakeholders. Similar discussions are centred around the question how clear the stake of stakeholders should be, or whether these stake can also be unclear and/or change over time. In this study, we use the definition of Van de Kerkhof (2004) in which both citizens and representatives of non-governmental organizations are seen as stakeholders.

Just like citizen science, stakeholder participation in decision-making should not be considered as a binary variable that is either present or absent. Indeed, there are various forms, or degrees, of participation. A classic reference point in this discussions is the participation ladder by Arnstein (1969), as depicted in Figure 2. This ladder, which despite being published some 45 years ago is still the most prominent characterisation of the different forms of participation, identifies eight different degrees of participation. The degrees vary from low level involvement at the lowest rung, described as *manipulation*, to the slightly higher rung of *therapy*, which Arnstein defines as essentially symbolic efforts or types of "non-participation" in which the public is "educated" or "cured". The next rung, *informing*, provides stakeholders with knowledge, yet the flow of information is usually one-way. The *consulting* rung aims to involve the opinions of stakeholders, but gives no guarantee that their input will in practice also be taken into consideration. In the *placation* case, this is somewhat less of a problem, for instance through including community representatives on decision-making boards, but the project's initiators may still have exclusive decision-making power through a larger number of votes or the right to ignore given advice. At the *partnership* level, stakeholders are given a more direct influence on the content of a project: rules regarding participation are laid down and may thereafter not be changed without consensus across actors. Only the highest two levels, *delegated power* and *citizen control*, would award stakeholders real power. The differences between the different degrees of participation depend on what kind of information is given to stakeholders, what kind of options they get to voice their opinion, and most important, what kind of power they get to actually influence decision-making (Arnstein 1969).

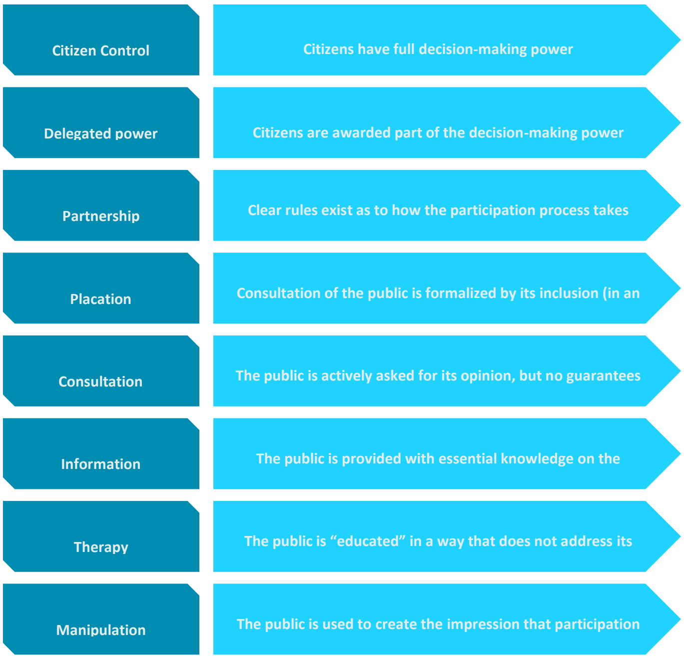

Figure 2: Ladder of Participation by Arnstein (1969)

Despite, or perhaps because of its popularity, Arnstein's (1969) ladder, as well as its revisions and extensions, has been criticized on various points. Perhaps the most important critique centres around the idea that control is always considered to be better (Collins & Ison 2006). Just as various authors argue that the answer on the question *who* to include to be context-specific, the same is said of *to what degree* to include them (Lawrence & Deagan 2001; Richards et al. 2004; Lane 2005; Tippet et al. 2007; Dietz & Stern 2008; Reed 2008; Smiley et al. 2010). In relation to this, Tritter & McCallum (2006) highlight the implicit assumption of ladder-type approaches that all citizens always want to be involved, which as discussed above, is highly questionable. Further, the ladder is seen as having an overly static view of the public, disregarding the changes that occur in people's values and therefore behaviour through experiences they undergo (Lawrence 2006). Although there is still no consensus on what factors should play a role in determining the degree of engagement (Smiley et al. 2010), the "ladder approach" to participation has been let go in some studies, making way for non-hierarchical models (e.g. the wheel of participation by Davidson 1998). Despite its shortcomings, Arnstein's ladder remains a valuable categorisation, if only to classify and interpret the numerous participation activities developed in the past few decades. To this end, Luyet et al. (2012) provide a useful simplification of Arnstein's ladder, identifying as the main rungs: *information,* which centres around the question whether stakeholders are given an explanation of the project, *consultation,* which includes listening to suggestions and critique from the public but leaving their use open to the discretion of the decision-maker(s), *collaboration,* where the results of *consultation* are taken into account in the final decision, *co-decision*, where stakeholders actively participate in the decision-making, and *empowerment*, where decision-making and implementation are delegated to stakeholders. Table 5 provides an overview of different participatory techniques, classified within the different degrees of participation.[14] Similar to what we have seen in relation to the choice of citizen participation types, there is no standardised method to select the most promising participatory technique. Luyet et al. (2012) argue that the most relevant participatory technique within a particular context depends on many factors, including the degree of involvement, the type of stakeholders, local cultural and social norms, past events, intended timing, and knowledge and experience of the project manager.

[14] For an extensive overview and elaborate descriptions of different participation methods we refer to http://participationcompass.org/article/index/method

Degree of participation	Information	Consultation	Collaboration	Co-decision	Empowerment
Newsletters, press releases	X				
Reports	X				
Presentations / public hearings	X	X	X		
Websites	X	X			
Interviews, surveys	X	X			
Field visit and interactions	X	X	X		
Idea banks		X	X		
Workshop		X	X	X	X
Participatory mapping			X	X	X
Focus group		X	X	X	X
Citizen juries		X	X	X	X
Decision support system	X	X	X	X	X
Cognitive map	X	X	X		
Role playing			X	X	X
Multi-criteria analysis			X	X	
Scenario analysis		X	X	X	X
Consensus conference		X	X	X	X
User led research				X	X
Crowdsourced data			X	X	X

Table 5: Classification of participation methods. Compiled from Davidson (1998), Davies et al. (2012) and Luyet et al.'s (2012) compilation of Rowe and Frewer (2000), Van Asselt et al. (2001), OECD (2001), Richards et al. (2004), HarmoniCOP (2005), Tippett et al. (2007), and IAP2 (2006).

Apart from Arnstein's (1969) vertical categorisation in which eight different rungs of participation are distinguished, it is interesting to consider (the development of) participation horizontally, i.e. in time. In the Netherlands, the roots of an increasingly active role of citizens lies in the 1970s (Kilic 2008). In this period, which retrospectively can be characterised as the first generation of stakeholder participation, the government, although not spontaneous, and certainly not always wholeheartedly, for the first time seriously started to consult with stakeholders. In the course of time, the possibilities and right to participate developed steadily in many different domains of society. From the 1990s, a new form of participation came into practise, with a strong emphasis on co-production. This so-called second generation participation, where stakeholders are enabled to co-shape policy in an early stage, originated from the idea that in this manner better and more widely supported policy could be produced (Kilic 2008). At present, this type of participation the most common form, despite the rise of the so-called third generation of participation in the 2000s. In this new form of participation, the government has more of a facilitating role, i.e. is only in focus when stakeholders need her. Central are the initiatives of stakeholders themselves, in other words, the starting point is no longer the logic of the government but the initiative of stakeholders. Provided that it is interpreted as a form of participation based on the initiative of stakeholders, the highest rung of Arnstein's (1969) ladder of participation could be interpreted as this third generation stakeholder participation.

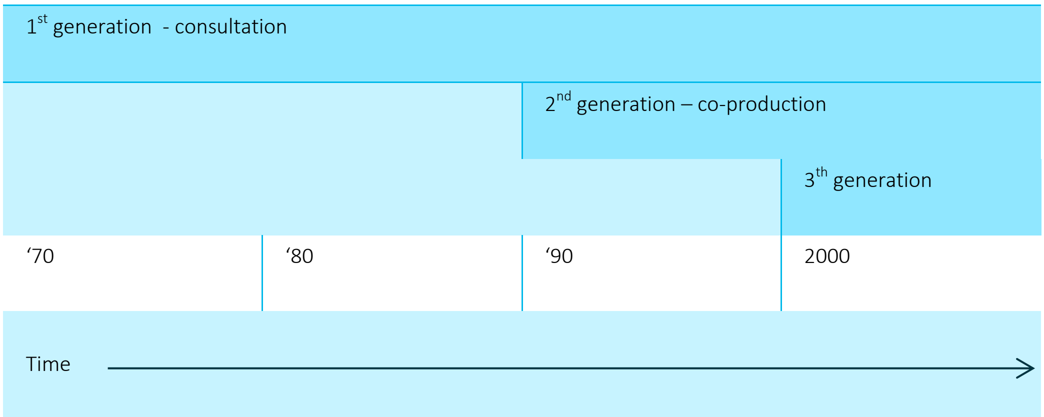

Figure 3: The transformation of participation in time

Just like citizen science, participation in decision-making is promoted for substantive, instrumental, and normative reasons. In the substantive area, it is argued that participation improves the outcome of a project, for instance by including contextual knowledge (Habron 2003; Irvin & Stansbury 2004). More instrumentally, authors argue that participation increases trust in decisions, making them more acceptable (Beierle 2002; Junker et al. 2007; Reed 2008), which in turn promotes ownership of the decision, making the implementation easier (Koninksy & Beierle 2001; Irvin & Stansbury 2004; Renn et al. 2011). As mentioned in the main text, a normative approach to participation considers it to have intrinsic value (O'Faircheallaigh 2010), allowing those who will be affected by a decision to have a say (Glucker et al. 2013). Part of this is also the idea that it may emancipate groups who are otherwise not heard (Glucker 2013), although doubts exists whether these groups are able to enter the debate (O'Faircheallaigh 2010). Finally, Wesselink et al. (2011) identify a fourth reason with regard to the actual practice of participation, what they call a "legalistic" approach. Here, participation is practised because of legal obligations. Important criticism on participation focuses on the costs (Lawrence & Deagen 2001; Mostert 2003) and time involved in the process (Vroom 2000; Luyet 2005). Other authors highlight the risk that is posed by the involvement of non-representative stakeholders (Smith Korfmacher 2001; Junker et al. 2007; Reed 2008), or the further empowerment of stakeholders that already have a prominent voice, also referred to as the participation paradox (Buttoud & Yunusova 2002).

Attachment II

Practical considerations in setting up citizen science projects

This attachment presents the main considerations for scientists and practitioners when designing a citizen science project. It is not intended to be an exhaustive guide that can ensure a successful project, but rather a number of guiding thoughts to keep in mind. Figure 4 shows a broad overview of the project design process, which is set-up as a cycle to highlight the value of the definition, the design, and the evaluation stage. Table 6 shows key tips and (control/evaluation) questions to ask for each of the three main stages, which should be of interest to both academics and practitioners aiming to set up citizen science projects.

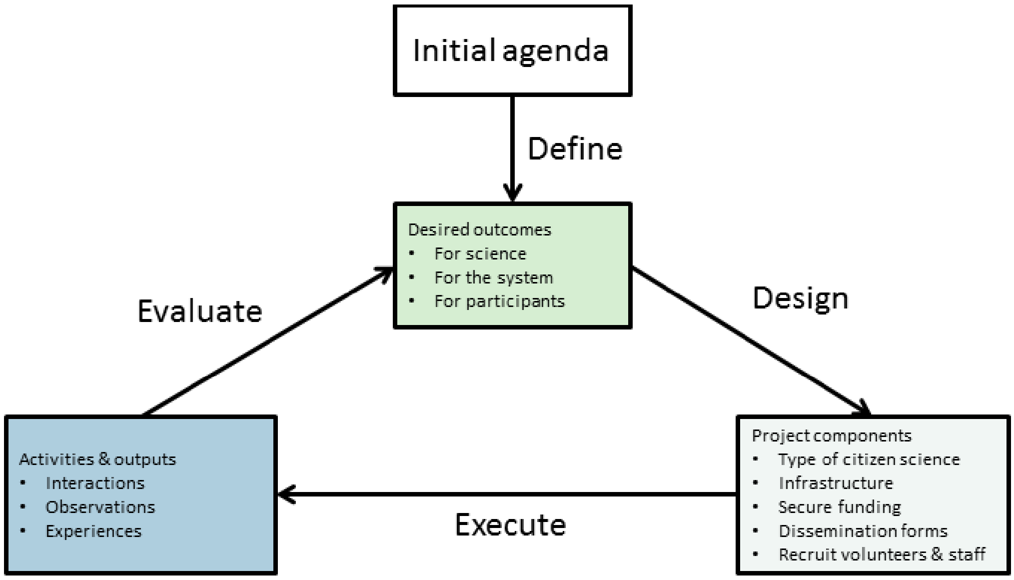

Figure 4: Design process citizen science projects

Table 6: Key tips and questions for setting up citizen science projects

Desired outcomes	Tips	Discuss the (desired) outcomes with all (potential) partners in an early stage.[1] Discuss the expected quality of data across all (potential) partners in an early stage.[1]
	Questions	What are the expected outcomes of the study? (Evaluation: are these outcomes sufficiently being met?)[2, 3] - Should the project aim to expand participants' knowledge of the system studied and/or the scientific process? Should the project aim to teach participants new skills?[1] - Should the project facilitate scientists interacting with a broader range of perspective on science and society? Should it facilitate knowledge generation on how to do citizen science projects?[1] - What research questions exist with regard to the system studied?[1] What is the most appropriate scope and scale of the study?[4] How are research results expected to influence policies or management

		practices? (Evaluation: Are research results having the expected influence? What are implications across social, economic, and environmental dimensions?)[1]
Project components	Tips	In setting up the project tools: - Avoid an overload of information: the public should be able to understand what the project is about in a few minutes[6] - Avoid detailed technical terms, but allow for a “read more” option[6] - Provide interactive tutorials and/or videos[6] - Gamification mechanisms may award individual progress[6,7] Allow for a sense of community in the project: provide volunteers with ways to interact with each other.[5,6] Identify and recruit participants (including their skills and resources).[8]
	Questions	Who should be involved?[2] Is representativeness of participants important? If so, are participants sufficiently representative? Are groups affected by the research represented?[1] When (in what stages of the research process) should the participants be involved? e.g. is it beneficial to include them in the design phase of the project?[1,2] With which tools should the project be organised?[2] How will the project be monitored and evaluated?[4]
Activities & Outputs	Tips	Understand the expertise level of the participants: start with basic contribution tasks and allow experienced volunteers to take on more advanced tasks.[6] Provide intellectual challenge and allow learning to occur on both the task, the project, and the science behind the project.[4,6] Remind participants of the value of their input, why their task is important, and how it is related to the “big picture”/project’s goals.[4,6] Provide support to participants in completing their task, make sure they can ask questions/retrieve more information/pose ideas.[1,6] Keep participants informed about their personal progress (e.g. you have contributed three photos/ have completed 3 out of 4 steps) as well as the progress of the overall project.[6] Acknowledge and discuss potential conflicts.[1] Enclose quality assurance/quality control tests to enhance trust.[9] Make the research results openly accessible[10,11]
	Questions	Are participants being intellectually challenged too much/little?[1] Can participants meet expectations of time commitment?[1] Are the participants able to use the project’s tools?[6] Is the data produced of acceptable quality?[1] Are participants and scientists engaged in discussions on values, perspectives, opinions, and attitudes (VPOA)? Do they respectfully challenge pre-existing beliefs? Do changes in these VPOA occur?[1] Is trust being built between the various partners?[1] Is trust being built in science in general?[1]

[1] Haywood & Besley 2014; [2] Ridder et al. 2005; [3] Shirk et al. 2012; [4] Haywood 2015; [5] Jennet et al. 2013; [6] Jennet & Cox 2014; [7] Bowser et al. 2013; [8] Conrad and Hilchey 2011; [9] Thornton & Leahy 2012; [10] Hessels 2015, pers. comm. 20 July; [11] Sijbrandij 2015, pers. comm. 4 August

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