SCIENTIA POTENTIA EST?
A DIVERSE CASES ANALYSIS OF THE PROCESS THROUGH WHICH CITIZEN SCIENCE COALITIONS ATTEMPT TO CHANGE DUTCH AIR QUALITY POLICY AND THE WAY IT IS MADE

by

Jurre Honkoop

MASTER'S THESIS SUBMITTED TO

Dr. Julia Wittmayer
Assistant Professor at the Erasmus School of Social and Behavioural Sciences

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR A DEGREE IN

GOVERNANCE AND MANAGEMENT IN THE PUBLIC SECTOR
MASTER OF SCIENCE

ERASMUS UNIVERSITY ROTTERDAM

August 10th, 2020

WORD COUNT: 19.996

Abstract

Citizen Science (CS) has tried to find a place in the traditionally technocratic and centralized field of Dutch air quality policy for over a decade. CS has shown to be effective in engaging citizens with and educating them on the content and procedures of policy-making by engaging them in the scientific process. Yet, the reasons for and type of political impact of specific CS-projects merit further academic attention. This thesis integrates a typology of political impact of CS-projects into the Advocacy Coalition Framework (ACF), and explores how the particular strengths of a CS-coalition and structure of a policy subsystem, relate to the type of political impact generated by a CS-coalition. To do so, 4 CS-projects in the realm of Dutch air quality policy are studied using a diverse cases design. The thesis finds that CS-coalitions come to make political impact through a process in which they establish and build particular strengths, either through gaining technical expertise, through forging ties with government authorities or other societal organizations, or through strengthening their legitimacy, and find a right mode of interaction with more or less collaborative governing coalitions. Within the technical constraints posed by the characteristics of the air quality policy field, governing coalitions decide to counter expected political impact by maintaining distance from the CS-coalition or through co-opting a CS-project or steer CS-work to benefit their own interests by working closely with a CS-coalition or by educating CS-participants from a distance. In collaborative policy subsystems CS-coalitions serve to gather public support for progressive air quality policy, come up with innovative data-based solutions for policy problems or function as a pilot and enabling actor for future forms of interactive governance. In case of lacking cooperation and political will or potential to accommodate wishes of CS-coalitions, CS-coalitions make an impact through changing the political agenda and mobilizing public pressure or through developing the scientific quality of CS-data. The thesis shows that knowledge gains value when politicized, especially in a highly centralized technocratic field such as the air quality field, where official data are not up for discussion, yet the political desirability of stricter norms and impacts of political decisions on people's health and everyday lives, should be.

“I make no apology for the central role of advocacy in this paper; I see little point in thinking about politics without it.”

-Paul Hirst (2002), Renewing Democracy through Associations

Acknowledgements

I would like to express my great appreciation to Dr. Julia Wittmayer for her valuable and constructive suggestions during the planning and writing of this thesis. Her enthusiasm in our discussions did not only improve the quality and coherence of the argument made throughout the thesis, but sparked zeal for the involvement and active engagement of citizens in the policy process, specifically through Citizen Science. Similarly, I would like to extend my gratitude to Dr. Jasper Eshuis, who oversaw the procedural side of this thesis and provided substantive input and steering wherever possible from his position as my second reader and supervisor. I also thank all those interviewed for this thesis for their openness, insights and vision on the present and future role of Citizen Science in the policy process. A last word of appreciation goes out to my friends who have been willing to listen to my sometimes-incoherent verbalizations of thoughts on the thesis before you. Just like in politics, sometimes a sounding board, that deflects information from a slightly different angle, is needed to sharpen one's own ideas.

Table of contents

List of tables and figures

1. Introduction

1.1. Citizen Science in a changing political context

State decision-making processes are increasingly (Rhodes 2012) characterized by the involvement of networks of societal stakeholders. Complex societal problems are commonly intersectoral and touch upon many interests. Different forms of knowledge and information from multiple stakeholders about the problem at hand and its solutions are involved in solving such problems. Scientific information in complex multi-stakeholder *governance* settings loses some of its "objective value" as experts are sensitive to the political context in which they function (Fisher & Gottweis, 2012), and societal actors construct their own "meaning" for evidence (Klijn & Koppenjan, 2016).

Citizen Science (CS) has emerged over the past two decades, as a way to involve citizens in the scientific process (Bonney 2007, Cohn 2008). Through this involvement, citizens contribute to the formulation of research questions, collection of data, and/or analysis of data, and gain knowledge and scientific literacy. Literature on CS has shown that CS-data can trickle down into policy (Andrews et al., 2019; Rome and Lucero, 2019; Göbel, 2019). Others argue that knowledge acquired through CS, should be actively used by citizens to construct a policy narrative with data (Ponti & Craglia, 2020) and advocate policy change (Turbé et al., 2019). It is in this active role for citizens in giving meaning to data and advocating this meaning that the fields of politics, science and political participation unite in CS.

One of the policy fields in which CS has a strong presence is the field of air quality. As a highly industrialized and urbanized nation, the Netherlands has a history of subpar air quality. In this context it has had to apply for a derogation from EU air quality norms in 2008, and lost a court case against Milieudefensie (Friends of the Earth Netherlands) in 2016 that forced the state to take more stringent measures to improve air quality. More recently, in 2019, the Dutch supreme administrative court ruled against the state's nitrogen policy, inciting a process of nitrogen policy reform in which farmers and construction workers protested frequently against the measures taken to adhere to the court's ruling. Given the political sensitivity of the topic it comes as no surprise that CS in the field of air quality is often politically-motivated (Van Elshout et al. 2019).

Citizens in air quality CS-projects primarily measure local air quality using low-cost, experimental sensors. Historically air quality has been a highly centralized, technocratic policy field in the Netherlands (RIVM, 2020). More context on Dutch air quality policy and the

traditional monitoring network can be found in Appendix A. The decentralized approach of CS-projects, and more broadly speaking, the trend of interactive governance, seems to clash with the centralized approach to air quality monitoring, suggesting it would be difficult for CS-projects to address societal problems through policy change. On a basic level CS-projects attempt to show their value for a specific (technocratic) policy, equipped with CS-information. On a deeper level, CS-projects attempt to open up a policy system formerly closed to the public.

Whereas it is acknowledged in the literature on CS that CS-data can be used to make political impact, it is unclear why particular CS-projects, within the decision-making structure of a particular policy system, manage to generate political impact, while other projects fail to make such an impact. This thesis will therefore draw on the literature on CS and the literature on the Advocacy Coalition Framework (ACF), to explore and analyse the process through which a CS-project formulates political goals, advocates these goals, and eventually makes, or fails to make a particular type of impact. In doing so this thesis answers the following question:

"*How do the structure of a policy subsystem and particular strengths of a Citizen Science coalition influence the type of political impact of a Citizen Science coalition, in the context of Dutch air quality policy?".*

The thesis develops a framework to understand political impact of CS-projects by integrating a typology of political impact of CS-projects into the ACF. By analysing a diverse set of CS-projects in the field of air quality the thesis shows that CS-coalition strengths are dynamic and to some extent manageable. It further shows that governing coalitions are constrained by social and technical policy system characteristics and the collaborativeness of a policy subsystem, and influenced by CS-coalition strengths in deciding on a mode of interaction with the CS-coalition. The mode of interaction influences coalition strengths and restricts and shapes opportunities for political impact.

The thesis has a variety of societal and academic uses. To citizens active in the field of air quality it provides insight into how (self-gathered) data and knowledge can be used effectively to propagate the desirability of air quality improvements. To politicians, the thesis shows how CS can be used as a tool for mobilizing public support for necessary policy change, or to enhance public understanding of complex policy processes, enabling forms of interactive governance. Academically, the thesis adds to the literature on the Advocacy Coalition Framework (Koebele et al. (2019); Sabatier & Weible (2005); Lundin & Öberg (2013)) by integrating a typology of political impact of CS-projects into the framework, rendering it

suitable for analysis of processes in which CS-coalitions attempt to make political impact. It further adds to the literature on political impact of CS (Turbé et al. (2019); Kieslinger et al. (2019); Göbel et al. (2019); Roger et al. (2019)) by further developing said typology of political impact and by highlighting the sequential nature of various types of impact in the policy process as well as the central role of citizens in "selling" CS-data to make political impact.

1.2. Roadmap

Section 2.1 assesses the state of literature on CS, particularly the literature on the CS/policy-nexus, to find potential political impacts of CS-projects and factors that enhance and hamper political impact. Section 2.2. reviews the literature on the Advocacy Coalition Framework (ACF) as a framework to analyse the process through which CS-projects aim to change policy and analyses the theoretical implications of the ACF for CS-projects. Chapter 3 conceptualizes political impact, the policy process, coalition strengths and the collaborativeness of policy subsystems and formulates working propositions on the way coalition strengths and collaborativeness of a policy subsystem influence political impact of a CS-project. Chapter 4 introduces the methodology of the thesis. Chapter 5 describes the process leading to political impact for four Dutch CS-projects and applies the conceptual framework to these cases. Chapter 6 assesses the validity of the working propositions and reconceptualizes the core concepts for future research. Chapter 7 concludes the thesis, reflects on methodological limitations and suggests avenues for future research.

2. Theoretical Framework

2.1. Citizen Science

2.1.1 Defining Citizen Science

No academic consensus has been reached on the definition of citizen science (CS) (Eitzel et al. 2017). The emerging field of CS is placed somewhere within the wider field of public participation in scientific research (Shirk et al., 2012), which covers any type of involvement of citizens in the scientific process. The Oxford Dictionary Scientific gives a rather sec definition of CS as "*work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions*." This definition however fails to enlighten the aim or added value of CS as well as the exact tasks of citizens in a CS-configuration.

Bonney et al.'s (2009) definition serves as a good starting point for fleshing out these aspects of CS. They define CS as "*a research technique that enlists the public in gathering scientific information*" (Bonney et al., 2009, p. 977). This definition sees CS as a tool at the

disposal of researchers. By incorporating citizens in traditional science, scientific research could amass greater quantities of data, than could have been gathered with scientists solely. The role of citizens in this definition is rather limited.

Other definitions stress the democratizing effect of CS on traditional science (Irwin, 2002). Irwin (1995) regards CS as "*a developing concept of scientific citizenship which foregrounds the necessity of opening up science and science policy processes to the public*" (Irwin, 1995, p. 36). CS in this perspective is a response to scientific elitism and serves to engage citizens in scientific practice. CS has a transformative effect on citizens.

A last stream of definitions addresses the value of CS in enabling citizens to generate knowledge (Nielsen, 2011). Wiggins & Crowston (2011) define CS as a "*form of research collaboration involving members of the public in scientific research projects to address real-world problems*" (Wiggins & Crowston, 2011, p.1). Through CS citizens can address (local) societal issues. Local knowledge about real world issues is combined with academic practice to create action-driven knowledge.

Contrary to the limited role of citizen participants in CS-projects in the first stream of definitions, the role of citizens in the latter two streams is potentially broader. Rather than merely contributing to data gathering, citizens could for example help analyse data, help in the design of the project, or act as advocates for results (Groom. et al., 2019).

Definitions are thus broadly classified by the added value of CS as compared to traditional science, and the type and magnitude of the role of citizens on the other. In Appendix B, a summary of the definitions of CS can be found with the corresponding goals of CS-projects (Wiggins & Crowston, 2011) and the respective roles citizens have under these definitions. For the purpose of this thesis we look at projects that explicitly try to address some real-world problem by generating knowledge to induce change. Citizens contribute to this, not only by providing manpower, but also through intrinsic engagement and local knowledge. We thus define CS as "*form of research collaboration involving members of the public in scientific research projects to address real-world problems*" (Wiggins & Crowston, 2011, p. 1).

2.1.2. Citizen Science and politics

Citizens in our definition of CS provide their local knowledge and translate their own values into research projects that have potential impact on the real world. Sometimes political change might prove necessary to address a real-world problem. The CS/politics-nexus has not been in the limelight of the emerging field of CS-scholarship and the role of CS in decision-making

processes is still poorly understood (Conrad and Hilchey 2011; Newman et al. 2017; Roy et al. 2012). In the following we give a broad overview of the literature on the CS/politics-nexus, focussing on the barriers to political impact and strategies to break down such barriers. For this purpose, we define political impact as the ability of a CS-coalition to influence a specific policy or the way policies are made.

2.1.2.1. Barriers to political impact

Much of the literature has focused on barriers to inclusion of CS-derived knowledge in politics. Among others such barriers include a disconnect between the civic, scientific and political communities and a lack of face-to-face interaction between these communities (Hecker et al., 2019). Further barriers are the lack of recognition of the value of CS by policy communities, partly induced by a lack of monitoring of data quality in CS-projects or semblance of partiality (Hecker et al., 2019). Furthermore, a mismatch could exist between the scientific and policy process both in timing and type of data (Hecker et al., 2019). Data might not be gathered in formats that are easy to use for civil servants, might use different units of measurement, might not feed into a specific legislative process, and might be released after or too far before decision-making happens. Furthermore, as CS-projects focused on environmental sensing tend to use low-cost sensors, data quality/accuracy might be relatively low (Ponti & Craglia, 2020).

Roger (2019) adds issues relating to communication and branding of CS. In this he is part of another stream of literature that focuses on the perception of CS by policy makers. Nascimento (2018) argues CS is increasingly seen as a valuable source for policy making, yet is still rarely actively used in policy processes. Turbé et al (2019) find that CS-projects commonly report decision-maker resistance as a barrier to policy uptake. Göbel et al (2019) find that CS is often perceived by policy makers as merely a tool for data gathering. Lacking usage of CS-data could then be caused by lack of awareness of CS-data or misunderstanding of what a CS-project does.

In summary, barriers to political impact of CS-projects can roughly be categorized into 1) network barriers, relating to mutual understanding between citizens, scientists and policy makers and 2) scientific barriers, relating to (perception of) data quality, 3) legitimacy barriers, relating to a lack of academic credentials of a CS-project or (the perception of) a limited role for citizens and 4) procedural barriers relating to a mismatch between scientific and political processes in timing and aptness of data to a specific policy process.

2.1.2.2. Strategies for enhancing political impact

Another stream of literature on the CS/politics-interface emphasizes factors that contribute to effective uptake of CS-knowledge in the policy process. Turbé et al. (2019) review a range of European CS initiatives' reported policy-rationales, i.e. theories of (policy) change, and find that public awareness of policy problems and involvement of citizens in decision-making processes is most frequently identified as the linking pin between CS and policy. In this the added value of CS for policy making lies not necessarily in the knowledge generated, but in an external process in which citizens advocate policy change and become agents of change (Ponti & Craglia, 2020). Irwin & Michael (2003) argue that CS can play a role in bridging a divide between citizens and the political community, especially by facilitating close interactions between local governments and citizens engaged in CS-projects. Rome & Lucero (2019) stress the important role of citizens in communicating research results. Even though data might be of lower quality, they can be part of a broader "data story", integrating data and political goals, raising concerns and possibilities for a specific policy solution (Ponti & Craglia, 2020). The potential effects of CS on connections between citizens and politicians, and the potential legitimating effect of citizen support for knowledge, is reported on much less (Turbé et al., 2019).

Most of the above literature has looked at CS as a factor external to the political sphere. Göbel (2019), rightfully indicates that CS can in fact also be used as a tool by public agencies, for example in the field of monitoring environmental quality. Andrews at al. (2019) look at a public CS-project that enlists local fishers in Washington State, USA, in the (de)listing process of three species on the endangered species list. Due to the local knowledge of the fishers, suitable sampling locations could be identified and sampling could be conducted, leading to successful listing of species. Rome and Lucero (2019) find a similar case in which citizen participants were educated to be civilian measurement specialists. These measurement specialists were instrumental in creating a more effective weed management policy. The latter project highlights the added values of education and engagement, apart from the added value of including local knowledge in science.

In summary, a selection of networking, scientific, legitimacy and procedural barriers hamper political usage of CS data, decreasing the opportunity for CS-projects to make political impact. CS-projects try to overcome such barriers in various manners, including the equipment of citizens with knowledge and skills to become engaged in politics and communication of

research results, the creation of lasting relations between citizens and politicians, and the clarification and demonstration of what CS is, as to increase its legitimacy.

Research undertaken has looked at *ex ante* policy rationales - i.e. theories of policy change - of CS-projects as to understand how such projects attempt to make political impact, and has looked at *ex post* realised impact, as to analyse exactly how CS-data are reflected in new policy. It is however still poorly understood why specific projects, within a given political context decide to adopt a policy rationale and manage to translate this policy rationale into realised impact. A framework for understanding CS policy-entrepreneurship during political processes is needed to be able to further analyse this.

2.2. Advocacy coalitions

One of the more established frameworks for analysing the process through which a variety of state and non-state actors attempt to influence policy is the Advocacy Coalition Framework (ACF) (Jenkins-Smith & Sabatier, 1994). The ACF was developed as a critique on a rather simplistic phased heuristic of the policy process, in which policy is shaped by politicians in a set cycle consisting of different phases. This phased heuristic was not able to account for bottom-up change to policy and did not account for change occurring over a longer period of time than the length of one policy cycle (Jenkins-Smith & Sabatier, 1994). Over time the ACF has grown to incorporate a variety of different theories on the policy process, including Ostrom's Institutional Analysis and Development (IAD) framework (Ostrom, 1990), and more recently, theories of collaborative governance (Koebele, 2018). In the following we flesh out the basics and development of the ACF.

2.2.1. ACF-fundamentals

In its most basic form, the ACF is concerned with clashing coalitions consisting of a variety of (state and) non-state actors, trying to effectuate change in an otherwise relatively stable policy subsystem (Jenkins-Smith & Sabatier, 1994). Coalitions coalesce over a set of core beliefs. Generally a distinction is made between core values that are difficult if not impossible to change, policy core beliefs that rest on a firm belief of what type of policy instrument works, and lower level secondary (empirical) beliefs that are more prone to change, when confronted with external events or new information (Luxon, 2019; Jenkins-Smith & Sabatier, 1994.). Winning coalitions coalesce to defend the status quo, potentially accepting minor change, losing coalitions coalesce to attack the status quo. Given the stable beliefs of the winning coalition, the losing coalition generally relies on external pressure, e.g. public pressure, research, or policy events, that provide an opportunity for the losing coalition to advocate

change more effectively. Every policy subsystem in this provides a unique opportunity structure for policy change that actors can or cannot exploit to various extents because of their (lack of) resources (Weible et al., 2009) and bounded rationality (Jenkins-Smith et al. 2014). Opportunities are thus specific to an actor that seeks to influence policy.

2.2.2. Advocacy coalitions and collective action

In later literature on the ACF a coalition is conceptualized as a coalition of collective action, aside from being coalitions of shared beliefs (Schlager, 1995). Beliefs do not spark policy change over time. Instead, persistent, concerted, attempts to "sell" the belief system incite change. Coalitions in this regard share a particular belief system as well as a non-trivial degree of coordinated activity over time (Sabatier, 1988). Where the traditional conception of coalitions deemed action preferences as an exogenous variable, proscribed by the structure of a problem situation, the later conception also looks at coalition preferences as endogenous to the advocacy coalition.

2.2.3. Advocacy coalitions and collaborative governance

So far Advocacy Coalitions have been depicted as acting in relative isolation. Given coalition opportunity structures enclosed in the structure of a policy subsystem, a coalition coordinates and decides on an initial path of action. Coalitions then struggle to "fight" another coalition within a given policy subsystem, adapting to actions of their opposing coalition. With the rise of forms of interactive or collaborative governance however, there has been a growing awareness of the existence of "collaborative subsystems" (Sabatier and Weible 2007; Weible 2008). Collaborative subsystems generally consist of coalitions that hold some overlapping beliefs and share decision-making power and generally arise from previous political deadlock and a dissatisfaction with the status quo across coalitions (Sabatier and Weible, 2007). A distinction is made between adversarial and collaborative subsystems. Weible et al. (2009) note that the two are extremes on a continuum, rather than a binary.

Academic interest with the rise of this literature shifts towards factors explaining coordination between, instead of within, coalitions. Factors such as perceived trustworthiness and value of resources to be provided, the belief that belief systems are complementary and that another coalition's consent is needed to achieve one's own policy goals, are explored (Calanni et al. 2015; Weible et al. 2017). Coalitions act based on some advanced perception of their own interest that recognizes that other coalitions are useful towards forwarding their own interests. Because of this more fluid perception of one's own interest, coordination within and among coalitions varies over time, and is strategically more so than ideologically oriented. Coalitions

then tend to be fluid and cross ideological boundaries. Over the process, coalitions might find that their strategic interests are better served by altering their interaction patterns.

2.2.4. Advocacy coalitions and science

A tension seems to exist between the ACF and the usage of scientific knowledge by coalitions. The core values and beliefs that are a key unifying factor to advocacy coalitions, and scientific objectivity seem difficult to rhyme. Turnheim et al. (2020) argue that engaging with policy can negatively affect conceptual and methodological rigour or nuance of findings. Fisher and Gottweis (2012) argue along similar lines that the political context in which knowledge is used, makes knowledge neither value free nor purely technical, because experts adapt to the political context in which they function. Kerkhoff and Lebel (2006) show that scientific knowledge does not just trickle down, but needs to be actively inserted into the policy system. The ACF provides insight into how advocacy coalitions use knowledge to influence policy. Weible et al. (2009) say the ACF is particularly useful in situations where conflicting goals and scientific information are combined in a policy process.

Jenkins-Smith and Sabatier (1994) argue that knowledge can have important impacts on policy through policy learning even if it is unlikely to change core beliefs of an opposing coalition. Knowledge could change lower level, secondary, beliefs of the opposing coalition, or can change beliefs of an impartial third-party policy broker. Schlager (1995) adds to this by stressing the possibility of coalitions changing their own beliefs, based on research done within the context of that specific coalition.

A role for scientific knowledge is theorized particularly in the context of collaborative subsystems (Pierce et al., 2020). Weible and Sabatier (2009) suggest that science is less likely to be used as a weapon within a collaborative context. Cross-coalition learning, including through joint-commissioned research, can occur and policy core beliefs and secondary beliefs can converge over the duration of the collaborative process as knowledge from an "opposing coalition" is not necessarily seen as a threat. Schlager (1995) subscribes to this suggestion and proposes that policy-oriented learning is more likely to occur when processes require a high degree of consensus and when frequent interaction between parties involved in the solution of a policy problem enables deliberation on diverse information. The literature on advocacy coalitions within a collaborative context furthermore illuminates the complementarity of differing belief systems, showing that both the winning and losing coalition can see opportunities for cross-coalition cooperation. Knowledge, even if not directly in line with the winning coalition's beliefs might be requested because of other interests, such as legitimacy.

2.2.5. Advocacy coalitions and Citizen Science

CS, in the definition used for the purpose of this thesis combines public engagement, local knowledge, and scientific methods to address some societal problem. This combination could be a unique trinity within the ACF. Action-oriented research could equip advocacy coalitions with the tools to enhance policy learning within a specific policy subsystem (Schlager, 1995). This is especially so considering the mobilizing and engaging effects of CS. Lundin & Öberg (2013) argue that expertise-based policy is particularly prevalent when there is a lot of public attention for some societal problem. Schattschneider (1997) also argues that public mobilization adds to uptake of knowledge in the political process. Governing coalitions in such cases will attempt to overcome public upheaval through signaling usage of expert information (Boswell, 2008). CS-projects are ideal vehicles for generating public attention given the involvement of citizens in the scientific process.

Baekkeskov & Öberg (2017) stress the importance of public deliberation on various policy alternatives for effective decision-making. Informed discussion on policy alternatives enhances understanding of a social problem, reduces the risk of policy failure and adds democratic legitimacy to decision-making by increasing the chance of including different perspectives. This is even the case if scientific support for one option is overwhelming (Jordan et al. 2013). Informed discussions of policy options are only possible given relevant information and political engagement. The change-oriented nature of CS-coalitions' work, as well as their position opposed to a governing coalition is ideal for bringing up policy alternatives, based on scientific data, that would not be brought up by government-enlisted experts (Dunlop 2014).

CS can thus increase public attention, as well as public deliberation within a given policy subsystem. Governing coalitions can in turn use CS generated knowledge to alleviate public upheaval, enhance quality of policy, and enhance democratic legitimacy. CS in this creates its own demand for non-government expertise. CS-expertise is action-oriented and combines a local normative stance with scientific practice to suggest practically feasible policy interventions. This expertise can therefore render the policy process more practical than would be the case with "traditional expertise". Scientists, given their academic impartiality, have more difficulties taking a normative stance towards policy instruments.

3. Conceptual framework

In chapter 2 of this thesis we find that theoretically, a variety of factors internal and external to a policy coalition determine the policy rationale of a coalition, in turn shaping the coalition's external behaviour. We find that in particular the structure of the policy subsystem and

resources of a coalition shape long term coordinated advocacy work. In the following we conceptualize the core concepts of the ACF in such a way as to integrate the specific characteristics of CS-projects into the ACF and formulate working propositions to guide our empirical analysis of cases.

3.1. Conceptualization of the ACF for CS

3.1.1 Conceptualizing CS-Coalitions

Coalitions are conceptualized as groups of actors who share a particular belief system and who show a non-trivial degree of coordinated activity over time (Sabatier, 1988). CS-projects and their participants can either form a coalition on their own, or can cooperate with other societal actors. Given their problem-oriented nature, CS-coalitions and their participants try to make some societal/political impact and try to change the status quo. As governmental actors are responsible for the political status quo, they represent the winning, governing coalition in this thesis. This thesis maintains the distinction between CS-coalitions and governing coalitions, even if they choose to cooperate in a joint CS-project.

3.1.2. Conceptualizing subsystem collaborativeness

Expounding the concept of the structure of the problem situation we find especially a distinction between collaborative and adversarial subsystems. The degree of "collaborativeness" of a subsystem indicates how open a winning governing coalition is to input from the losing CS-coalition and therefore determines the "ease" with which a CS-coalition can penetrate the political system to change policy without external pressure or structural change in the policy subsystem. With this it shapes an opportunity structure for political impact.

We conceptualize the "collaborativeness" of the subsystem based on Koebele's (2018) hypotheses on advocacy coalitions in collaborative contexts. Koebele firstly hypothesizes that advocacy coalitions will be less stable over time in collaborative subsystems as actors will use open networks for their own benefit and will coalesce for other reasons than shared beliefs. He then hypothesizes that deliberation over diverse information and consensus-finding in collaborative systems are conducive to policy learning. Lastly, he hypothesizes that integration of implementing actors into the decision- making structure are likely to lead to policy change through negotiated agreement. The fluidity of coalitions, deliberative nature and consensus-orientation of a policy process, and the openness to implementing actors in the policy process are thus determinants of the collaborativeness of a subsystem. Sabatier and Weible (2005) further add the overlap of societal cleavages with the policy subsystem as a factor enhancing

collaborativeness of the subsystem. Societal "sensitivity" of a policy issue would lead to willingness of decision makers to take account of diverging voices in society.

3.1.3. Conceptualizing coalition strength

Within an opportunity structure, the extent to which a coalition can actually use opportunities to its own benefit is largely determined by the strength of the coalition. We conceptualize the strength of a coalition as the sum of its material, positional and ideational quality of its resources (Pustovitovskij & Kremer, 2011), in which the resources of CS-coalitions are its data and data-advocacy. The material quality of a CS-project's research would in this conceptualization lie in the academic value, societal use, and value of the coalition's network that can be used to "sell" data, i.e. the "objective value", of the research for science and society. The positional quality would lie in the applicability of research findings to policy for a specific location. The positional quality is thus concerned with the extent to which research matches a specific policy problem. Ideational quality is more difficult to define, but would lie in the democratic or academic legitimacy that a CS-project's research possesses, or the trustworthiness of a coalition. Ideational quality thus lies in hard to define "soft" value of CS research.

3.1.4. Conceptualizing the policy process

Based on a given opportunity structure and specific strengths, a coalition determines a course of action – policy rationale - with which it attempts to influence a policy subsystem. This process of determining and executing a policy rationale is a matter of internal coordination (Schlager, 1995) and strategic interaction between the two coalitions (Calamni et al. 2015). In other words, the governing coalition will formulate a counter-strategy to be able to maintain the status quo, after which a CS-coalition might change its course.

3.1.5. Conceptualizing political impact

In section 2.1.2. we defined political impact as the ability of a CS-coalition to influence a specific policy or the structure of a policy subsystem. Note that political in this sense is conceptualized as meaning more than direct influence over a specific policy process. Political can also refer to the functioning of a policy subsystem, without a direct link to a specific policy process.

Within this concept we differentiate between 3 dimensions, derived from the literature on CS, broadly introduced in section 2.1.3.2.. The first dimension is direct impact on the policy process, through direct impact of data on new policy, agenda setting, or monitoring or enforcement of policy (Turbé et al., 2019). The second dimension, political participation, is concerned with enhancing citizen's political interest, knowledge and own engagement in

political groups (Kieslinger et al., 2017). This is a less direct approach that makes societal impact through citizens instead of through provision of data. More active participation of citizens can either pressure policy makers to change their stance on a specific issue, or lastingly change the way they reach decisions (Klijn & Koppenjan, 2016). The third dimension is concerned with political support for CS (Göbel et al., 2019). Through proving the concept of CS, successful CS-projects help to create political impact. Lasting partnerships between governments and CS-associations or new funding for CS can emerge, changing the role of CS and citizen participation more broadly in future policy decisions. The conceptual framework outlined above is graphically depicted in figure 1.

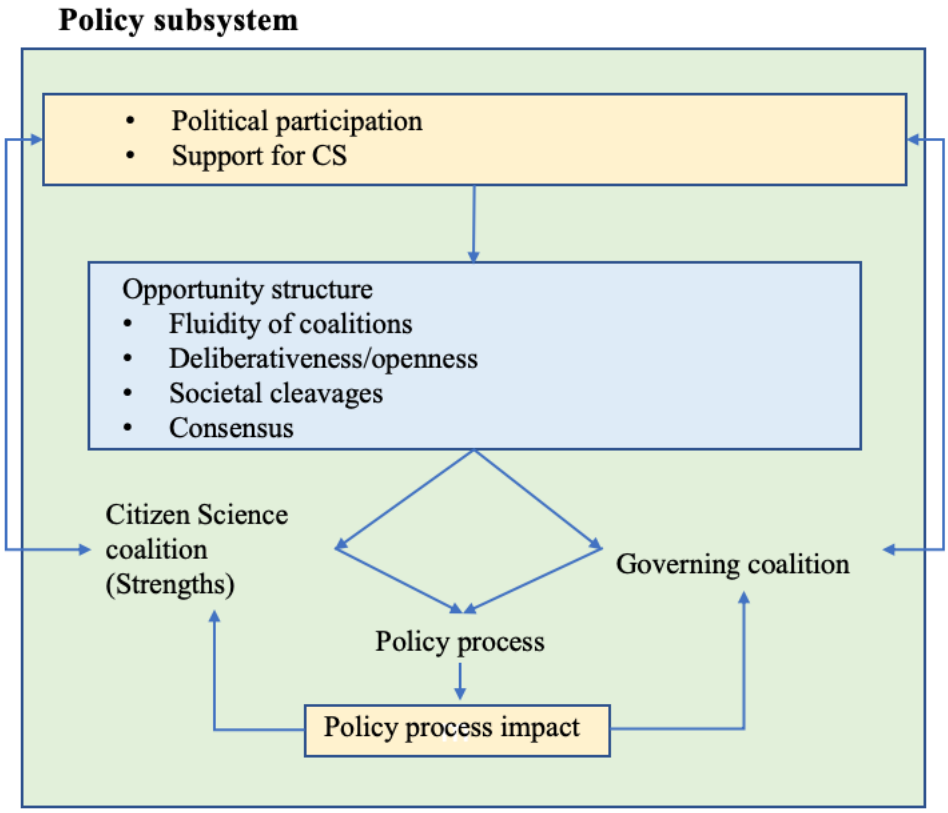

Figure 1: Conceptual Framework[1]

[1] The basic model of the ACF from Jenkins-Smith & Sabatier (1994) formed the basis of the conceptual framework.

3.2. Working propositions

To steer the data analysis in chapter 6 of this thesis, we formulate working propositions on the links between coalition strength, subsystem collaborativeness and type of political impact, based on the literature reviewed.

3.2.1. Subsystem collaborativeness

As to the link between the collaborativeness of a subsystem, and political impact, Weible and Sabatier (2009) suggest that scientific information is perceived as less politically biased in collaborative systems. Because of this, science would be more likely to lead to cross-coalition learning and convergence of beliefs in such contexts. Direct cooperation of CS-coalitions and (opposing) policy makers would thus pay off more in such contexts. Lundin & Öberg (2013) suggest for the other end of the collaborative/adversarial continuum that expertise is more likely to be used in an adversarial system when the policy problem has the public's attention. In adversarial systems we would therefore expect CS-coalitions to focus on making an impact on political participation and engagement of citizens, rather than on making a direct impact on policy makers.

Proposition 1: In collaborative policy subsystems scientific information is considered less biased. Therefore, CS-coalitions focus on making policy process impact.

Proposition 2: In adversarial policy subsystems evidence is taken up when the topic of interest is on the public agenda. Therefore, CS-coalitions focus on making impact on political participation

3.2.2. Coalition strengths

As to the relationship between the strength of a CS-coalition and type of political impact, we expect relatively strong CS-coalitions to be more crucial to consensual decision making than relatively weak coalitions (Sabatier, 1988). Relatively strong coalitions would thus have the highest incentive to participate directly in the policy process. Strong CS-coalitions would also generally be able to mobilize external pressure in the form of public pressure to budge the winning coalition's beliefs (Lundin & Öberg, 2013). We would thus expect strong coalitions to focus on making impacts on the policy process and political participation. Relatively weak coalitions would benefit from focusing on enhancing the scientific quality or legal force of their work, as this increases the likeliness of usage of data without intensive political participation or prior connections to the governing coalition (Göbel et al., 2019; Ponti & Craglia, 2020).

Proposition 3: Strong CS-coalitions are crucial to consensual decision making and have the strength to mobilize substantial external pressure. Therefore, strong coalitions focus on making policy process impact and impact on political participation.

Proposition 4: Weak CS-coalitions are not crucial to consensual decision making and do not have the force to mobilize substantial external pressure. Therefore, weak coalitions focus on affecting support for CS.

3.3. Operationalization

To be able to assess the validity of our working propositions the conceptual framework needs to be operationalized. Table 2 displays the operationalization of our variables.

Worth noting is that the variables for the concepts of coalition strength and subsystem collaborativeness are operationalized as the "perceived" extent to which the respective variable occurs within a given case. This considering the qualitative nature of this thesis.

A further point of interest is the operationalization of political impact variables as "expected" political impact. This decision allows us to analyse projects whose final impact is not yet clear, because the project is still ongoing. Only researching finished cases would force us to research rather old cases, that might not be fresh in the minds of interviewees anymore, troubling the quality of interview data. The decision to operationalize impact as expected impact further allows analysis of longer-term impacts that have materialized after the formal "closure" of a project. The full operationalization can be seen in table 1.

Concept	Variables	Indicator	Source
Coalition strength	Material strength	Perceived scientific quality and societal use of the work and value of connections with the governing coalition and other societal actors of a CS-project and its coalition partners.	Schlager (1995), Pustovitovskij & Kremer (2011)
	Positional strength	Perceived applicability of the work of a CS-project and its coalition partners to a specific policy problem.	Pustovitovskij & Kremer (2011)

	Ideational strength	Perceived legitimacy of the work of a CS-project and its coalition partners.	Pustovitovskij & Kremer (2011)
Collaborativeness of subsystem	Fluidity of coalitions	Perceived likeliness of working with different coalition partners for different policy processes within a policy subsystem.	Koebele et al. (2019); Weible & Sabatier (2009)
	Deliberativeness/openness	Perception of the extend of openness to and deliberation over various information sources in decision-making within a policy subsystem.	Koebele et al. (2019); Luxon (2019)
	Consensus	Perception of necessity of consensus between coalitions for effectively solving a policy problem within a policy subsystem.	Koebele et al. (2019)
	Societal cleavages	Perceived societal/political sensitivity of a specific policy issue.	Sabatier and Weible (2005); Lundin & Öberg (2013)
Political impact	Policy process	Expectation of directly influencing a specific policy process through changing policies, discourses or agendas.	Turbé et al. (2019)
	Political participation	Expectation of empowering and activating CS participants and the broader public to get involved in a specific policy subsystem or contribute to self-governance within this subsystem.	Kieslinger et al. (2017) Göbel et al. (2019)
	Support for CS	Expectation of contributing to the	Roger et al. (2019)

		trust in and perceived legitimacy of CS or the development of partnerships between decision makers and CS-projects, within a specific policy subsystem.

Table 1: Operationalization

4. Methods

4.1. Case selection methods

This thesis used qualitative research methods as qualitative research gives in depth contextual knowledge on mechanisms that have yet been undertheorized (Neuman, 2014). More specifically this thesis investigated a diverse set of cases using a mix of semi-structured interviews and desk research.

Case studies help to elucidate the variance of a specific causal mechanism for a population of cases (Seawright & Gerring, 2008). The comparative case study approach in this is particularly valuable to exploratory research as it can illuminate the full range of workings of a causal link for varying contexts. The thesis took a diverse cases design as outlined by Seawright & Gerring (2008). This design seeks to select a small group of cases that overall represent the full variance in the relation between the dependent and independent variable of the entire population of cases. As such it might be less representative of the full population in not weighing the representativeness of selected cases explicitly. For this thesis the diverse case design means we select cases based on their "unique" relation between coalition strength and collaborativeness of the policy subsystem on the one hand, and type of political impact on the other. In the next section we justify our case selection in the context of this research design.

4.2. Case Justification

The first case is the case of Stadslab Luchtkwaliteit Rotterdam that uses CS to support a wide range of activities aiming to improve air quality broadly. Measurements started around the heavily polluted area of the 'S-Gravendijkwal. Measurements are performed with a small number of high-quality sensors. Initially Stadslab Luchtkwaliteit was financed by the municipality of Rotterdam, which suggests the municipality is relatively collaborative. The slim organization of Stadslab and loose partnerships with partners suggest the coalition is relatively weak. The approach to political impact taken by Stadslab seems to be an interesting mix of policy process impact and impact through political participation.

A second case is the case of the 2009-2018 Milieudefensie air pollution measurement campaigns. The campaigns employed citizens in measuring NO_2 concentrations in ambient air in some of the Netherlands' most polluted streets. This approach suggests that Milieudefensie targeted problems that governments are not keen or unable to solve. Milieudefensie has relatively little staff, and because of its activist nature supposedly has relatively low academic credentials. Milieudefensie seems to have focused on making political impact through political participation.

The third case is that of Hollandse Luchten, a projected initiated by the Province of Noord-Holland and ran by Waag Society in partnership with a broad coalition of partners, public and private. The project seeks to test innovative sensors and change relations between citizens, government and companies, as to enable better cooperation in reducing air pollution (Waag, 2020). Measurement pilots within the project are executed around Tata Steel in Ijmuiden and in Amsterdam and Zaanstad. The policy subsystem seems to be adversarial of nature – Tata steel is notoriously one of the biggest polluters in the country and economic stakes are high. A fairly strong coalition and relatively adversarial subsystem are thus combined with a focus on impact on support for CS.

A fourth and last case is the Urban AirQ project in Amsterdam ran by Waag Society. The project partners with knowledge partners and governmental authorities. This broad partnership suggests that the policy subsystem is relatively collaborative (RIVM, 2020). Together the partners researched how to incentivize citizens to participate in air quality measurements, and how CS data adds value to the official monitoring network. Urban AirQ thus seems to combine a relatively strong coalition and a collaborative subsystem with an indirect support to citizen science and political participation approach to political impact. An overview of the case justification is found in table 2.

Project	Coalition strength (X)	Nature of subsystem (X)	Expected political impact (Y)
Stadslab Luchtkwaliteit Rotterdam	Weak	Collaborative	Political participation/policy process
Meetcampagnes Milieudefensie	Weak	Adversarial	Political Participation
Hollandse luchten	Strong	Adversarial	Support for CS

Urban AirQ	Strong	Collaborative	Political participation/ support to CS

Table 2: Case selection

4.3. Data collection methods

Data was collected through a combination of desk research and semi-structured interviews. Semi-structured interviews fit the exploratory nature of this study as they allow the interviewer to explore new mechanisms during an interview (Lune & Berg, 2016). An interview guide, containing the main topics of interest guided the interviews, was supplemented by case and interviewee specific questions. The interview guide used can be found in Appendix C. Data analysis of the interviews and additional documents was performed through an open coding method in ATLAS.ti, in which an initial coding scheme derived from the conceptual framework was further developed during the coding process. The final coding scheme can be found in Appendix D.

Interviews were conducted with 15 actors from a wide range of project partner organizations, and different governmental organizations involved in a case. An overview of interviews can be found in Appendix E. Interviewees were approached by email and participated in interviews of lengths ranging between 40 and 80 minutes, with an average of +/- 50 minutes. Supplementary interviews were sought after a negative response by an organization. Interviewees were sent an informed consent form (Appendix F) that outlined the conditions of their participation in the research project, to be returned by email. Within 2 weeks after the interview, interviewees were sent a *verbatim* transcript of the recorded interview. Interviewees had the chance to make changes to this transcript on request. Participants that asked to be sent any literal quotes that would be used in the thesis were sent any literal quotes for approval.

Content analysis of documents by and about the CS-projects researched complemented the semi-structured interviews. Documents added specific knowledge on the aim of a project and procedural detail, where intended interviews could not be conducted and where therefore a key actor could not be interviewed or where interviewees were not aware of the project-specific role of their organization. A list of additional documents used can be found in Appendix G.

4.4. Validity and retractability

Several methods were used to enhance the validity and replicability (in case of qualitative research rather retractability) of the project. Triangulation of data between interviewees from different perspectives speaking about the same case and triangulation between interview data and additional documents helped enhance the internal validity of the thesis. The fact that an interview guide was used to guide the interviews made interviews comparable. Interviewees were allowed to correct the transcript as to make sure they were not misunderstood. A last factor that helped internal validity of the thesis was the process of supervision with trained academic staff.

Factors enhancing the external validity of the thesis are the explication of the context of Dutch air quality policy and its impacts on the work of CS-coalitions, and substantiated and supervised process of case-selection to make sure the selection of cases fitted the diverse cases research design. Further efforts were made to make the thesis retractable. A list of interviewed organizations and the professional role of the particular interviewee is made available to the reader and case descriptions are supported by references to specific interviews so that views in the case descriptions can be linked back to organizational backgrounds of interviewees. Additional documents used for analysis and the coding scheme used to analyse interviews and documents are shared in the Appendix.

5. Results

In the following we describe the strengths of the CS-coalitions and collaborativeness of the policy subsystems in which they operate. We then describe the strategic interaction between coalitions to understand the reasons why specific types of political impact were made. For each case we conclude by applying our conceptual framework to the empirical findings.

5.1. Stadslab Luchtkwaliteit

5.1.1. Core information

Name of CS project	**Stadslab Luchtkwaliteit**
Duration of CS project	2014-ongoing
Members of CS-coalition	Stadslab Luchtkwaliteit, Coalitie Gezond Verkeer, B.O.O.G.
Involved governing coalition members	DCMR, RIVM, Municipality of Rotterdam, Province of South-Holland

Funders	Stimuleringsfonds Creatieve Industrie, Municipality of Rotterdam
CS activities	• Measurement of NO_2 and PM2.5 in Rotterdam, primarily surrounding 's-Gravendijkwal, using 2 high quality sensors.
Policy rationale	• Gathering public support for progressive air quality policy. • Feeding arguments for progressive air quality policy into the political debate. • Raising awareness of (poor) air quality.
Political impact	• Improvement of the local official air quality monitoring system. • 2 mobility/spatial planning "climate deals" under the Rotterdam climate agreement. • Air quality on the political/public agenda. • Lasting cooperation between Stadslab Luchtkwaliteit and the municipality. • Independent follow-up DCMR CS-projects.

Table 3: Stadslab Luchtkwaliteit - Core Information

Stadslab Luchtkwaliteit started out in July 2014 after an open call from the municipality of Rotterdam for measures to improve air quality on the 's-Gravendijkwal (Stadslab Luchtkwaliteit, 2020). The then councillor was tasked with improving air quality in the city under the NSL. Especially in the area around the 's-Gravendijkwal norms were exceeded. After a joint response to the open call, a few entrants organized themselves in Stadslab Luchtkwaliteit.

With the initial funding from the municipality of Rotterdam and Stimuleringsfonds Creatieve Industrie, Stadslab bought 2 high-quality sensor stations for NO_2 and PM2.5 and started air quality measurements on the 's-Gravendijkwal, which are still ongoing. Aside from this long-term monitoring project, Stadslab conducted shorter measurement projects at Charlois and Pompenburg.

Aside from activities directly focused on measurement of air quality, such as data visualization at events, or meetings in which residents discuss long-term measurement results, Stadslab organizes activities that are supported by CS. For example, a Stadslab member uses measurement data to visualize exposure to PM in the glazing of tableware. Another member planted moss around 's-Gravendijkwal and used sensors to monitor the impact of this

intervention. The Stadslab member in charge of CS activities is involved in the Rotterdam Healthy Traffic Coalition. In the following we do not assess the impact of activities organized by Stadslab Luchtkwaliteit that do not draw on or use CS data.

5.1.2. Coalition strengths

Stadslab Luchtkwaliteit combines relatively high-quality equipment and a well-developed political and societal network in its work. A Stadslab member explains that the quality of the sensors purchased with initial subsidies, together with an awareness of the limitations of the equipment, is sufficient to make sure "*they [municipality experts ed.] take us very seriously*"[2].

At inception a municipal project manager was involved in the Stadslab project from the sidelines. One Stadslab member emphasizes that *"we could come for coffee with councillor Bonte. The municipality is active, they know of us, come to our meetings, sometimes you call someone. […] lines are short."*[3]. One of the civil servants working on air quality characterizes the relations between municipality and Stadslab differently: "*we last were in contact 1.5 years ago. Contact watered down after that*"[4]. A DCMR official states that the municipality is in frequent contact with Stadslab[5].

In its work Stadslab, apart from being connected to the municipality, is connected to a wider network of Stadslab and air quality measurement projects. One Stadslab member works together with a.o. Milieudefensie's luchtwachter network, Brak, and the national network of Citylabs. Another member represents Stadslab in the Rotterdam Healthy Traffic Coalition, consisting of a handful of (environmental)interest and residents' organizations.

Stadslab's data in the first years of its existence were used to inform local advocacy. A municipal civil servant states that while Stadslab started "*we were working on measures to improve air quality, particularly around the 's-Gravendijkwal, since there was a legal violation*

[2] Interview with Member of Stadslab Luchtkwaliteit, 12.05.2020. Translated from Dutch. NL: "*Die nemen ons dan ook zeer serieus*."
[3] Interview with Member of Stadslab Luchtkwaliteit, 05.05.2020. Translated from Dutch. NL: "Bij de nieuwe wethouder Bonte konden we op de koffie komen. Andersom is de gemeente actief, ze weten van ons bestaan, komen op bijeenkomsten, soms bel je één op een iemand […] De lijntjes zijn heel kort."
[4] Interview with a civil servant working on air quality from the municipality of Rotterdam, 22.04.2020.
[5] Interview with two civil servants from DCMR working on environmental monitoring, 06.05.2020. Translated from Dutch.

of air quality norms"[6]. With upcoming spatial developments and in-city construction Stadslab data could be particularly valuable according to a Stadslab member[7].

5.1.3. Policy subsystem

With the above strengths, Stadslab primarily attempted to change local planning and traffic circulation policies as a means to improve air quality. After an initial phase Stadslab grew more independent and less targeted on 's-Gravendijkwal. In 2016 the Healthy Traffic Coalition targeted national as well as municipal policy by sending a letter to both governments (Rotterdams Milieucentrum, 2016). Plans for a more comprehensive "greening" of Rotterdam were launched in these years. The coalition for example proposed a parc surrounding the city centre and one-way traffic on a busy road, to help solve problems of air quality.

Most interviewees agree that the policy matter at hand is particularly politically sensitive and emotional of nature. Apart from general worries about health and freedoms, some people distrust government authority models. This sensitivity translates into a lack of administrative vigour. A Stadslab interviewee claims that "*Their [DCMR's ed.] own measurements show that air quality is not up to par*"[8]. However, this awareness did not directly lead to different policies.

The process of progressive policy making thus is a long one. According to a Rotterdam civil servant working on air quality, it is however a relatively open one, considering that the municipality is still relatively new at participatory policy making[9]. The current councillor for mobility openly solicited ideas to improve air quality that carried public support. DCMR states that the current councillor for air quality sees CS as part of his communications strategy[10]. Not everyone is as convinced of the openness of policy processes in the air quality domain however. An interviewee from B.O.O.G. speaks of "sham participation[11]" and suspects that civil servants are organizing their own opposition by allowing minor policy experiments before taking real decisions[12].

---

[6] Interview with a civil servant working on air quality from the municipality of Rotterdam, 22.04.2020. Translated from Dutch. NL: "*We waren bezig met een maatregelenpakket om de luchtkwaliteit te verbeteren, met name rond de 's-Gravendijkwal, daar was een wettelijke overschrijding van de norm."*

[7] Interview with Member of Stadslab Luchtkwaliteit, 12.05.2020. Translated from Dutch.

[8] Interview with Member of Stadslab Luchtkwaliteit, 12.05.2020. Translated from Dutch. NL: "*Hun eigen metingen geven aan dat ze nog niet voldoen aan de normen."*

[9] Interview with a civil servant working on air quality from the municipality of Rotterdam, 22.04.2020. Translated from Dutch.

[10] Interview with two civil servants from DCMR working on environmental monitoring, 06.05.2020. Translated from Dutch.

[11] NL: Schijnparticipatie.

[12] Interview with the president of B.O.O.G., 26.05.2020. Translated from Dutch.

When speaking about the added value of CS to this policy subsystem, civil servants as well as interviewees from Stadslab stress that measures are difficult to take, as they require public support and spatial measures in one place need to be embedded in an integral package of measures as to make sure a solution in one location does not create a problem elsewhere. Decisions such as the imposition of a low emissions zone that keeps old cars from the city centre are heavily contested. The municipality furthermore says that "*it is often better than citizens expect*"[13].

5.1.4. Generating political impact

Stadslab adopted a multi-facetted strategy to generating political impact within this opportunity structure. The first facet was an intended direct impact on the policy process. DCMR states that Stadslab wanted the councilor to take far-reaching decisions based on data. Stadslab itself explains this as "*we constantly try to feed arguments* [into the political system ed.]"[14]. This approach to impact can also be seen where Stadslab sent a concept report to the municipality about measurements at 's-Gravendijkwal in 2016, and where the Healthy Traffic Coalition sent a letter to the municipality and state government. Another road to impact from Stadslab is through the mobilization of public support for political decisions. Stadslab argues that "*You need a very large number of people on the same page* [To change policy ed.]."[15]. Stadslab then is more than "only" an advocacy organization: "*We are not a resident organization that fights for 30km/h instead of 50km/h in this street. We are more comprehensive"*[16]. This more abstract approach to political impact can be found where Stadslab visualizes data in porcelain tableware, or where Stadslab experiments with minor spatial and landscaping adjustments to show the impact of minor interventions on air quality. It can also be found in the fact that Stadslab now pleads for improvements to air quality in Rotterdam, broader than on the 's-Gravendijkwal only.

Both the municipality and DCMR responded to Stadslab's data by a two-partite strategy. Both parties were present at Stadslab meetings to explain "their side of the story". The municipality states that "*we give an explanation as to our stance and you see that people start*

[13] Interview with a civil servant working on air quality from the municipality of Rotterdam, 22.04.2020. Translated from Dutch. NL:*"het is vaak schoner dan bewoners vermoeden"*

[14] Interview with Member of Stadslab Luchtkwaliteit, 12.05.2020. Translated from Dutch. NL: *"We proberen constant argumenten te voeden."*

[15] Interview with Member of Stadslab Luchtkwaliteit, 05.05.2020. Translated from Dutch. NL *"Je hebt een hele grote groep mensen nodig die meegaat."*

[16] Interview with Member of Stadslab Luchtkwaliteit, 05.05.2020. Translated from Dutch. NL *"We zijn geen bewonersorganisatie die zich hard maakt voor 30 in plaats van 50 in de straat, maar veel overkoepelender."*

to develop an understanding"[17]. This desire of the municipality to explain itself actively also shows in a follow-up CS-project planned by the municipality, according to a civil servant involved in CS: "*We want to attract a broader audience. A fairly specific group is interested in air quality. (…) people think they can measure everything. We want to make gathering information easier. The municipality helps you steer your worries."*[18] DCMR says to mainly share technical expertise at such meetings, and refrains from actively "steering" the project. DCMR was further involved by conducting a small research project on the Stadslab "car wash" project, that was supposed to filter PM out of the air by nebulizing water over the 's-Gravendijkwal. DCMR in this is interested in facilitating Stadslab activities, but stresses that there is a resource limit to this facilitation.

The response of (local) authorities to Stadslab initiatives as well as internal changes led to a few changes in strategy over time. An interviewee from Stadslab states that "*people are a bit done with measuring*" as there was insufficient follow-up to data[19]. To maintain public engagement Stadslab now focuses more on festivalesque events, such as the planned "longen van Klaas" event, a walk-through festival focused on health. Data in such activities are used to illustrate a problem.

The lack of concrete impact from initial experimental work reflected in a loss of "*some sort of naivety. (…) It vanishes because you have more knowledge, that it [experiments ed.] is marginal and that you need to intervene at the source after all. (…) It starts to become important to influence policy and that you can think along*"[20]. The letter sent to parliament was, according to a Stadslab interviewee a response to the loss of naivety. The letter further reflects a growing cooperation between Stadslab and other environmental interest groups. B.O.O.G. for example uses Stadslab data in its contact with the municipality. Stadslab's own non-confrontational approach in this sense is complemented by informing other, more activist organizations.

[17] Interview with a civil servant working on air quality from the municipality of Rotterdam, 22.04.2020. Translated from Dutch. NL: "We geven dan een toelichting en je ziet dan dat mensen begrip krijgen."
[18] Interview with a civil servant working on citizen science from the municipality of Rotterdam, 21.04.2020. Translated from Dutch. NL: *Een redelijk specifieke groep is geinteresseerd in luchtkwaliteit. Wij willen een breder publiek aanspreken (…) Mensen denken dat je alles wel zal kunnen meten. We willen die informatievoorziening vergemakkelijken. De gemeente helpt je verder met richting geven aan je bezorgdheid.*
[19] Interview with Member of Stadslab Luchtkwaliteit, 05.05.2020. Translated from Dutch. NL. *"Mensen zijn het meten een beetje beu".*
[20] Interview with Member of Stadslab Luchtkwaliteit, 05.05.2020. Translated from Dutch. NL: *een soort naïviteit, in het begin denk je we gaan de luchtkwaliteit verbeteren door zo'n waternevel, of door mos. In het begin ben je hoopvol. Die verdwijnt, omdat je meer kennis hebt, dat het marginaal is en dat je uiteindelijk toch bij de bron moet zijn. Je komt dan wel weer bij de gemeente. Het wordt belangrijk dat je invloed hebt over beleid en dat je daarover mee na kan denken.*

A higher level of knowledge within Stadslab reflects in more invitations for direct participation in policy processes from the side of the municipality, as could be seen in Stadslab's participation in the Rotterdam Climate Agreement process.

5.1.5. Political impact

Impact of Stadslab can be found in several instances. Firstly, Stadslab was part of the Rotterdam Climate Agreement Negotiations, leading to participation in two "deals", making them executors of research on a parc surrounding the city centre and the change of a two-way street into a one-way street (RKA, 2020). Furthermore, extra municipal measuring stations were added on the 's-Gravendijkwal after discussions between the municipality and Stadslab.

Aside from this, impact can be found in engagement, awareness and informed activation of people. An interviewee from Stadslab humbly states that "*there is a discussion on the topic of air quality in the city and I guess we added to that*"[21]. DCMR adds that Stadslab liaises frequently with the municipality as they know each other from the political scene[22]. DCMR notices that Stadslab measurement participants are more critical towards government policy than are "regular citizens"[23]. An interviewee from the municipality nuances Stadslab's impact on political participation by arguing that "*the effect is temporary (…) there used to be a lot of attention. If it takes longer that fades away*."[24].

Stadslab further added to follow-up CS work by DCMR and municipality. As reported by DCMR, Stadslab was consulted for a follow-up CS-project from the side of the municipality[25]. However, as Stadslab does not market itself primarily as CS initiative, the effect on support for CS seems limited.

5.1.6. Conceptual application

Stadslab thus started out as a loose, experimental CS-coalition targeting a very specific problem. Material strength started out relatively high because of the high-quality equipment procured and grew over time as political wit, expertise and societal and political networks grew.

---

[21] Interview with Member of Stadslab Luchtkwaliteit, 05.05.2020. Translated from Dutch. NL: "*Er is wel een discussie over het onderwerp luchtkwaliteit en daar hebben we wel aan bijgedragen."*

[22] Interview with two civil servants from DCMR working on environmental monitoring, 06.05.2020. Translated from Dutch.

[23] Interview with two civil servants from DCMR working on environmental monitoring, 06.05.2020. Translated from Dutch.

[24] Interview with a civil servant working on air quality from the municipality of Rotterdam, 22.04.2020. Translated from Dutch. NL:*het effect is heel tijdelijk. (…) Er was veel aandacht. Als het langer duurt ebt zoiets ook weg."*

[25] Interview with two civil servants from DCMR working on environmental monitoring, 06.05.2020. Translated from Dutch.

Further involvement of government authorities in the process of measurement however could have enhanced material strength. Ideational strength grew together with material strength as expertise and constructiveness in debate were recognized. Positional strength initially was high, because of the strong focus on ‘s-Gravendijkwal, yet declined as Stadslab started to focus on Rotterdam-wide issues of air quality, making the specific measurements less applicable to advocacy work.

The policy subsystem in which Stadslab operated was relatively collaborative. The municipality regularly spoke to various societal partners, and researches policy solutions coined by societal coalitions. The subsystem is close to people’s hearts and political decision are generally made on the basis of (implicit) societal consensus. Spatial experiments are used to test public support for progressive policy.

The opportunity structure proscribed a role for Stadslab in finding public support for progressive policies and in pointing DCMR at flaws in their models. Indeed, Stadslab partially focused on raising awareness of air quality in Rotterdam. Stadslab’s pursuit of policy influence, either through autonomous policy process participation, or through cooperation with other coalition partners is not so much connected to the opportunity structure.

Stadslab’s realised political impact lies mainly in the realm of political participation. Data from the semi-professional equipment are used as input for discussions with the municipality and societal stakeholders are actively equipped with this knowledge. Through activities that visualize pollution, citizens, inside and outside of Rotterdam, are further engaged with air quality. The policy process impact consists of the two climate agreement “deals” and the positioning of air quality on the Rotterdam political agenda. The fact that authorities are positive towards the idea of citizens “educated” by CS participating in the political process can also be deemed a direct impact on the policy process, be it procedural rather than on content. Effect on the support for CS is low.

5.2. Milieudefensie

5.2.1. Core information

Name of CS project	**Measurement campaigns Milieudefensie**
Duration of CS project	2009-2018
Members of CS-coalition	Local Milieudefensie branches, Milieucentra and interest organizations

Involved governing coalition members	RIVM, DCMR, GGD Amsterdam
Funders	Milieudefensie, participants, Municipality of Amsterdam
CS activities	• Measurement of NO_2 in areas of assumed poor air quality using Palmes tubes.
Policy rationale	• Engagement of participants. • Political participation of participants. • Setting and maintaining air quality/public health on the political agenda.
Political impact	• Parliamentary motions filed on air quality models and data scrutiny. • Air quality featured in party manifestos for the 2018 municipal elections and consequent coalition agreements. • Several small local branches participating politically to attain local air quality goals.

Table 4: Measurement Campaigns Milieudefensie - Core Information

The measuring campaigns of Milieudefensie started in 2009 with the project "Zelf meten is zeker weten", in which Milieudefensie measured NO_2 in 700 locations across the Netherlands, in cooperation with Milieucentrum Amsterdam. This was followed by the project "Hoe gezond is onze lucht" from 2012-2014, that measured NO_2 in 101 locations with 60 "measuring groups". In 2015, the project "Wat adem jij in" was conducted in which NO_2 concentrations in ambient air were measured in 58 locations. The final report of this last project served as a start for a crowdfunding campaign that funded a court case against the state, to force the state to comply to European air quality standards. Eventually Milieudefensie won this court case. In 2018 the "Luchtwachters"[26] project closed the list of projects, with the intention of monitoring the progress of the Dutch government in executing the court case verdict and commitments of the Dutch government under the "Schone Lucht Akkoord". After the termination of the project due to a shift of focus of Milieudefensie towards climate issues, some of the local groups of "luchtwachters" continued their work with minimal support of the Milieudefensie headoffice. As the above mentioned court case did not draw on CS data, we exclude the court case from the analysis below.

[26] En: guardians of the air

5.2.2. Coalition Strengths

Milieudefensie measured NO_2 levels using Palmes tubes, and with this was one of the pioneers in participatory measurements in the Netherlands (GR1P, 2020e). According to the interviewed government authorities it is difficult to derive specific policy conclusions from Palmes Tube measurements because of their monthly, instead of more frequent, data points. RIVM indicates to have advised Milieudefensie to use Palmes tubes. An interviewee from the Delft Luchtwachters project indicates to have used (experimental) electronic sensors instead of Palmes tubes for measurements, to be able to generate more real-time, long-term data and personal ownership over data[27]. This particular local project also measured PM2.5 instead of NO_2, because of the local problem of woodburning.

Equipment was funded partially by Milieudefensie itself, partially by the participants. Donations helped Milieudefensie fund its share (Knol, 2016). The first campaign was partially funded by the municipality of Amsterdam (Poel & Stumpe, 2009).

Tubes were hung on "representative locations" within areas of concern on advice of local authorities. Participants chose themselves what these areas of concern were in cooperation with Milieudefensie. Data were analysed by a laboratory (Buro Blauw) that also cooperates with RIVM and GGD. RIVM hereafter analysed the congruence between Milieudefensie tubes and other "official" tubes.

Another strength of Milieudefensie's campaigns were the relatively strong connections between Milieudefensie and (local) politicians and interest groups. Milieudefensie's leader during the third campaign had previously worked at RIVM. Also, the local branches interviewed indicate to be well connected to local politicians and other environmental action groups. Participants were largely already aware of and concerned with air quality before starting measurements (Van Elshout et al. 2019).

Ivo Stumpe, the campaign leader for the second and third campaign argues that the "brand" of these campaigns was especially powerful, as it highlighted the health-aspect of air quality (GR1P, 2020e). Regarding the fourth campaign, a member of the Rotterdam Milieudefensie branche mentions that the term "luchtwachter" was particularly powerful in opening political doors[28].

[27] Interview with member of Luchtwachters Delft, 17.05.2020. Translated from Dutch.
[28] Interview with member of Milieudefensie Rotterdam, 13.05.2020. Translated from Dutch.

5.2.3. Policy subsystem

Milieudefensie took a multi-level approach in engaging both with local and national policies. Locally, Milieudefensie branches engage mostly with traffic policy. Nationally, Milieudefensie pled for following the higher WHO norms for air quality instead of the EU norms and for better environmental monitoring.

Most interviewees, both from Milieudefensie and governmental organizations, indicate that the air quality policy system is politically sensitive. Not only do people distrust governmental models and measurements, health implications of CS-data invoke strong personal feelings. One of the Milieudefensie interviewees argues the national campaign was less societally sensitive, as the topic matter felt further from home[29].

Interviewees from the municipalities, RIVM and DCMR attested to being willing to taking a facilitating role in CS-projects. Most interviewees from these institutions however also emphasized that management of expectations was important, in the sense that CS data cannot be used to "force" a municipality/province to do anything as it is not officially accredited or of subpar quality.

An interviewee from Luchtwachters Delft points at difficulties in getting meetings with office holders and civil servants[30]. Another interviewee from Milieudefensie Rotterdam did not experience these same difficulties and states that they "*are invited by the municipality for all sorts of things*"[31].

The extent to which radical policy change is possible is disputed. Spatial choices in one place have implications elsewhere. Coalition government dynamics add another aspect to this complexity. The interviewee from Milieudefensie Rotterdam argues it is only this latter aspect of coalition dynamic that hampers "effective" decision-making: "*It is not complex; it is a matter of making decisions."*[32].

Added value for CS within this system lies mainly in the further development of sensors and creation of public support in order to capacitate a befriended politician to pass progressive policies. Additional sensors are mainly "useful" in cities where the official measurement

[29] Interview with member of Milieudefensie Rotterdam, 13.05.2020. Translated from Dutch.
[30] Interview with member of Luchtwachters Delft, 17.05.2020. Translated from Dutch.
[31] Interview with member of Milieudefensie Rotterdam, 13.05.2020. Translated from Dutch. NL: *"we worden ook steeds uitgenodigd voor dingen."*
[32] Interview with member of Milieudefensie Rotterdam, 13.05.2020. Translated from Dutch. NL: *"het is niet complex. Het is een kwestie van keuzes maken."*

network is not as highly developed, according to an interviewee from the municipality of Amsterdam[33]. Luchtwachters Delft points at difficulties in the fact that sources of air pollution cross municipal borders, necessitating political cooperation across political boundaries and the fact that measurement data are not "official"[34]. Policy change, according to an interviewee from Milieudefensie Rotterdam, is more difficult in cities that have historically been designed for cars[35].

5.2.4. Generating political impact

Millieudefensie started its first campaign with the goal of "*actively engaging people with their environment and making air pollution visible to people*" (Milieudefensie, 2009). The project explicitly did not aim to measure in a "better way" than official institutes. The title of the campaign "zelf meten is zeker weten", however, seemed to question the validity of official measurements. Milieudefensie hoped that "*people, also after the campaign has ended, will enter into discussion with their municipality*." (Milieudefensie, 2009). According to the Milieudefensie interviewees the strength of the CS approach lies in the combination of "*concrete actions on the one hand, coupled to engaging people, and making publicity, and a group of people that goes in depth for the longer term"*[36]. The project as such is not about proving to be right, but about "*proving that this type of club can keep this point on the political agenda[37]*".

Milieudefensie thus tried to interfere directly in the policy process by setting the political agenda. RIVM indicates that contact with Milieudefensie was maintained, partially for the fact that Milieudefensie is an "activist" organization[38]. By keeping tabs, RIVM would know of output and of possible conclusions from this output. Policy makers strayed away from responding directly to measurement results. In Delft, the municipality did not respond to a policy report following from the Luchtwachters campaign. In Rotterdam, Milieudefensie also claims that there was a lack of political follow-up to data[39]. On the political level Rotterdam

[33] Interview with a civil servant of the municipality of Amsterdam working on air quality, 29.04.2020. Translated from Dutch.
[34] Interview with member of Luchtwachters Delft, 17.05.2020. Translated from Dutch.
[35] Interview with member of Milieudefensie Rotterdam, 13.05.2020. Translated from Dutch
[36] Interview with member of Milieudefensie Rotterdam, 13.05.2020. Translated from Dutch. NL: *"concrete acties aan de ene kant, gekoppeld aan meer mensen betrekken en publiciteit maken, en een groep mensen die echt de diepte ingaat voor de langere termijn".*
[37] Interview with member of Milieudefensie Rotterdam, 13.05.2020. Translated from Dutch. NL: *"om te laten zien dat dit soort clubs het punt op de agenda kunnen houden"*.
[38] Interview with civil servant from the RIVM "samen meten" team, 08.05.2020. Translated from Dutch.
[39] Interview with member of Milieudefensie Rotterdam, 13.05.2020. Translated from Dutch.

seems to have been more open for Milieudefensie's ideas. B.O.O.G. reports that then elderman Arno Bonte asked B.O.O.G. to participate in the 2015 campaign[40].

Over time Milieudefensie has changed its strategy because of a lack of political impact, partially caused by the above governing coalition-strategy. After the first campaign Milieudefensie changed focus towards health aspects of air quality and decided that measurements should be conducted by local residents' and interest groups, rather than by individual citizens. This to increase the public and, consequently, political impact of the campaign. After the court case against the state was won, the campaign goal shifted towards overseeing the government, rather than "lobbying". When Milieudefensie stopped the national Luchtwachter campaign, the local branch in Rotterdam collapsed and turned to supporting autonomous CS-initiatives, such as at the Rotterdam cruise terminal. In Delft, after initial lack of political-uptake of data, and initial negative feedback on data quality, the branch decided to focus on developing a better sensor for PM2.5, while pausing the roll-out of sensors.

5.2.5. Political impact

There seem to be various perceptions of the direct impact of the measurement campaigns. In Rotterdam it has taken a long time to make concrete policy changes. Milieudefensie claims that policy change – one-way traffic on the Binnenweg and a reduction of the number of lanes in the Maastunnel – is upcoming, partially because of the efforts of Milieudefensie Rotterdam and its partners. On the other hand, it was a lack of policy consequences to the campaigns that demotivated Luchtwachters in the same town. Luchtwachters Delft is more sceptical of policy change because of CS. The final measurement reports report largely agenda-setting impacts: During the municipal elections of 2014 most parties spoke up about air quality and air quality was featured in various coalition agreements. A representative from B.O.O.G. Rotterdam argues that Milieudefensie's 2015 campaign "*has been very important to us in shifting the discussion towards a new argument: public health*"[41]. On the national level several Parliamentary motions were filed with the aim of improving air quality models and data scrutiny.

During the campaigns a large group of people was mobilized for Milieudefensie's cause. There still is a small active network of Luchtwachters, indicating this network is relatively self-

[40] Interview with the president of B.O.O.G., 26.05.2020. Translated from Dutch.
[41] Interview with the president of B.O.O.G., 26.05.2020. Translated from Dutch. NL: *"dat is echt heel erg belangrijk geweest voor ons om de discussie te verschuiven naar een nieuw argument, volksgezondheid."*

sufficient. However, in several locations the Luchtwachters network stopped after Milieudefensie shifted resources to broader climate issues. There is however evidence of new groups finding their way to Milieudefensie to start measurements themselves. Local Milieudefensie branches provide these new groups with advice. Luchtwachters, particularly in Rotterdam, are still invited to municipal events, even after the Rotterdam network itself has largely collapsed.

The Milieudefensie campaigns did not focus on improving CS-data, or enhancing support for CS. Palmes tubes were not developed further and are already accepted by authorities as semi-valid measurement tools. In Zuid-Holland and Delft government-initiated CS-projects were started. However, it is unclear whether these projects were a response to the Milieudefensie campaigns.

5.2.6. Conceptual application

Milieudefensie's material strength was relatively small due to its small paid staff and decision to use Palmes Tubes. The decision to work together with local environmental- and residents' organizations increased the material strength. Positional strength was high because of the decision to target some of the known-to be most polluted areas in the Netherlands and joint decision making of citizens, authorities and Milieudefensie on measurement locations. Milieudefensie, as an activist organization, is regarded with suspicion when it concerns scientific projects. Its scientific legitimacy (ideational strength) as such is not particularly high, where its public legitimacy as a well-known NGO (ideational strength) is higher. The fact that Milieudefensie collaborated with Buro Blauw however enhances its material as well as ideational strength. The strength of the brands "Luchtwachters" and "Wat adem jij in?" also raised the ideational strength.

The subsystems in which Milieudefensie operated, especially during the earlier campaigns, were not very collaborative. Even though government authorities were willing to advise Milieudefensie on several occasions, they shied away from "true" cooperation. Even though governments grew, and had to grow, more accustomed to the idea of citizen participation in environmental monitoring over the years, decision making stayed fairly technocratic. Societal cleavages on the national level were low, yet were higher on the local level.

The subsystems then left opportunities for development of a better monitoring network as well as the gathering of public support for progressive policy. Milieudefensie decided to

focus on this second opportunity, but only partially. Instead of seeking broad public support across municipal boundaries, Milieudefensie focused on pushing its agenda through direct political participation of local members and events to attract media attention.

The political impact realised by Milieudefensie holds the middle between direct policy process impact and political participation. Policy process impact consists of impact on the political agenda in municipalities and the tabling of parliamentary motions. Actual change in policy in municipalities was low. The CS-coalition made no retraceable impact on support for CS. Luchtwachters Delft started experimenting with PM-sensors during and after the last campaign, yet as this was not encouraged by Milieudefensie it seems unreasonable to list these experiments as an impact of Milieudefensie's campaigns.

5.3. Hollandse luchten

5.3.1. Core information

Name of CS project	**Hollandse luchten**
Duration of CS project	2018-ongoing
Members of CS-coalition	Waag Society, Smart City Haarlem, Stadslab Buiksloterham Circulair, Studio O, Stofmelder, Brak! Ijmuiden
Involved governing coalition members	Province of North-Holland, RIVM, TNO, ECN, Municipalities of Zaanstad, Haarlemmermeer and Haarlem, Port of Amsterdam, Omgevingsdienst Ijmond and Noordzeekanaal, Tata Steel
Funders	Province of North-Holland
CS activities	• Measurement of NO_2, PM2.5, PM10 and O_3 surrounding areas of particular concern and areas of spatial development, using self-developed HoLu2 sensors.
Goals	• Supporting participant activism with data and knowledge. • Gathering scientific data to allow scientific analysis of local problems. • Bridging a gap between authorities and society.
Political impact	• Development of more accurate sensor equipment. • More effective political participation of participants.

	• New scientific analyses that can be used by politicians. • Willingness of the governing coalition to pledge extra resources to the project.

Table 5: Hollandse Luchten - Core Information

The Hollandse Luchten project was initiated by the province of Noord-Holland in 2019 with the goal of "*gaining insight into air quality and setting up a measuring network that is as broad as possible. (…) In this manner the province lays the groundworks for a conversation about causes of pollution and possible solutions*." (Noord-Holland, 2020). Waag Society coordinates the project together with RIVM and TNO. Further partners to the project include private companies, interest/residents' organizations, and municipalities. The project consists of 3 measurement "pilots", of which the pilot in Ijmuiden is the most prominent. Measurement strategies and research questions for data analysis are formulated together with citizens. Initially the project was projected to last for a year, but extension is likely at the time of writing.

5.3.2. Coalition strengths

Sensors were developed specifically for the purpose of Hollandse Luchten. Both the official authorities TNO, RIVM and GGD, and Waag society, that has a long history of developing CS sensors, were involved in this development. Sensors, because of this expertise are of high quality relative to their price. The project emphasizes that sensors and the LoRa network that connects them are not perfect yet even though development is done by experts. Smart City Haarlem is a partner that focusses on innovative data analysis. Smart city in this does not have to follow governmental protocols for data analysis and thus adds to data analyses made by the official authorities.

The core team that makes the day-to-day decisions for the project consists of representatives of GGD, RIVM, Waag, the province of North-Holland and Smart City Haarlem. Partners to this core team were invited partially based on their central position to the content matter, and in the case of Smart City Haarlem, based on their personal connections with the province and position "closer to the citizen". The rest of the partners was selected based on the basis of public legitimacy, prior contact between partner and province, and quality of a participation proposal. Partners in general are well connected to their respective local governments. Contacts between partners and the core team are relatively scarce.

Pilots, especially in the case of Ijmuiden, respond to a local wish for more knowledge on air quality and more insight into models and measurements of official institutions. Ijmuiden

is close to Tata Steel, one of the top pollutant industrial complexes in the Netherlands, and a canal with heavy shipping. In Amsterdam and Zaandam spatial planning developments are taking place, making it desirable to monitor air quality developments during these spatial changes. Pilots thus have the potential to feed into specific policy processes.

5.3.3. Policy subsystem

The policy subsystem of interest differs per pilot and is a mix of local industrial and spatial planning policies. Whereas the province is the licensing authority for large industries, such as Tata steel, municipalities are responsible for policy concerning smaller industries and spatial planning. Just like in the two former cases GGD and RIVM are responsible for the official measurements and models of air quality. For the project as a whole the target policy subsystem is air quality monitoring policy.

The province of North Holland highlights that the Hollandse luchten project is a response to a new spatial planning law (Omgevingswet) that requires governments to include citizens in decision-making and monitor air quality developments in areas of special concern[42]. Furthermore, the project gives substance to the obligations of governments under the intergovernmental "Schone Lucht Akkoord" that strives to achieve the WHO norms for air quality. This participatory manner of working is self-reportedly new to the province and input from experienced partners such as Waag was actively solicited[43]. Other partners were found during an innovation conference. The current ruling coalition in the province attaches value to involving citizens in decision-making on their own environment and embraces CS initiatives, such as Hollandse Luchten.

Participation, partially through CS, is thus becoming a bigger part of decision-making. Several interviewees however point at the "narrow definition" of participation used by most governments that includes citizens in measurements and informative campaigns but not in decision-making. It is pointed out that spatial planning policy is particularly complex, necessitating an integrated response to policy problems. This, according to an interviewee from Brak! Ijmuiden, particularly holds true for provincial industrial policy as multiple levels of

[42] Interview with civil servant of the province of North Holland working on air quality, 29.04.2020. Translated from Dutch.
[43] Interview with civil servant of the province of North Holland working on air quality, 29.04.2020. Translated from Dutch.

government and other stakeholders are involved[44]. This general complexity is supplemented by a general felt distrust of Tata Steel and the province as its licensing authority.

5.3.4. Generating political impact

The non-governmental project partners seek to influence these policy subsystems with CS in various ways. Brak highlights the role of CS in "*providing a framework to support that [activism ed.]*" and "*providing those [data ed.] to science, that can in turn come up with innovative solutions*"[45]. Support from citizens is necessary for radical policy measures. Stadslab Buiksloterham Circulair also hopes to be able to gain new knowledge on PM to be able to better monitor spatial developments. Waag sees a more abstract role for CS in "*Bridging the gap between authorities and society*", influencing the way policy is generally made (Parool, 2019).

The more classical institutions keep charge over the project through the core team. Citizens are not represented in this core team. Waag and the authorities together come up with deliverables and map out when each deliverable has to be delivered. Based on political pressure the core team decided to give more sensors than planned to the pilot in Ijmuiden after "graphite rains" at Tata Steel, indicating the governing coalition is politically sensitive. The core team further decided to focus working groups within the project on PM and the technical facets of measurement. As the project is still in its early stages and data exploration meetings were suspended because of COVID-19, it is difficult to assess the governing coalition's response to the first data.

From preliminary evaluations from partners we find that the project should spend more resources on community support in its next phase. This sentiment is shared across all partners interviewed. Communities should be relatively self-supporting and be able to execute easy reparations to sensors, says an interviewee from Stadslab Buiksloterham Circulair[46]. A proposal to include citizens in the core team is tabled, the final decision has not yet been taken at the time of writing.

5.3.5. Political impact

A couple of tangible effects of Hollandse Luchten have already materialized. One of such effects is the development of a more accurate sensor. Through tweaking standard sensors, "HoLu" sensors have proven to be more accurate than other sensors. Possibly this would

[44] Interview with a Brak! Ijmuiden employee, 15.05.2020. Translated from Dutch.
[45] Interview with a Brak! Ijmuiden employee, 15.05.2020. Translated from Dutch. NL: *"die beschikbaar stellen voor de wetenschap, die daar dan weer met innovatieve oplossingen kan komen."*
[46] Interview with a member of Stadslab Buiksloterham Circulair, 21.04.2020. Translated from Dutch.

enhance political support for CS as a component to official measurements or correction to models. RIVM and GGD have said to be surprised by the data quality. In Amsterdam, support for the current generation of sensors is still low.

A further effect is scientific knowledge on air quality. Both Brak and Smart City Haarlem report that new insights as to the causes of poor air quality have been gained throughout the first stage of the project. Smart City Haarlem mentions the integration of pollution and meteorological data surrounding Tata Steel as an example for this new knowledge[47].

As to the potential effect of CS on citizen engagement we find that much of the potential long-lasting effect is subject to decisions taken in the next stages of the project. The potential to engage a broader share of the population is subject to resources for community support, resources the province has said it is willing to pledge. In fact, this already seems to be a sign that the province has gained more trust in CS as an instrument. An effect on citizen engagement and quality of participation on a smaller scale can already be seen in the existing pool of participants. A citizen in Buiksloterham took newfound knowledge to develop a program that shows when sensors are online.

The engaging effect of CS also reflects on the potential of citizens to enter into dialogue with policy makers. The province already reports that a more constructive dialogue can be had with Hollandse Luchten participants than with general citizens[48]. This signals a potential impact of Hollandse Luchten on the policy process, as the province would be more likely to involve constructive citizens in policy processes.

5.3.6. Conceptual application

The strong and formal connections between Waag, government authorities, technical experts, and residents' organizations, as well as the expertise of Waag make the CS-coalition in Hollandse Luchten both materially and ideationally strong. Sensors are of as high quality as can be expected from low-cost sensors at this point in time. The fact that Tata Steel is a project partner decreases ideational strength (public legitimacy). Positionally, citizens were involved in creating a measurement strategy and particularly in the Ijmuiden pilot measurements were executed in an area of high concern.

[47] Interview with a member of Smart City Haarlem, 24.04.2020. Translated from Dutch.
[48] Interview with civil servant of the province of North Holland working on air quality, 29.04.2020. Translated from Dutch.

The project focuses on several local policy subsystems. In case of Ijmuiden the project scores high on the societal cleavages dimension. In both other pilots, spatial developments are not as controversial. The province has shown itself open to new forms of governance and to working with new partners. The municipality of Amsterdam seems less open when speaking about outside data and air quality policy input. The fact that the municipality of Amsterdam is no partner to the project illustrates its doubts towards CS.

The opportunity structure of the project leaves opportunities for improvement of CS as an academic method and method of improving the official measurement network, and for a larger role of informed citizens in future decision making, through participation trajectories early in the policy making process. The CS-coalition's policy rationale closely follows this opportunity structure.

Impact is expected on the dimensions of policy process and support CS. The project is likely to lead to a larger role for citizens in (provincial) decision making on the policy process dimension. The CS project in this sense is a pilot for general participation of citizens in policy making. The project furthermore is a pilot for a wider roll-out of a citizen measurement network. Already in the second phase, the province aims to expand the measurement network. Impact on support for CS is thus also expected. The impact of the project on political participation seems uncertain and subject to support for community building and political follow-up to data.

5.4. Urban AirQ

5.4.1. Core information

Name of CS project	**Urban AirQ**
Duration of CS project	January 2016 – October 2017
Members of CS-coalition	Waag Society, Longfonds
Involved governing coalition members	RIVM, KNMI, ECN, GGD Amsterdam
Funders	Horizon 2020, Amsterdam Institute for Advanced Metropolitan Studies (AMS)
CS activities	• Measurement of NO_2, PM2.5, PM10 in two of the most-polluted streets in Amsterdam, using self-developed sensors.
Policy Rationale	• Engaging the local communities with air quality.

	• Improving the knowledge position of local communities. • Experimenting with low-cost sensors to help develop air quality monitoring systems with a higher spatial resolution.
Political impact	• Political participation of citizens in Amsterdam spatial planning. • Further CS-projects by former participants. • Follow-up CS-projects by RIVM and the municipal ombudsman. • Usage of Urban AirQ sensors as an inspiration for further RIVM sensor development efforts.

Table 6: Urban AirQ - Core Information

The Urban AirQ project is a pilot project part of the 2015-2018 EU Horizon 2020 Making Sense Project. Through pilots in Amsterdam, Barcelona and Pristina the Making Sense Project developed a toolkit for CS-projects, giving guidelines for empowerment and engagement of communities, as well as citizen-sensing. The Urban AirQ project ran from January 2016 until October 2017, with measurements being performed from June until August, and aimed to connect experts and citizens to jointly identify and analyse problems, and to experiment with low-cost sensors. With 16 low-cost electronic sensors the participants measured NO_2 and PM10 and PM2.5. Energy research institute ECN pledged 2 expensive measurement devices to the project to complement the sensor-data.

5.4.2. Coalition Strengths

The sensory equipment used in Urban AirQ was of relatively high quality. Waag used lessons learned from previous projects on sensor development, such as from the Smart Citizen Lab. Furthermore, partners KNMI, ECN, RIVM and GGD helped in the sensor development. The 2 expensive measuring stations provided by ECN further helped improve data quality of the project.

Measurements were performed in the Weesperstraat and Valkenburgerstraat, two of the most polluted streets in Amsterdam. Measurements were performed during a short time span of 3 months, arguably making it difficult to derive policy conclusions from data.

Citizens were involved along the entire “research cycle”. Through meetings, participants were asked for input for research questions and locations for data gathering. The full research design was co-created with experts.

5.4.3. Policy subsystem

Urban AirQ as a project does not have a clear "target policy". However, the participants living in Weesperstraat and Valkenburgerstraat, partially due to the prior Milieudefensie campaign in their street, were already concerned about air quality. A particular point of concern was the circulation of taxi's through the streets. Where participants thus have clear air quality policy goals, the project as a whole mainly experiments with CS as a technique and as a tool for citizen engagement.

The municipality within this policy subsystem listens closely to advice by GGD, that also manages the local measurement network (GR1P, 2020c). Science and data as such are central to the air quality policy process. GGD states to be open to people asking questions about air quality (GR1P, 2020b). The municipal government of Amsterdam had, prior to the project, expressed the will to invest in citizen participation. An interviewee from the Amsterdam municipality however questions whether CS is the best way to expand citizen participation in policy making[49].

Several interviewees emphasize the complexity of decision-making within the policy subsystem in Amsterdam. An interviewee from RIVM says that "*you need an integrated plan for decision-making. You need to know which policy measures match certain measurement results*[50]". Another interviewee from the municipality states that "*if you look at that street, that is the only bigger connection through town. There is not a lot of room to manoeuvre in taking traffic of this street. The city will be inaccessible for cargo and all sorts of other people. It is not about policy freedom, but about a lack of possibilities*"[51]. The city also has to adhere to national and international rules and regulations. The same civil servant also suggests that air quality policy in Amsterdam has "reached maturity" making it difficult to make improvements.

Within this policy subsystem opportunities seem to lie mainly in the development of better sensory equipment for enriching the information of the official measurement network in the long run. Waag reports that "*it is known that no traditional monitoring network is able to*

[49] Interview with a civil servant of the municipality of Amsterdam working on air quality, 29.04.2020. Translated from Dutch.

[50] Interview with a civil servant from the RIVM "Samen Meten" team, 08.05.2020. Translated from Dutch. NL: "Je hebt een geïntegreerd plan nodig. Je moet van tevoren weten welke maatregelen bij bepaalde meetresultaten horen."

[51] Interview with a civil servant of the municipality of Amsterdam working on air quality, 29.04.2020. Translated from Dutch. NL: "*Als je kijkt naar die straat, dat is de enige grotere verbinding door de stad heen. Er is niet veel bewegingsruimte om daar veel verkeer af te halen. Dan wordt de stad onbereikbaar voor goederen en allerlei andere mensen. Het gaat niet over beleidsruimte, maar over gebrek aan mogelijkheden"*

capture the local variations in air quality" (Waag Society, 2017). A former participant argues that many sources of air pollution lie outside the municipality's boundaries, making it hard for municipalities to tackle air pollution (GR1P, 2020g).

5.4.4. Generating political impact

Waag aimed to influence the above policy subsystem by "*engaging the community of interest on air quality, targeting the most polluted street in Amsterdam: Valkenburgerstraat*" (Waag, 2017). "Valuable" data was seen as a core aspect to this goal. Additionally, the goal was to enhance the knowledge position of citizens as compared to the official authorities.

A policy rationale that seems more prominent in communications by other partners than Waag is the experimental value of measurement with low-cost sensors. Bas Mijling (KNMI) shares in an interview that "*they [Waag, ed.] were more interest in – I exaggerate – the interaction during public meetings and the questions and interests and worries emerging, than in a watertight measuring strategy that would really make the experiment succeed. (…) They were already pleased with demonstrating the fact that people wanted to measure*." (GR1P, 2020a). The expert partner organizations, primarily KNMI, stressed the need to safeguard data quality during the project, conceiving the project as a scientific exercise. If data quality would not be guaranteed this would have made the data unfit for purpose, demotivating participants. KNMI and GGD, during Urban AirQ project meetings, stressed that data was not official and therefore hard to directly "use". On a more practical scientific level, expert authorities helped calibrate sensors and compared sensor data to data from the more expensive measurement stations. KNMI eventually analysed the data. According to Bas Mijling (KNMI) this focus of the authorities impelled Waag to pledge more resources towards the "scientific" sides of the project (GR1P, 2020a).

5.4.5. Political impact

Urban AirQ's direct influence on the policy process stays somewhat theoretical, apart from an experiment consisting of the planting of 8 "CityTrees", walls of moss that filter air, around the Valkenburgerstraat. An employee of Waag argues citizen's opinions carried more political weight in decision-making after the project (GR1P, 2020d). She however also recalls a group of citizens trying to block a new parking lane using Urban AirQ data. Even though data were "shown to be valuable", the complaint was rejected as the data used to support the opinion were not official.

With regards to participation, Waag reports that 40 participants were involved in the core of the project, yet hundreds more attended events or joined other activities (Jansen-Dings

et al., 2017). Luchtwachters Delft claims to have used the CS toolkit, the output of the broader Making Sense project, as guidance for their own work[52]. The initiator of the "Tree-Wifi" startup, that makes air quality sensors that light up when air quality is poor, is also a former participant of Urban AirQ (GR1P, 2020g).

The biggest impact however seems to lie in Urban AirQ as proof of concept and driving force behind new CS-projects. Waag self-reports that RIVM's "samen meten" platform, a collaborative platform for CS, was a result of the Making Sense project (Making Sense, 2018). Waag also refers to a 2018 joint project between the Amsterdam Municipal Ombudsman and Waag. More generally data were deemed of good quality. RIVM confesses to "borrow" ideas from Waag sensors as they were one of the first organizations to design a reasonably good CS sensor[53]. Bas Mijling (KNMI) was author to an academic article on the use of low-cost sensors, that is positive about the added value of low-cost sensor data for air quality monitoring and identification of local variations, especially in locations where official equipment is sparse (Mijling, 2019). The article took Urban AirQ as its case.

5.4.6. Conceptual application

The Urban AirQ CS-coalition formally cooperated with government authorities and used cheap CS-sensors complemented with high quality stations. As such its material strength and ideational strength was high. Positional strength was high due to the choice of location. The fact that no particular air quality policy was targeted slightly takes away from this strength.

The Amsterdam government is characterized as relatively conservative towards CS. Even though the current Mayor and Aldermen advocate public participation in a broad sense, decisions making tends to be largely technocratic. This apparent lack of fluidity, and openness/deliberativeness holds true even though the topic of air quality in the streets in which the project took place is hotly debated.

Opportunities in this sense lay only in the development of a measurement network that is of higher quality and cheaper than the more traditional network of stations. The outspoken policy rationale, as well as the short time span of the project suggest that the project indeed almost exclusively focusses on the piloting of a sensor, not on political follow-up. Subgoals of engaging the community and enhancing the knowledge position of citizens are less prevalent.

[52] Interview with member of Luchtwachters Delft, 17.05.2020. Translated from Dutch.
[53] Interview with civil servant from the RIVM "samen meten" team, 08.05.2020. Translated from Dutch.

Political impact was mainly made on the support for CS-dimension. RIVM reports impact of Urban AirQ on the quality of sensors RIVM uses itself for its CS projects. Bas Mijling from KNMI also seems positive about Urban AirQ and its impact on the quality of CS data (Mijling, 2019). Urban AirQ itself reports follow up CS projects such as the RIVM Samen Meten platform. On the political participation dimension, we find luchtwachters and "Tree-Wifi" using the CS-toolkit from the broader making sense project as an inspiration for further work in the realm of air quality. For these latter examples we find an overlap between political participation and support for citizen science, in the sense that support for citizen science is gained from other citizens, not from a member of the governing coalition. No direct policy process impact was found.

We summarize the findings of sections 4.1. through 4.4. in table 7.

	Coalition Strength			Subsystem collaborativeness				Political impact		
	Material	**Positional**	**Ideational**	**Fluidity**	**Consensus**	**Deliberativeness**	**Societal cleavages**	**Policy process**	**Political participation**	**Support for CS**
Stadslab Luchtkwaliteit	+	-	+	+	+	+/-	+/-	+	+	-
Milieudefensie[54]	-	++	+	**NA**	+/-	-	+/-	+	+/-	--
Hollandse Luchten[55]	++	+	+	+	**NA**	+	+	+/-	+/-	+
Urban AirQ	++	+	++	-	**NA**	+/-	+	-	+	++

Possible values: --, -, +/-, +, ++

Table 7: Summary of Empirical Findings

[54] Indications of the subsystem collaborativeness are based on the national policy subsystem targeted by Milieudefensie.
[55] Indications of the subsystem collaboratiiveness are based on the Ijmuiden pilot.

6. Discussion

After having described the process through which political impact was made in our cases, we now turn to assessing the validity of our working propositions. Based on this assessment we suggest improvements to our conceptual framework and formulate a working proposition on the interlinkages between our conceptual variables.

6.1. Subsystem collaborativeness and political impact

Proposition 1: In collaborative policy subsystems scientific information is considered less biased. Therefore, CS-coalitions in collaborative subsystems focus on making policy process impact.

Proposition 2: In adversarial policy subsystems evidence is taken up when the topic of interest is on the public agenda. Therefore, CS-coalitions in adversarial subsystems focus on making impact on political participation.

Across cases, the air quality policy system in its entirety is characterized by high quality official monitoring equipment and expert modelling combined with additional monitoring equipment where spatial variation in air quality so requires. Interviewed government authorities question the added value of current CS-sensors for the existing official network. Furthermore, many authorities stress that air quality is better than citizens expect. Therefore, there is little opportunity to point out unknown transgressions of norms.

Most interviewees from CS-coalitions acknowledge these limitations embedded in the opportunity structure of the air quality policy system. Indeed, none of the CS-coalitions adopts as its main policy rationale the provision of "new information" directly to policy makers. Rather, CS is seen as a way to enhance their own knowledge position, and thereby their capacity to convince policy makers, either through public pressure, participation, or contribution to the development of CS as a supplement to national monitoring networks. Individual project partners Brak! Ijmuiden and Smart City Haarlem form an exception to this. Hence, policy process impact purely from CS-data is hard to make in air quality policy. Rather policy process impact is made through CS-coalitions informing themselves with data and creating "data-stories", in line with the argument made by Ponti & Craglia (2020).

Policy subsystem opportunity structures add nuance to the general policy system opportunity structure. A collaborative government that is used to working with various stakeholders, such as was seen in the case of Stadslab Luchtkwaliteit, discusses improvements to air quality policy with CS-coalitions, or at least explains why it is not able or not willing to

make policy adjustments based on input. Less collaborative government authorities see this kind of involvement as encouragement of the spread of "wrong information" and rather avoid extensive contact with CS-coalitions if not in charge of a project.. Political impact in these latter cases can almost exclusively be made through gathering public support and hence amassing political pressure to change the political agenda (Lundin & Öberg, 2013), as was seen in the case of Milieudefensie, or by focusing on the long-term development of sensors that needs no "political blessing" on the short term, as was seen in the Urban AirQ case.

6.1.1. Collaborative subsystems and political impact

The above contradicts *proposition 1* based on Weible and Sabatier (2009) that CS-data is perceived as less politically motivated in collaborative subsystems and is therefore more likely to make direct policy process impact. It is exactly the political motivation and integration of CS-data in politicized data-stories that shapes an opportunity for CS-coalitions to make policy process impact with CS-data (Ponti & Craglia, 2020). These data stories can then be used to (passively) mobilize public support for progressive air quality policy, or to actively equip policy advocates for debates to which they are invited. CS-coalitions in collaborative subsystems can thus use political participation as a stepping stone towards later policy process impact.

This impact on participation is made both in "depth" and "width". Not only can CS equip a select group of participants and other citizens with the knowledge, skills and contacts to participate in political processes, it can add to "passive" participation of a wider group of citizens by helping to shape opinions on and latent support for policy measures that enhance air quality. We find this latter take on political participation primarily in the cases of Stadslab Luchtkwaliteit and Hollandse Luchten where coalition members report to "find public support" for policy measures. The literature on political impact of CS does not yet reflect the distinction between "width" and "depth". It can however be found in the literature on political participation (Farrington and Bebbington, 1993).

Political participation in collaborative subsystems can also lead to impacts on government support for political participation and support for CS as a tool for citizen engagement apart from the impact on the policy process described above. "Core team" seats in Hollandse Luchten were almost exclusively reserved for governing coalition members. Formal participation in the CS-project was an explicit way of piloting a more open model of decision making and environmental monitoring, under government control. A successful pilot, measured by the quality of discussions with citizens and engagement of a large group of citizens, can lead to a larger role for citizens in future policy processes. This impact of political participation on

procedures for future decision-making is not yet recognized in the literature on CS (Turbé et al. 2019; Wiggins et al. 2018; Kieslinger et al. 2017). At the same time CS was tested as a tool for effectively engaging citizens in the policy process. If CS would be effective in "educating" citizens to participate in policy processes, it could be used by governments as a tool for citizen engagement more often. It is then not only the politicization of data, but also the organization of friendly participation of citizens in policy processes that shapes eventual impact in collaborative systems.

6.1.2. Adversarial subsystems and political impact

Proposition 2 on the role of public attention in enhancing knowledge uptake in adversarial policy subsystems, holds true to the extent that Milieudefensie used political participation, largely in the form of public sentiments, as a means to set the political agenda. Impact on political participation then enabled a CS-coalition to impact the political agenda. In this it should be noted that agenda impact, in the form of political attention for a specific (dimension of) a problem, is usually not the desired impact of a CS-coalition. The mere recognition of a problem, such as is implied by Turbé et al. (2019), does not necessary lead to a solution to the problem. Rather the fact that an issue is on the political agenda could enable a CS-coalition to participate in a policy process that is new on the agenda, or to find public support for a specific policy solution.

Alternatively, as was seen in the case of Urban AirQ, a coalition in an adversarial subsystem can decide to focus on longer-term impact on support for CS, potentially translating into a different manner of policy making in the longer run. By focusing on the scientific quality of data and sensor development, CS-data could be used more often in future policy processes as their capacity to supplement official data increases. Political participation in this case is a by-product rather than the main goal of the project. Where Hollandse Luchten focuses on impacting the support for CS as a tool for citizen engagement, Urban AirQ rather focused on CS as a tool for data-driven governance. This latter dimension of support for CS is less likely to translate into support for political participation of citizens in policy processes in the longer run. Arguably, a rather adversarial subsystem would be less open to CS as a tool for citizen engagement.

The difference in approach to political impact within an adversarial subsystem between Milieudefensie and Urban AirQ and difference in approach within a collaborative subsystem between Hollandse Luchten and Stadslab Luchtkwaliteit cannot be explained by subsystem

collaborativeness. Section 6.2. assesses the explanatory value of coalition strength in this regard.

6.1.3. Reconceptualizing subsystem collaborativeness

Following from the above, subsystem collaborativeness should be conceptualized as including the characteristics of the policy system as a whole. The characteristics of a policy subsystem function as an extra layer on top of those of a policy system. Together these characteristics feed into the further process of decision making. Jenkins-Smith et al. (2014), refer to such policy system characteristics as "relatively stable parameters" that shape the long-term opportunity structures for actors in a policy subsystem. Such parameters include policy from superior jurisdictions, social structure, distribution of natural resources and "basic attributes of the problem area" (Jenkins-Smith et al. (2014), p. 66). These somewhat broad terms could benefit from a clearer distinction between the technological and (social) institutional attributes of a policy system in the context of CS as they respectively determine the capacity of CS to make impact through scientific value of data and through politicization of data and thus shape opportunities for different types of political impact (Koppenjan & Groenewegen, 2005).

It should be noted that the extent of collaboration between governing coalition and CS-coalition within a given CS project is different from the collaborativeness of a policy subsystem. In the case of Urban AirQ we find formal participation between the governing-coalition and CS-coalition, even within a relatively non-collaborative subsystem. It seems authorities were willing to participate formally, because Waag Society primarily wanted to pilot a new sensor. The fact that GGD Amsterdam, part of a reluctant municipality when it comes to CS, was a partner to the project, supports this image. Within the project a short measurement period was decided on, making data largely unfit for drawing policy conclusions, yet fit for technological development. Waag Society seems to have made a trade-off between collaboration with the governing coalition and impact through quality of data, and political impact through activism without collaboration. Interviews with Waag Society in future research should confirm this way of thinking.

In the cases of Milieudefensie and Stadslab Luchtkwaliteit we find a more distant role for the governing coalition. Cooperation primarily aims to show that it is difficult to draw policy conclusions from CS-data and that policy changes in general are difficult to make because policy subsystems are interdependent. Other cooperation efforts are at times dubbed "sham participation" by interviewees. In some cases, formal collaboration then is rather a sign of governing coalition reluctance or hesitation towards policy change, than it is a sign of

collaborativeness of a policy subsystem. The above however does not yet show why government authorities opt for formal collaboration in some CS projects, where they opt for a more distant approach elsewhere. In section 6.2. we assess the role of coalition strengths in explaining this difference.

In conclusion, we find that the characteristics of the air quality policy system make raw-data impact on the policy process difficult, if not impossible to make. Collaborative and adversarial subsystems to some extent prompt different ways for CS-coalitions to change policy in the longer run. In collaborative subsystems, CS-coalitions tend to position themselves as allies to the governing-coalition. Impact on political participation is focused on generating support for policy, political participation and support for CS as tool for citizen engagement, not on generating public uproar. Adversarial subsystems prompt a CS-coalition approach that uses external pressure to make the status quo unsustainable, or that attempts to change decision making processes in the long run by developing a cheaper and equally effective alternative to existing monitoring networks. The characteristics of the policy system, policy subsystem and project-cooperation then form the backdrop for the eventual political impact made by a CS-coalition. Collaborativeness and cooperation should not be confused. In fact, the air of collaborativeness can be used by governing-coalitions to restrict avenues to impact for CS-coalitions, by co-creating a CS-project in such a way that data are unfit for political purpose, through emphasizing the flaws of CS and impossibilities of policy change, or through "sham participation" with little policy consequences.

6.2. Coalition strengths and political impact

Proposition 3: Strong CS-coalitions are crucial to consensual decision making and have the strength to mobilize substantial external pressure. Therefore, strong coalitions focus on making policy process impact and impact on political participation.

Proposition 4: Weak CS-coalitions are not crucial to consensual decision making and do not have the force to mobilize substantial external pressure. Therefore, weak coalitions focus on affecting support for CS.

To be able to assess the validity of the working propositions on the link between coalition strengths and political impact we first reflect on the validity of our conceptualization of material strength and its role in the policy process. We find large variance in coalition strengths across cases. This variance is not only found in different distributions of material, positional and ideational strength, but also in differences within these types. Where the CS-

coalitions in Urban AirQ and Hollandse Luchten mainly derive their material and ideational strength from their connections with the governing coalition, their trustworthiness in cooperation, and the relative quality of their sensors, Milieudefensie and Stadslab Luchtkwaliteit derive most of their material and ideational strength from their cooperation with other societal actors and strong links with citizens. We thus note that our concepts of strength are pluriform.

The impact that this pluriformity has on political impact is illustrated by the difference in political impact between cases that derived material strength from different sources. As was shown section 6.1, CS-coalitions that pride themselves on the quality of their sensors (i.e. Urban AirQ and Hollandse Luchten) and therefore seem trustworthy to a governing coalition are more likely to engage in formal cooperation, which in turn is likely to lead to a project setting that focuses on support for CS as a tool for data-driven governance or as tool for citizen engagement. The CS-coalition is restricted in its ways to make policy process and political participation impact, because of the cooperation. Milieudefensie and Stadslab derived their material strength largely from ties with other societal actors, did not enter into formal cooperation with the governing coalition and did therefore not face these same restrictions.

Our case descriptions further show that coalition strength is not stable over time. Especially in the case of Stadslab we find that initial positional strength was traded for material and ideational strength a few years on. After an initial focus on ‘s-Gravendijkwal, connections were sought with governmental and societal partners working on a wider set of issues. Stadslab started as a partner to the municipality and used data as a support for citizen engagement activities and for policy experiments. After a lack of clear political follow up and “loss of naivety”, material strength was lost as participants lost interest in measurements. However, a core of Stadslab members, with political wit, connections and expertise gained from earlier work, continued work and decided to cooperate with other societal partners, such as in the Healthy Traffic Coalition, and focus on activities that were not specific to ‘s-Gravendijkwal. Material strength was then enhanced through collaboration with societal actors, and ideational strength was enhanced through a constructive stance in the local political debate. These changes in strengths further capacitated Stadslab to participate in policy processes. The government was willing to “educate” and involve Stadslab as Stadslab was seen as a constructive partner in a broad air quality discussion.

The case of Milieudefensie illustrates that strengths are not only variable over time, but can to some extent be consciously composed. Milieudefensie decided to measure in areas of

specific concern in consultation with authorities and citizens. Government authorities advised Milieudefensie to use Palmes tubes, because they are the most accurate in measuring NO_2. This decision, despite the activist nature of Milieudefensie and non-representative hanging of Palmes Tubes in areas of known poor air quality, gave them some scientific legitimacy (ideational strength) in exchange for a loss of material strength, in the sense that Palmes tubes only measure long term variations in air quality. By the choice of measurement locations and technique, Milieudefensie thus chose its own strengths. The chosen position on the spectrum between activist and scientist enabled Milieudefensie to find broad public support and media attention for addressing the issue of air quality, while the relation between Milieudefensie and the governing coalition remained more distant.

Strengths cannot only be built by activities within the initial target subsystem but also through activities in other subsystems. For Milieudefensie we find that early campaigns particularly aimed to create general attention to air quality on the political agenda. After air quality penetrated the political agenda, and was translated into political commitment from the collective governments, the Luchtwachter campaign had greater opportunities to influence specific local policy processes. In case of Stadslab Luchtkwaliteit the specific case of 's-Gravendijkwal was used to build expertise and connections, after which Stadslab was "allowed" to put these strengths to use in the broader Rotterdam air quality policy. CS-coalitions can thus manoeuvre through various policy subsystems over time and make an impact in one subsystem in order to open up new opportunities for impact in the initial target subsystem.

In assessment of propositions 3 and 4 we conclude that strengths specific to a CS-coalition influence the project-interaction of the governing and CS-coalition. The specific mode of interaction opens up or closes off avenues for political impact. Cooperation, or the lack thereof, plays a role in determining change and stability of CS-coalition strengths over time. Strengths can be tweaked to fit the policy rationale of a coalition to a certain extent. Evidence suggests positional and ideational strength, in the sense of public legitimacy, are somewhat linked to impacts on political participation, where material and ideational strength, in the sense of scientific legitimacy and trustworthiness, are linked to impacts on support for CS and on the policy process. It is however too straightforward to propose a direct link between the strength of a coalition and the type of political impact made. CS-coalitions have very specific strengths and weaknesses that differ over time and to some extent at will. These strengths differ also within our conceptual dimensions of strengths derived from Pustovitovskij & Kremer (2011). Notably we argue a new division between social and technological strengths should be made

within the material strength dimension. Within the social subdimension we distinguish between social ties of a CS-coalition with the governing coalition, and ties with other societal actors. Within the ideational strength a division should be made between scientific legitimacy, public legitimacy, and trustworthiness in processes of cooperation.

6.3. Reconceptualizing the policy process

From sections 6.1. and 6.2. we find that the collaborativeness of a subsystem and strengths of a CS-coalition feed into a complex process of cross-coalition project-interaction leading to an eventual political impact of a CS-project. We therefore explicitly reconceptualize the policy process based on our findings, leading to the formulation of a fifth working proposition on the interdependence of our conceptual variables for future research.

6.3.1. Policy rationales

In our initial conceptualization of the policy process (Sabatier & Weible, 2007) a policy rational adopted by a CS-coalition was the result of the coalition's strengths and the collaborativeness of the subsystem (opportunity structure). Strategic interaction between coalitions could lead to a change in the policy rationale. Based on our findings, we note that policy rationales are not always a logical consequence of a given opportunity structure and "objective", static coalition strengths. The determination and adaptation of a policy rationale is a more dynamic process. As we primarily saw in the case of Milieudefensie, strengths can be selected based on a previously determined policy rationale or based on a perceived opportunity structure. Strengths within the context of policy system and subsystem characteristics then shape a mode of project-interaction between CS-coalition and governing coalition and consequently an updated policy rationale. Over the course of the CS-project strengths can change or be modified, the policy rationale can be modified accordingly.

6.3.2. governing coalition counter-strategies

Governing coalition counter-strategies were initially conceptualized as conscious efforts of a governing coalition to maintain the status quo. In our analysis however, we find a broader range of more or less cooperative counter-strategies with goals ranging from maintenance of the status quo to a controlled form of change. Expected political impacts are not only countered, but sometimes rather steered in a direction desirable to the governing coalition.

With regards to the link between CS-coalition strengths and governing coalition counter-strategies we find that positional strength in combination with a low material strength, translating into an anti-status quo policy rationale, is a determinant of a counter-strategy that attempts to counter political impacts made. A high material strength in combination with a

somewhat lower positional strength, translates into a cooperative stance towards the governing coalition and is a determinant of a more cooperative, steering, counter-strategy.

Subsystem collaborativeness seems to explain the governing coalition counter-strategy to a lesser extent than the particular strengths of a CS-coalition. Rotterdam responded differently to Milieudefensie and Stadslab Luchtkwaliteit, even though Stadslab and Mileudefensie worked together on traffic circulation plans in the Healthy Traffic Coalition. This signals it is a quality inherent to Stadslab, not a quality inherent to the policy subsystem, that elicited a more open approach to Stadslab being involved in the negotiations for Rotterdam climate deals. In the case of Hollandse Luchten however, we see a difference in the response of different municipalities to pilots that are part of the same project. Where the municipality of Zaanstad is an official partner to the project, the municipality of Amsterdam is not involved. As the pilots in both municipalities are concerned with spatial development policy, this suggests a difference in collaborativeness of the subsystem across municipalities. Alternatively, the different modes of involvement of the two municipalities could indicate that the specific groups from the CS-coalition active in the two municipalities differ in strengths or are perceived to differ in strengths by the governing coalitions. More research on the specific coalition fractions active in the two municipalities, their strengths, and perceptions of the governing coalition of their strengths is needed to test the validity of these alternative explanations.

Regarding the link between a governing coalition counter-strategy and political impact we find that governing coalitions roughly decide between "distant education" of a CS coalition, such as was seen in the case of Stadslab Luchtkwaliteit, "passive listening", such as in the case of Milieudefensie, and "co-optation", as in the cases of Hollandse Luchten and Urban AirQ. Where the strategy of "distant education" educates CS-participants to become valuable to the governing coalition over time through a distant mode of cooperation and steers impact, the strategy of "passive listening" primarily aims to counter impact through maintaining distance between coalitions and listening to worries of a CS-coalition to be able to pre-empt political impact. The strategy of co-optation in which a governing coalition takes a leading role in a CS-project can either serve to counter impact through making data unfit for political purpose or to steer CS-coalition worries to the governing coalition's benefit. The distant education strategy is roughly linked to policy process impact, and support for political participation, the distant listening strategy necessitates impact to be made through agenda impact, the "co-optation" strategy prompts either impact on support for CS as a data-gathering tool or on support for

political participation and CS as a tool for citizen engagement, depending on the favourability of the governing coalition towards the CS-coalition.

Having reconceptualized the policy process, we formulate the following working proposition on the process through which coalition strengths and subsystem collaborativeness shape a CS-coalition's political impact:

Proposition. 5: Subsystem collaborativeness and policy system characteristics shape the general favourability of a governing coalition towards a CS-initiative. Based on an initial policy rationale CS-coalitions build strengths. Based on these strengths' and the general favourability of a governing coalition towards a CS-initiative, the two coalitions decide on a mode of project-specific-interaction. The project-specific-interaction affects the (future) strengths of the CS-coalition and its eventual political impact.

An adapted conceptual framework for future research can be found in figure 2. The conceptual framework is operationalized in Appendix H.

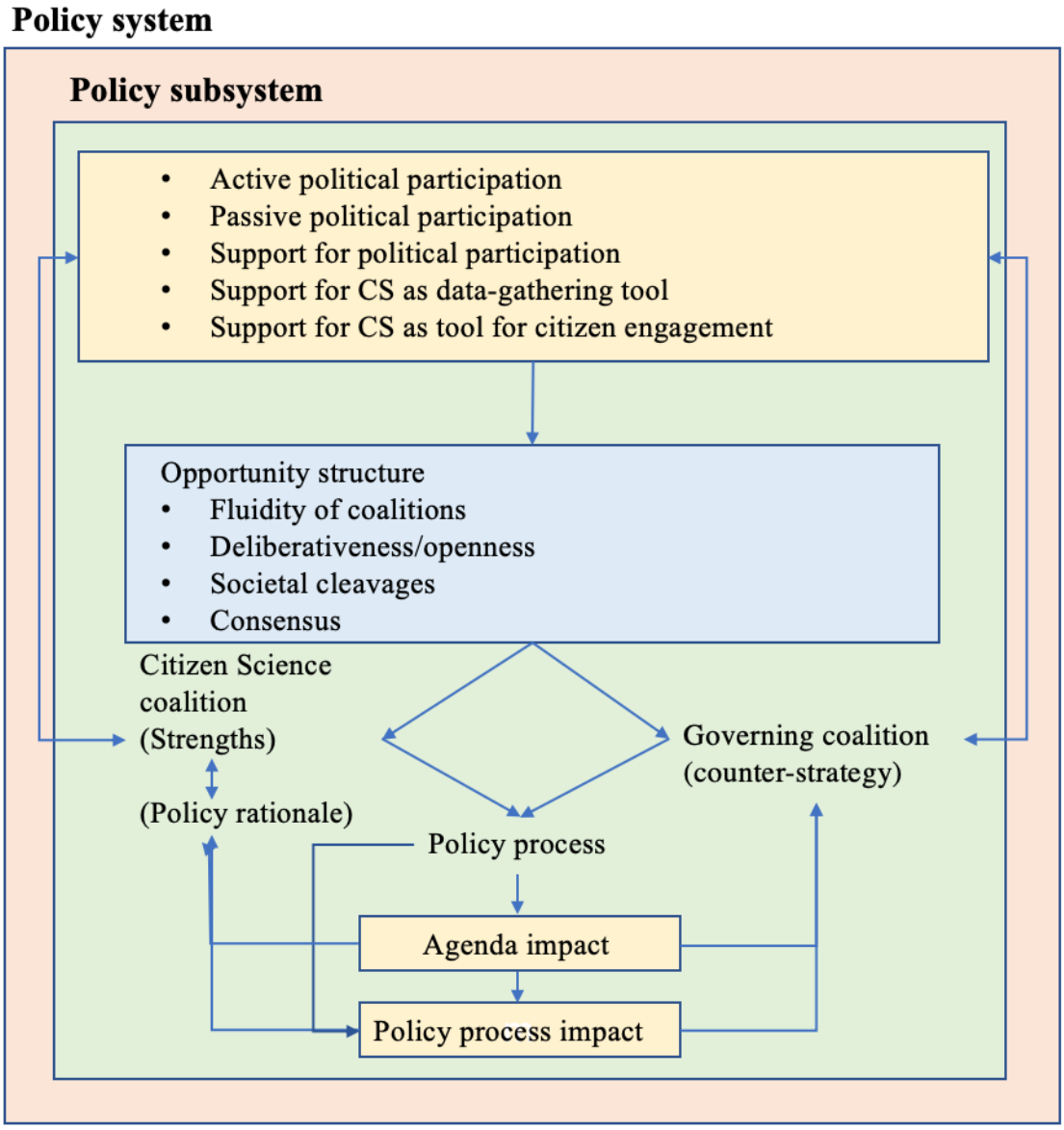

Figure 2: Adapted Conceptual Framework

7. Conclusion

This thesis has adapted the Advocacy Coalition Framework (ACF) based on the literature on Citizen Science (CS) to understand the process through which CS-coalitions make political impact. In adapting the ACF for the context of CS, the thesis further developed a typology of political impact of CS-projects. The thesis finds that CS-coalitions differ to a large extent in their political impact and process towards impact. Initial (composed) strengths of a coalition shape a CS-coalition's policy rationale and a governing coalition counter-strategy against the backdrop of the collaborativeness of a policy subsystem and characteristics of a policy system. In the process of strategic interaction that follows, strengths develop and are managed, and coalitions can change their target policy subsystem to build strengths and maximize political

impact. In cases where coalitions decide not to enter into formal cooperation, coalitions tend to focus on political participation to generate broad public support for existing policy ideas, to equip a smaller group of people to propagate new policy ideas, or to generate external pressure to the status quo, depending on the composition of coalition strengths and the governing coalition's approach towards the CS-coalition. Where coalitions cooperate formally, CS-coalitions attempt to proof the value of CS as a tool for citizen engagement and the merit of political participation in policy making, or aim to further develop CS as a future tool for data-driven governance.

It should be pointed out that the choice of theoretical framework, particularly the choice of the ACF, led to a focus on policy change in this thesis. Whereas political impact was conceptualized in a broader fashion, to include impact on the functioning of a policy subsystem, this change of a policy subsystem in the ACF feeds back into opportunities for policy process impact. This is not withstanding the fact that impact on e.g. political participation can be valuable in itself.

Whereas this thesis is focused on the context of Dutch air quality policy, it does not solely hold implications for this context. More broadly, it provides input for political reflections on the role of CS in the policy process, by primarily highlighting the role of CS as a political, rather than purely scientific tool at the disposal of citizens and policy makers alike. For other policy systems, such as the noise, odour and light pollution systems in which CS is often seen, the theoretical framework developed can be used, as the theoretical model is not context specific. In other policy systems, factors such as the political salience of the system, relative quality of sensors, and historic trends of centralization and technocracy can however change the opportunity structure to and strengths of a CS-coalition.

Future research could use the theoretical model developed in this thesis to test the causal relationships explored in a more in-depth fashion. Further interviews, both with actors from the analysed cases and other actors active in the field of CS could shed more light on strategic reasons for cross-coalition cooperation or the lack thereof, the impact of the extent of formality of cooperation on the type of political impact made, and the impact of (perceived) heterogeneity of CS-coalitions on interactions between coalitions in different policy subsystems. This could also be done in CS-projects in policy systems other than the air quality system as to show how opportunities for political impact differ for political contexts that are less technocratic, centralized, politically salient or technology-driven than is the Dutch air quality policy system.

In conclusion, this thesis has shown that the power of CS-data lies not necessarily in its scientific value and legal force. What makes CS-data particularly valuable is the role of CS-participants in "selling data" to policy makers and other citizens, and power to point out the desirability of policy change given the costs of policy change. Data should be included in a politicized data-story that paints a picture of what the city, country or province should integrally look like and should be used for active advocacy of policy instruments or interactive governance more broadly. In solving complex problems, no single unilateral decision suffices and ignorance of parties not involved in decision making is no bliss (Klijn & Koppenjan, 2016). In a traditionally technocratic and centralized policy system, such as the air quality system, an informed opinion does not automatically equal power. If knowledge however does not equal power in the identification of legal transgressions of norms, it definitely should in the judgement of sufficiency of current norms and policy.

References

Andrews, K., Nichols, K., Harvey, C., Tolimieri, N., Obaza, A., Garner, R. and Tonnes, D., 2019. All Hands on Deck: Local Ecological Knowledge and Expert Volunteers Contribute to the First Delisting of a Marine Fish Species Under the Endangered Species Act. *Citizen Science: Theory and Practice*, 4(1), p.37. DOI: http://doi.org/10.5334/cstp.221

AT 5. (2009, October 19). Milieudefensie:'Kwaliteit lucht slechter dan gedacht'. Retrieved May 19, 2020, from https://www.at5.nl/artikelen/25628/

Baekkeskov, E., & Öberg, P. (2017). Freezing deliberation through public expert advice. *Journal of European Public Policy*, 24(7), 1006–1026. doi: 10.1080/13501763.2016.1170192

Blokhuis, C., Devilee , J., Voogt, M., Volten, H., & Alphen , A. van. (2019). De gewone burger meet zelf luchtkwaliteit: Op weg naar een andere wisselwerking tussen burgers en overheden . *Tijdschrift Lucht*.

Bonney, R., Cooper, C.B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K.V. and Shirk, J., 2009b. Citizen science: a developing tool for expanding science knowledge and scientific literacy. BioScience, 59(11): 977–984. DOI: https://doi.org/10.1525/bio.2009.59.11.9

Boswell, C. (2008). The political functions of expert knowledge: knowledge and legitimation in European Union immigration policy. *Journal of European Public Policy*, 15(4), 471-488.

Cohn JP. 2008. Citizen science: Can volunteers do real research? BioScience 58: 192–197.

Calanni J. C., Siddiki S. N., Weible C. M. and Leach W. D. (2015) Explaining Coordination in Collaborative Partnerships and Clarifying the Scope of the Belief Homophily Hypothesis. Journal of Public Administration Research and Theory 25(3): 901–927.

Conrad, CC and Hilchey, KG. 2011. A review of citizen science and community-based environmental monitoring: issues and opportunities. Environmental Monitoring and Assessment, 176(1–4): 273–291. DOI: https://doi.org/10.1007/s10661-010-1582-5

Dunlop, C.A. (2014) 'The possible experts: how epistemic communities negotiate barriers to knowledge use in ecosystems services policy', Environment and Planning C: Government and Policy 32: 208–28.

Eitzel, M V et al 2017 Citizen Science Terminology Matters: Exploring Key Terms. Citizen Science: Theory and Practice , 2(1): 1, pp. 1–20, DOI: https://doi.org/10.5334/cstp.96

Elshout, S. van den, Breugel, P. van, & Tsounaka , N. (2019). Burgermeetproject Rijnmond: wie doet er mee en waarom? *Tijdschrift Lucht* , (June 2019). Retrieved from https://www.dcmr.nl/publicaties/burgermeetproject-rijnmond-wie-doet-er-mee-en-waarom.html

Farrington, J., Bebbington, A., with Wellard, K. and Lewis, D. J. (1993) *Reluctant Partners: Non-governmental Organisations, the State and Sustainable Agricultural Development*, Routledge, London.

Fisher, F. and Gottweis, H. (2012) The Argumentative Turn Revisited. Policy as Communicative Practise, New York: Duke University Press.

Fung, A. (2015). Putting the Public Back into Governance: The Challenges of Citizen Participation and Its Future. *Public Administration Review*, *75*(4), 513–522. doi: 10.1111/puar.12361

Göbel, C, et al. 2019. How Does Citizen Science "Do" Governance? Reflections from the DITOs Project. Citizen Science: Theory and Practice , 4(1): 31, pp. 1–13. DOI: https://doi.org/10.5334/cstp.204

GR1P. (n.d. a). De politiek van luchtkwaliteit: interview Bas Mijling, KNMI. Retrieved April 18, 2020, from https://gr1p.org/blog/politiekvanluchtkwalitiet/de-politiek-van-luchtkwaliteit-interview-serie-deel-3-bas-mijling-knmi/

GR1P. (n.d. b). De politiek van luchtkwaliteit: interview Dave de Jonge, GGD. Retrieved April 18, 2020, from https://gr1p.org/blog/politiekvanluchtkwalitiet/de-politiek-van-meten-interview-serie-dave-jonge-ggd-amsterdam/

GR1P. (n.d. c). De politiek van luchtkwaliteit: interview David Gelauff, Gemeente Amsterdam. Retrieved April 18, 2020, from https://gr1p.org/blog/politiekvanluchtkwalitiet/de-politiek-van-meten-interview-serie-deel-4-david-gelauff-gemeente-amsterdam/

GR1P. (n.d. d). De politiek van luchtkwaliteit: interview Ivonne Jansen-Dings. Retrieved April 18, 2020, from https://gr1p.org/tag/urban-airq/

GR1P. (n.d. e). De politiek van luchtkwaliteit: interview Ivo Stumpe. Retrieved April 18, 2020, from https://gr1p.org/blog/politiekvanluchtkwalitiet/de-politiek-van-meten-interview-serie-ivo-stumpe/

GR1P. (n.d. f). De politiek van luchtkwaliteit: interview Joost Wesseling, RIVM. Retrieved from https://gr1p.org/blog/politiekvanluchtkwalitiet/de-politiek-van-luchtkwaliteit-interview-serie-deel-7-joost-wesseling-rivm/

GR1P. (n.d. g). De politiek van luchtkwaliteit: interview Joris Lam, TreeWifi. Retrieved April 18, 2020, from https://gr1p.org/blog/politiekvanluchtkwalitiet/de-politiek-van-luchtkwaliteit-interview-serie-deel-5-joris-lam/

Groom, Q, et al. 2019. Empowering Citizens to Inform Decision-Making as a Way Forward to Support Invasive Alien Species Policy. Citizen Science: Theory and Practice , 4(1): 33, pp. 1–11. DOI: https://doi.org/10.5334/cstp.238

Hecker, S, et al. 2019. How Does Policy Conceptualise Citizen Science? A Qualitative Content Analysis of International Policy Documents. Citizen Science: Theory and Practice , 4(1): 32, pp. 1–16. DOI: https://doi.org/10.5334/cstp.230

Irwin, A., 1995. Citizen Science: A study of people, expertise and sustainable development (Vol. 136). London: Routledge.

Irwin, Alan, and Mike Michael. 2003. Science, Social Theory and Public Knowledge. Berkshire: Open University Press.

Jansen-Dings, I., Boerwinkel, G., Boschman , D.-S., & Boonstra , M. (2017). *Documentation on activities in Amsterdam*. Making Sense .

Jenkins-Smith H., Daniel Nohrstedt C., Weible C. M. and Sabatier P. A. (2014) The Advocacy Coalition Framework: Foundations, Evolution and Ongoing Research. In Sabatier P. A. and Weible C. (eds.), Theories of the Policy Process. Boulder, CO: Westview Press, 184–217.

Jenkins-Smith, H. C., & Sabatier, P. A. (1994). Evaluating the Advocacy Coalition Framework. *Journal of Public Policy*, *14*(2), 175–203. doi: 10.1017/s0143814x00007431

Jordan, A., Rayner, T., Schroeder, H., Adger, N., Anderson, K., Bows, A., Le Quéré, C., Joshi, N., Mander, S., Vaughan, N. and Whitmarsh, L. (2013) 'Going beyond two degrees? The risks and opportunities of alternative options.' *Climate Policy* 13 (6): 751–69.

Kenniscentrum Infomil. (n.d.). Nationaal Samenwerkingsprogramma Luchtkwaliteit (NSL). Retrieved June 3, 2020, from https://www.infomil.nl/onderwerpen/lucht-water/luchtkwaliteit/regelgeving/wet-milieubeheer/nsl/

Kerkhoff, L. V., & Lebel, L. (2006). Linking Knowledge and Action for Sustainable Development. *Annual Review of Environment and Resources*, *31*(1), 445–477. doi: 10.1146/annurev.energy.31.102405.170850

Kieslinger, B., Schäfer, T., Heigl, F., Dörler, D., Richter, A., & Bonn, A. (2017). The Challenge of Evaluation: An Open Framework for Evaluating Citizen Science Activities. doi: 10.31235/osf.io/enzc9

Kindon, S., Pain, R. and Kesby, M., 2008. Participatory action research. In: International encyclopaedia of human geography. Elsevier, 90–95.

Knol, A. (2016). *Wat adem jij in?* Amsterdam : Milieudefensie.

Koebele, E. A. (2018). Integrating collaborative governance theory with the Advocacy Coalition Framework. *Journal of Public Policy*, *39*(1), 35–64. doi: 10.1017/s0143814x18000041

Koppenjan, J., & Groenewegen, J. (2005). Institutional design for complex technological systems. *International Journal of Technology, Policy and Management*, 5(3), 240. doi: 10.1504/ijtpm.2005.008406

Lundin, M., & Öberg, P. (2013). Expert knowledge use and deliberation in local policy making. *Policy Sciences*, *47*(1), 25–49. doi: 10.1007/s11077-013-9182-1

Lune, H., & Berg, B. L. (2016). *Qualitative research methods for the social sciences*. Pearson Higher Ed.

Luxon, E. (2019). What do advocates know about policymaking? Revealing process in the Advocacy Coalition Framework. *Journal of European Public Policy*, 26:1, 106-125, DOI: 10.1080/13501763.2017.1400088

Making Sense. (2018). *Citizen Sensing: A Toolkit* .

Making Sense . (2018). *Making Sense, advances and experiments in participatory sensing*.

Making Sense . (n.d.). Urban AirQ. Retrieved May 13, 2020, from http://making-sense.eu/campaigns/urbanairq/

Mijling, B. (2019). High-resolution mapping of urban air quality with heterogeneous observations: a new methodology and its application to Amsterdam. *Atmospheric Measurement Techniques* . doi: 10.5194/amt-2019-410

Milieudefensie. (2019, August 5). Rechtszaak voor gezonde lucht. Retrieved May 13, 2020, from https://milieudefensie.nl/recht-op-gezonde-lucht/rechtszaak-voor-gezonde-lucht

Mueller, Michael P., Deborah Tippins, and Lynn A. Bryan. 2012. 'The Future of Citizen Science', Democracy & Education 20, no. 1: article 2. http:// democracyeducationjournal . org / home / vol20 / iss1 / 2 /.

Nascimento , S., Iglesias , J. M. R., Owen, R., Schade, S., & Shanley , L. (2018). Citizen Science for policy formulation and implementation . In *Citizen Science: Innovation in Open Science, Society and Policy* . London: UCL Press.

Nascimento, Susana, Ângela Guimarães Pereira, and Alessia Ghezzi. 2014. From Citizen Science to Do It Yourself Science: An Annotated Account of an Ongoing Movement. Luxembourg: Publications Office of the European Union. http:// publications . jrc . ec . europa . eu / repository / bitstream / JRC93942 / ldna27095enn . pdf.

Neuman, W. (2014). *Social Research Methods: Qualitative and Quantitative Approaches: Pearson New International Edition.* Pearson Education Limited.

Newman, G, Chandler, M, Clyde, M, McGreavy, B, Haklay, M, Ballard, H, Gray, S, Scarpino, R, Hauptfeld, R, Mellor, D and Gallo, J. 2017. Leveraging the power of place in citizen science for effective conservation decision-making . Biological Conservation, 208: 55–64. DOI: https://doi.org/10.1016/j.biocon.2016.07.019

Nguyen , P. L., & Wesseling , J. (2016). Metingen van stikstofdioxideconcentraties (NO2) met Palmes buisjes. RIVM.

Nielsen, M., 2011. Reinventing discovery. Princeton University Press.

Noord-Holland. (2020, March 16). Hollandse Luchten. Retrieved June 2, 2020, from https://www.noord-holland.nl/Onderwerpen/Duurzaamheid_Milieu/Hollandse_Luchten

Ostrom, Elinor. (1990) *Governing the Commons: The Evolution of Institutions for Collective Action*. New York: Cambridge University.

Pierce, J. J., Peterson, H. L., & Hicks, K. C. (2020). Policy Change: An Advocacy Coalition Framework Perspective. *Policy Studies Journal*, *48*(1), 64–86. doi: 10.1111/psj.12223

Poel , A. van der, & Stumpe , I. (2009). *Samen Meten is Zeker Weten*. Amsterdam: Milieudefensie .

Ponti M. and Craglia M. Citizen-generated data for public policy, European Commission, Ispra, 2020 JRC120231.

ProeftuinNL. (2017, October 2). Retrieved from https://podcastluisteren.nl/ep/Stimuleringsfonds-Designing-a-community-of-care-ProeftuinNL-Rotterdam-met-Annemarie-Piscaer#/

Pustovitovskij, Andrej and Kremer, Jan-Frederik, (2011), Structural Power and International Relations Analysis: "Fill your basket, get your preferences", No 191, IEE Working

Papers, Ruhr University Bochum, Institute of Development Research and Development Policy (IEE), https://EconPapers.repec.org/RePEc:zbw:ieewps:191.

Rhodes, R.A.W. (2012). Waves of Governance. In D. Levi-Faur (Ed.), *The Oxford Handbook of Governance.* Oxford. Oxford University Press.

Rijksoverheid . Schone Lucht Akkoord , Schone Lucht Akkoord (2020).

RIVM. (2020, January 24). Landelijk Meetnet Luchtkwaliteit. Retrieved June 9, 2020, from https://www.rivm.nl/landelijk-meetnet-luchtkwaliteit#:~:text=De technologie voor het meten,en toepassing van deze sensoren.

Roger, E, et al. 2019. Adopting Citizen Science as a Tool to Enhance Monitoring for an Environment Agency. Citizen Science: Theory and Practice , 4(1): 35, pp. 1–9. DOI: https://doi.org/10.5334/cstp.231

Rome, C and Lucero, C. 2019. Wild Carrot (Daucus carota) Management in the Dungeness Valley, Washington, United States: The Power of Citizen Scientists to Leverage Policy Change. Citizen Science: Theory and Practice , 4(1): 36, pp. 1–9. DOI: https://doi.org/10.5334/cstp.201

Rotterdamse Klimaat Alliantie . (n.d.). Klimaatdeals. Retrieved May 16, 2020, from https://www.energieswitch010.nl/klimaatdeals

Rotterdams Milieucentrum . (2016, May 25). Burgerbrief voor schone lucht. Retrieved May 17, 2020, from https://www.rotterdamsmilieucentrum.nl/site/schone-lucht-voor-rotterdam/

Rotterdams Milieucentrum . (2017, April 18). Coalitie voor gezond verkeer in Rotterdam. Retrieved May 16, 2020, from https://www.rotterdamsmilieucentrum.nl/site/coalitie-gezond-verkeer/

Roy, HE, Pocock, MJO, Preston, CD, Roy, DB, Savage, J, Tweddle, JC and Robinson, LD. 2012. Understanding citizen science and environmental monitoring. Final report. London, UK: UK Environmental Observation Framework. Available at http://www.ukeof. org.uk/documents/understanding-citizen-science.pdf [Last accessed 6 September 2018].

Sabatier, Paul (1988). An advocacy coalition framework of policy change and the role of policy- oriented learning therein.' Policy Sciences 21:129-168.

Sabatier, Paul, and Chris Weible. 2005. Innovations in the advocacy coalition framework. Paper presented at the National Conference of the American Society of Public Administration, Milwaukee, WI, April 2–5.

Sabatier P. A. and Weible C. M. (2007) The Advocacy Coalition Framework: Innovation and Clarification. In Sabatier P. A. (ed.), Theories of the Policy Process. Boulder, CO: Westview Press, 189–220.

Schlager, E. (1995). Policy making and collective action: Defining coalitions within the advocacy coalition framework. *Policy Sciences*, *28*(3), 243–270. doi: 10.1007/bf01000289

Schattschneider, E. E. (1997). *The semi sovereign people: a realists view of democracy in America*. Fort Worth: Harcourt Brace Jovanovich College Publishers.

Schrefler, L. (2010). The usage of scientific knowledge by independent regulatory agencies. *Governance*, 23(2), 309-330.

Seawright, J., & Gerring, J. (2008). Case Selection Techniques in Case Study Research: A Menu of Qualitative and Quantitative Options. *Political Research Quarterly*, 61(2), 294–308. doi: 10.4135/9781473915480.n31

Shirk, J.L., Ballard, H.L., Wilderman, C.C., Phillips, T., Wiggins, A., Jordan, R., McCallie, E., Minarchek, M., Lewenstein, B.V., Krasny, M.E. and Bonney, R., 2012. Public participation in scientific research: a framework for deliberate design. Ecology and Society, 17(2): 29. DOI: https://doi.org/10.5751/ES-04705-170229

Stadslab Luchtkwaliteit . (n.d.). Over Stadslab Luchtkwaliteit – Stadslab-Luchtkwaliteit. Retrieved May 16, 2020, from https://www.stadslabluchtkwaliteit.nl/portfolio/over-stadslab-luchtkwaliteit/

Turbé, A., Barba, J., Pelacho, M., Mugdal, S., Robinson, L.D., Serrano-Sanz, F., Sanz, F., Tsinaraki, C., Rubio, J.-M. and Schade, S., 2019. Understanding the Citizen Science Landscape for European Environmental Policy: An Assessment and Recommendations. *Citizen Science: Theory and Practice*, 4(1), p.34. DOI: http://doi.org/10.5334/cstp.239

Turnheim, B., Asquith, M., & Geels, F. W. (2020). Making sustainability transitions research policy-relevant: Challenges at the science-policy interface. *Environmental Innovation and Societal Transitions*, 34, 116–120. doi: 10.1016/j.eist.2019.12.009

Waag Society . (2017). *D3.1 Documentation on Activities in Amsterdam*.

Waag. (n.d.). Burgermetingen in Noord-Holland. Retrieved May 13, 2020, from https://hollandseluchten.waag.org/

Weible, C. M.(2008). Expert-Based Information and Policy Subsystems: A Review and Synthesis. Policy Studies Journal 36(4): 615–635.

Weible C. M., Heikkila T. and Pierce J. (2017) Understanding Rationales for Collaboration in High-Intensity Policy Conflicts. Journal of Public Policy; https://doi.org/10.1017/S0143814X16000301.

Weible, C. M., Heikkila, T., Deleon, P., & Sabatier, P. A. (2011). Understanding and influencing the policy process. *Policy Sciences*, *45*(1), 1–21. doi: 10.1007/s11077-011-9143-5

Weible C. M., Sabatier P. A. and McQueen K. (2009) Themes and Variations: Taking Stock of the Advocacy Coalition Framework. Policy Studies Journal 37(1): 121–140.

Wiggins, A. and Crowston, K., 2011. January. From conservation to crowdsourcing: A typology of citizen science. In: System Sciences (HICSS), 2011 44th Hawaii international conference on (pp. 1–10). IEEE. DOI: http://dx.doi.org/10.1109/HICSS.2011.207

Wiggins, A., & Crowston, K. (2012). Goals and Tasks: Two Typologies of Citizen Science Projects. *2012 45th Hawaii International Conference on System Sciences*. doi: 10.1109/hicss.2012.295

Appendix A: Dutch Air Quality Policy

Air quality in the Netherlands is regulated under EU Directive 2008/50/EC[56] and transposed to Dutch legislation in the Environmental Management Law[57]. The directive contains maximum annual and hourly average concentrations for NO_2, PM10 and PM2.5 in ambient air, and contains maximum durations for transgressions of these standards. PM10 and PM2.5 are small particles (Particulate Matter) that travel far and are primarily emitted by traffic, combustion and agriculture. Due to the high volatility of PM10/2.5 it is difficult to decrease concentrations through local policy only. NO_2 is a relatively local gas primarily emitted by traffic and industry. Because of its local nature, specific sources of NO_2 can be identified and addressed relatively easily, as compared to PM10/2.5. The World Health Organization provides more stringent guidelines for concentrations of these substances. An overview of the EU and WHO standards can be found below.

	NO_2	**PM10**	**PM2.5**
EU	Annual mean of 40µg/m^3. Hourly mean of 200µg^3, which cannot be exceeded more than 18 times a year.	Annual mean of 40µg/m^3. Daily mean of 50 µg/m^3, which cannot be exceeded more than 35 times a year.	Annual mean of 25µg/m^3 until 2020. Starting 2020 20 µg/m^3
WHO	Annual mean: 40 µg/m^3 Daily mean: 200µg^3	Annual mean: 20 µg/m^3 Daily mean: 50 µg/m^3	Annual mean: 10µg/m^3 Daily mean: 25µg/m^3

Table 8: Summary of Air Quality Norms

PM10 and NO_2 levels in the Netherlands have historically exceeded EU norms. Because the government could not meet the 2008 EU air quality standards it applied for and received a derogation from meeting the norms. Even though the government successfully applied for a derogation, it still had to make efforts to meet the EU standards at a later point in time. With the goal of meeting PM10 standards in 2011 and NO_2 Standards in 2015, the collective provincial, municipal and national governments initiated the Nationaal Samenwerkingsprogramma Luchtkwaliteit (NSL) on August 1st 2009 (Infomil, 2020). NSL made sure that future projects that would worsen air quality would have to be accompanied by mitigating measures. NSL also improved the national air quality monitoring structures in order

[56] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0050&from=NL
[57] NL: Wet Milieubeheer, https://wetten.overheid.nl/BWBR0003245/2019-11-14

to be able to report progress to the EU on an annual basis. After a 2016 Milieudefensie (Friends of the Earth Netherlands) subpoena and court case, over the fact that the State was not doing enough to meet air quality standards that was won by Milieudefensie, NSL was adapted. In 2020 the national government, together with 46 municipalities and provinces, adopted the "Schone Lucht Akkoord" (SLA), targeting to achieve the WHO guidelines by 2030 (Rijksoverheid, 2020). One of the pilots under SLA involves a CS pilot by the national government. In June 2020 an advisory commission to the government advised to decrease emissions of NO_2 and other nitrogenous substances by 50% by 2030 relative to 2019.

Air quality is monitored by the national government on the basis of calculations, not on the basis of measurements. The National Institute for Public Health and Environment however, (RIVM) does administer a national monitoring network of monitoring stations that measure air quality. Data from this national network are used as feedback and input for the models used for calculations. Regional Environmental Agencies (Omgevingsdiensten) supplement this national network with extra stations where spatial variance in air quality so requires. Local Health Agencies (GGD's) also have the possibility of adding stations to measure air quality. GGD's are further involved in advising their city on the health implications of poor air quality. Data from regional and local stations that deviate from official models can lead to model changes. This process towards the change of a model on the basis of local deviant information is lengthy per definition.

Technology for measuring NO_2, and PM2.5/10 in a cheap manner is improving (Mijling, 2019). For over a decade so-called Palmes Tubes have been an accepted instrument for measurement of NO_2 (Nguyen & Wesseling, 2016). Such tubes only gather monthly data points instead of the hourly data points of the national monitoring network. As such they are a useful instrument for measuring baseloads of pollutants, but are less suited for drawing conclusions on the exact source of pollutants. Low-cost sensors are in development for NO_2 as well as PM2.5/10. Such sensors gather data points every hour or minute and as such have more potential to inform policy makers. These sensors however did not reach the necessary level of accuracy yet and suffer from a.o. meteorological inaccuracies. Especially sensors for NO_2 are still fairly inaccurate. Because of their low costs CS-projects measuring NO_2. tend to use Palmes Tubes and low-cost sensors for monitoring air quality.

Appendix B: Types of CS-projects

Author	Definition	Goal (Wiggins & Crowston, 2011)	Role of Citizens
Bonney et al. (2009)	"*a research technique that enlists the public in gathering scientific information*"	• Investigation • Visual analysis	Active or passive sensors.
Irwin (1995)	"*a developing concept of scientific citizenship which foregrounds the necessity of opening up science and science policy processes to the public*"	• Education • Conservation	Participation in a transformative project and informative sessions to share local knowledge and get training.
Wiggins & Crowston (2011)	"*form of research collaboration involving members of the public in scientific research projects to address real-world problems*"	• Action	Participation in (the design of) an action-oriented project and advocacy of results.

Table 9: Types of Citizen Science Projects

Appendix C: interview guide

- **General introduction of the CS-project**

-How did your organization become involved in this project?

  - Existing relations with governments
  - Existing relations with other partners
  - Existing expertise

-What are the partners in the project and their respective roles?

- **Structural power of losing coalition**

-Was your organization involved in a CS-project prior to this project?

  - Technical expertise
  - Connections within a neighbourhood

-Has your organization been involved in air quality policy

  - Knowledge of policy subfield

-Is your organization known to the outside world as having expertise or societal backing?

- **Nature of subsystem**

-What are the specific air quality policies of importance to your organization?

-To what extent are non-government actors generally involved in formulating these policies?

  - Existing partnerships between governing coalition and other partners
  - Fluidity of these partnerships
  - Participation in actual decision-making

-To what extent is the governing coalition open to outside input?

-Is the policy societally sensitive?

- **Policy rationale**

-how does the project contribute to the change of air quality?

  - Reasons for this goal instead of other goals (opportunity structure)
  - Coherence in goals between coalition partners

- **Process**

-how did the municipality/province respond to the project?

  - Contributions of the governing coalition
  - Willingness to use or look at data

-Did you make changes to the project based on the response of the municipality/province?

- **Political impact**

-Did the government use your project outcomes in the policy process?

  - Different agenda
  - Different policy

-Did participants get more involved in air quality policy?

  - More connections with policy makers
  - More political/societal activities

-Did the government get more supportive of CS?

- New (government induced) CS-projects
- Financing for CS
- Partnerships between organization and governing coalition

Appendix D: Coding scheme

- **Coalition strength**
  - Material strength
  - Positional strength
  - Ideational strength
- **Collaborativeness of subsystem**
  - Deliberativeness/openness
  - Consensus
  - Societal cleavages
  - Fluidity
- **"opportunity"**
  - Policy rationale
  - Opportunity structure
- **Process**
  - Governing coalition counter-strategy
  - Strategy adaptation
  - Change in strength of coalition
- **Political impact**
  - Policy process
  - Political participation
  - Support for Citizen Science

Appendix E: List of interviewees

Interviewed organization	Interviewee function	Case	Date of interview
Municipality of Rotterdam	Project lead CS	Stadslab Luchtkwaliteit	21-04-2020
Municipality of Rotterdam	Advisor air quality	Stadslab Luchtkwaliteit	22-04-2020
Stimuleringsfonds Creatieve Industrie	Staffer action agenda spatial design	Stadslab Luchtkwaliteit	28-04-2020
Stadslab Luchtkwaliteit	Designer	Stadslab Luchtkwaliteit	05-05-2020
DCMR	Coordinator air quality Sr. air quality specialist	Stadslab Luchtkwaliteit/Milieudefensie	06-05-2020
Stadslab Luchtkwaliteit	Innovation consultant	Stadslab Luchtkwaliteit	12-05-2020
B.O.O.G.	President	Stadslab Luchtkwaliteit/Milieudefensie	26-05-2020
Stadslab Buiksloterham Circulair	Quartermaster	Hollandse Luchten	21-04-2020
Smart City Haarlem	Board Member	Hollandse Luchten	24-04-2020
Brak! Ijmuiden	Program Maker	Hollandse Luchten	15-05-2020
Municipality of Amsterdam	Policy advisor	Urban AirQ/Hollandse Luchten	29-04-2020
Province of North-Holland	Advisor environmental policy	Urban AirQ/Hollandse Luchten	29-04-2020
Milieudefensie Rotterdam	President	Milieudefensie	13-05-2020
Luchtwachters Delft	Luchtwachter	Milieudefensie	17-05-2020

RIVM	Innovation officer Environmental monitoring	All cases	08-05-2020

Table 10: List of Interviewees

Appendix F: Informed consent form

INFORMED CONSENT FORM

Project Title	ACTION
Name of Researcher	Jurre Honkoop (BSc)
Organisation	Dutch Research Institute for Transitions, Erasmus University Rotterdam
Name of Sponsor	European Union, H2020, grant agreement: 824603
Purpose of the Study	This research is being conducted in the context of a broader research project that seeks to develop a toolkit containing a mix of methodologies, methods, approaches and tools to support citizen science throughout its whole lifecycle. Specifically, this research aims to understand how Citizen Science projects aim to make political impact within their political context.
Procedures	You will participate in an interview lasting approximately 45 minutes. You will be asked questions about different aspects related to the political impact of the citizen science project that you are involved in. You must be at least 18 years old.
Potential and anti-cipated Risks and Discomforts	There are no obvious physical, legal or economic risks associated with participating in this study. You do not have to answer any questions you do not wish to answer. Your participation is voluntary and you are free to discontinue your participation at any time.
Potential Benefits	As a result of participating you may better understand your own involvement in citizen science and the role of citizen science in and for broader sustainability transitions. The broader goal of this research is making citizen science more participatory and inclusive.
Sharing the results	The interview summary will be provided to you within two weeks after the interview for you to check for factual errors and consent with or adapt the direct quotes included. The final thesis and, if desired, the toolkit for community engagement that is one of the outcomes of this research will be shared with you upon finalization. If wished, also academic publications will be shared.
Confidentiality	Your privacy will be protected to the maximum extent allowable by law. No personally identifiable information will be reported in any research product. Moreover, only trained research staff will have access to your responses. Within these restrictions, results of this study will be made available to you upon request. As indicated above, this research project involves making audio recordings of interviews with you. Transcribed segments from the audio recordings may be used in published forms (e.g., journal articles and book chapters). In the case of publication, pseudonyms will be used. The audio recordings, forms, and other documents created or collected as part of this study will be stored in a secure location in the researchers' offices or on the researchers password-protected computers and will be destroyed within five years of the initiation of the study.

Compensation	Not applicable.	
Right to Withdraw and Questions	Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalised or lose any benefits to which you otherwise qualify. If you decide to stop taking part in the study, if you have questions, concerns, or complaints, or if you need to report an injury related to the research, please contact the researcher. Jurre Honkoop (BSc), 527493jh@student.eur.nl	
Statement of Consent	Your signature indicates that you are at least 18 years of age; you have read this consent form or have had it read to you; your questions have been answered to your satisfaction and you voluntarily agree that you will participate in this research study. You will receive a copy of this signed consent form. If you agree to participate, please sign your name below.	
Audio recording (if applicable)	I consent to have my interview audio recorded ☐ yes ☐ no	
Secondary use (if applicable)	I consent to have the pseudonymized data be used for secondary analysis ☐ yes ☐ no	
Signature and Date	NAME PARTICIPANT	NAME RESEARCHER
	SIGNATURE	SIGNATURE
	DATE	DATE

Appendix G: List of additional documents per case

Milieudefensie

Interview with Joris Lam (former CS participant):
https://gr1p.org/blog/politiekvanluchtkwalitiet/de-politiek-van-luchtkwaliteit-interview-serie-deel-5-joris-lam/

Interview with Ivo Stumpe (Former employee of Milieudefensie):
https://gr1p.org/blog/politiekvanluchtkwalitiet/de-politiek-van-meten-interview-serie-ivo-stumpe/

Final report of the 3rd measurement campaign:
https://milieudefensie.nl/actueel/rapport-wat-adem-jij-in.pdf

DCMR report on the profile of CS-participants:
https://www.dcmr.nl/publicaties/burgermeetproject-rijnmond-wie-doet-er-mee-en-waarom.html

Final report of the 2nd measuremennt campagin:
https://aireas.files.wordpress.com/2014/10/milieudefensie-rapport-hoe-gezond-is-onze-lucht-20140626.pdf

Milieudefensie article on the impact of Milieudefensie on the Nationaal Samenwerkingsprogramma Luchtkwaliteit:
https://milieudefensie.nl/actueel/aanpassing-nsl-nationaal-samenwerkingsprogramma-luchtkwaliteit

Final report of the 1st measurement campagin:
http://www.utrechtanders.nl/wp-content/uploads/2009/10/Zelf-meten-is-zeker-weten.pdf

Article of the residents' organization of Valkenburgstraat on air quality in their street:
https://valkenburgerstraat.wordpress.com/

Hollandse Luchten

Report of the first data-analysis meeting:
https://hollandseluchten.waag.org/een-verslag-van-de-eerste-hollandse-luchten-dataverkenning/

Description of the project by the province of North-Holland:
https://www.noord-holland.nl/Onderwerpen/Duurzaamheid_Milieu/Hollandse_Luchten

News article on the Ijmond pilot:
https://www.nhnieuws.nl/nieuws/244334/zelf-luchtkwaliteit-meten-in-de-ijmond-waarom-deze-poppenkast

News article on Hollandse Luchten:

https://www.parool.nl/nederland/noord-hollanders-gaan-zelf-fijnstof-meten~ba8afef6/

Project description by Stadslab Buiksloterham circulair:
https://buiksloterham.nl/bericht/38337/hollandse-luchten-in-buiksloterham-

Urban AirQ

Documentation of work in Amsterdam:
https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5b5759da9&appId=PPGMS

Final report:
https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5b9596f8c&appId=PPGMS

Report of meeting with government authorities:
https://valkenburgerstraat.wordpress.com/2016/05/30/ggd-etaleert-duidelijke-visie-op-urban-airq/

Making Sense Citizen Sensing Toolkit:
http://making-sense.eu/wp-content/uploads/2018/01/Citizen-Sensing-A-Toolkit.pdf

Making Sense Urban AirQ project description:
http://making-sense.eu/urban-airq-citizens-measuring-air-quality-themselves/

Academic article Mijling (2019) on the value of low-cost sensors for environmental monitoring:
https://www.atmos-meas-tech-discuss.net/amt-2019-410/

Interview with Waag employee:
https://gr1p.org/blog/de-politiek-van-luchtkwaliteit-interview-ivonne-jansen-dings/

Interview with Bas Mijling (KNMI):
https://gr1p.org/blog/politiekvanluchtkwalitiet/de-politiek-van-luchtkwaliteit-interview-serie-deel-3-bas-mijling-knmi/

Interview with Dave de Jonge (GGD Amsterdam):
https://gr1p.org/blog/politiekvanluchtkwalitiet/de-politiek-van-meten-interview-serie-dave-jonge-ggd-amsterdam/

Interview with Joris Lam (former participant Urban AirQ)
https://gr1p.org/blog/politiekvanluchtkwalitiet/de-politiek-van-luchtkwaliteit-interview-serie-deel-5-joris-lam/

Appendix H: Adapted operationalization of conceptual variables

Coalition strength	Material strength	Quality of CS-data	Perceived scientific quality and societal use of CS-data.	Schlager (1995), Pustovitovskij & Kremer (2011)
		Connections with the governing coalition	Amount and perceived strength of ties between governing coalition and CS-coalition.	
		Connections with other societal actors	Amount and perceived strength of ties between CS-coalition and other societal actors.	
	Positional strength		Perceived applicability of the work of a CS-project and its coalition partners to a specific policy problem.	Pustovitovskij & Kremer (2011)
	Ideational strength	Scientific legitimacy	Perceived scientific legitimacy of a CS-project and its coalition partners.	Pustovitovskij & Kremer (2011)
		Public legitimacy	Perceived public legitimacy of a CS project and its partners.	Pustovitovskij & Kremer (2011)
		Trustworthiness	Perceived trustworthiness of a CS-project and its coalition partners.	Pustovitovskij & Kremer (2011)
Political impact	Policy process impact	Policy process	Expectation of directly influencing a specific policy process through changing policies.	Turbé et al. (2019)
		Agenda	Expectation of directly influencing a specific policy	Turbé et al. (2019)

			process through changing policy agendas and discourses.	
		Support for political participation	Expectation of contributing to a government willingness to involve citizens or CS participants in future policy processes.	
	Political participation	Breadth of political participation	Expectation of empowering and activating CS participants and the broader public to get involved in a specific policy subsystem or contribute to self-governance within this subsystem.	Kieslinger et al. (2017) Göbel et al. (2019) Farrington and Bebbington (1993)
		Width of political participation	Expectation of adding to the broader public's passive support for new policy within a subsystem.	Farrington and Bebbington (1993)
	Support for Citizen Science	Government support for Citizen Science	Expectation of contributing to the trust in and perceived legitimacy of CS among government authorities or the development of partnerships between decision makers and CS-projects, within a specific policy subsystem.	Roger et al. (2019)

	Citizens' support for Citizen Science	Expectation of contributing to the trust in and perceived legitimacy of CS among citizens or new participation in or development of CS-projects by citizens, active within a specific policy subsystem.	

Table 12: Adapted operationalization