“We do not measure for fun”

The Motivations of Stakeholders Participating in Citizen Science:

A Single Case Study on an Air Pollution Project

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Master thesis

25th of August, 2023

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Word count: 14511

Abstract

Citizen science projects often involve a diverse group of stakeholders beyond the citizens and the scientists. These stakeholders, organizations involved in citizen science who contribute with a vested interest in the project, and eventually benefit from the research activities and produced data, participate on various levels as they support, guide, or share their expertise. Existing literature on stakeholder motivation predominantly examines the motives of scientists, resulting in an incomplete understanding of the citizen science stakeholder landscape. This study considers various stakeholders involved, providing an insight into the diverse motivations driving these participating organizations.

This qualitative research employed a single case study approach following a citizen science project which aims at addressing the issue of air pollution. Various stakeholders are involved, all with distinct roles and expertise. To discover their motivations for participation, non-participant observations during project meetings and interviews with the involved stakeholders were conducted. Representatives from research organizations, municipalities, civil society organization, and the province participated in this study, resulting in nine different semi-structured interviews.

This study discovered an interplay of various stakeholder motivations, where a total of 13 motives were discovered, categorized into four themes. Collectively, these themes illustrate that stakeholders are motivated by a combination of curiosity, data collection, shared learning, connection-making, and personal driving factors. The two dominant motives, capturing knowledge and experience in citizen science and affiliation with the project goals, showcase the intertwinement between organizational and the representative's motivation in stakeholder participation. Their shared belief in the project's objectives, its explorative approach, and the potential impact on public understanding emphasizes the stakeholders' enthusiastic involvement and personal commitment. This active engagement highlights their curiosity about the project possibilities, potentially enriching their professional domains, as well as the personal desire to contribute to the public understanding of air quality issues.

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1. Introduction

In the past two decades, volunteer engagement in science has taken a big leap forward. Various approaches of public understanding and engagement in science, crowdsourcing, and community science have come together as the concept of citizen science (Hecker et al., 2018). At its core, citizen science is viewed as a partnership between volunteers and scientists in scientific research (Skarlatidou et al., 2019), and is becoming a more mainstream approach to collecting data across various scientific fields (Tiago, 2016). Nowadays, citizen science projects number thousands worldwide, where platforms foster their visibility and establish networks for knowledge exchange within the community (Hecker et al., 2018). Several governments and policy organizations are starting to support citizen science, creating a shift in the actors involved in these projects. Besides the 'original' citizen and scientist, a wide range of stakeholders are frequently engaged in these initiatives (Skarlatidou et al., 2019). Stakeholders, organizations that contribute to the citizen science project with a vested interest, and eventually benefit from the research activities and the produced data (Göbel et al., 2017), encompass a broad spectrum including government agencies, civil society organizations, businesses, primary learning situations and research organizations(Göbel et al., 2017). Their motivations and interactions can be determinants for the success of the citizen science project (Tiago, 2016), as their engagement can improve the social relevance of the research, or enhance the adoption of the results and knowledge (Garrison et al., 2021). The impact of stakeholder engagement goes beyond the research itself, as it is also favorable for the individuals involved. Their participation can shape attitudes that value science as part of cultural development, and enable an active role of scientists and citizens in social debates (Garrison et al., 2021).

In the context of citizen science projects, involved stakeholders provide a diverse contribution and participate in various governance models. Often, stakeholders find themselves having an initiating or coordinating role in the project (Pettibone et al., 2017). Furthermore, they undertake responsibilities ranging from project support, decision-making, data utilization, or leading the project (Gobel et al., 2017). However, despite their substantial involvement, there is no extensive research on why stakeholders are willing to take on these roles in citizen science. This provides an opportunity to investigate the motivational factors driving their participation in these projects, exploring the following research question in this study:

What are the motives of stakeholders to participate in citizen science projects?

Existing literature on stakeholder motivation predominantly examines the motives of scientists, where 'advancing scientific knowledge' is the most common motive (Geoghegan et al., 2016). However, exploring motivations among other stakeholder groups may shed light on various other strategic, societal, and organizational factors influencing their participation. When doing so, motives such as engagement with external audiences and meeting charitable objectives were discovered in the study of Geoghegan et al. (2016), one of the few studies to be known to incorporate other stakeholder groups besides scientific organizations in their study. As citizen science is becoming more mainstream, the motivational range has expanded from pure data collection to additional ways in which participants or stakeholders benefit from the initiative. Geoghegan et al. (2016) highlight the importance of personal motives to join the project, as the motivation of the representative may be embedded with institutional motives.

To highlight the complexity of stakeholder motivation, this qualitative research followed a citizen science project for five months, resulting in a single case study applying the method of observation and interviews. A diverse group of stakeholders was involved in this study, as representatives from research organizations, municipalities, a civil society organization, and the province participated on behalf of their organization. By engaging with a wide variety of involved stakeholders, this study aims to capture their diverse perspectives on their involvement in the citizen science project. By doing so, the literature on stakeholder motivation in citizen science will broaden, as it reduces the necessity of relying on scientists' motivations as the foundation.

2. Theory

This chapter will explain the theories and concepts used to eventually lay out the motives of stakeholders collaborating in citizen science. At first, a general overview of citizen science will be given (2.1), followed by an explanation of the levels of participation of involved individuals (2.1.1). Second, the involved stakeholders in citizen science will be laid out (2.2). In the last section of this paragraph, motivation on participation will be explored (2.3)

2.1 Citizen science

Haklay et al. (2021) state that citizen science comprises three main factors: the generation of scientific data, engagement with the public, and addressing a politically relevant issue. However, numerous studies question the criteria for qualifying as a citizen science project, as well as their definitions and terminology. This is evident in the usage of terms like Public Participation in Scientific Research (PPSR), amateur science, participatory science, and civic science while discussing projects using the citizen science approach (Haklay, 2015). In this study, citizen science is defined as per the US Crowdsourcing and Citizen Science Act, which describes citizen science as a form of open collaboration in which individuals or organizations participate in various ways within scientific research (Haklay et al., 2021). Their involvement can span various processes, including 1) Formulating research questions 2) Refining project design 3) Conducting scientific experiments 4) Collecting and/or analyzing data 5) Interpreting the data results 6) Developing technologies and applications 7) Making discoveries 8) Solving problems. This public contribution to science, on both individual and organizational levels, results in a positive influence on citizen science democratization (Irwin, 2015), as it gives universal access to scientific data and information. With the facilitation of technological and societal changes, the scale and possibilities of citizen science is more significant than ever before. However, citizen science projects can be traced back to the 17th century with weather and nature observations (Hakley, 2015).

In practice, citizen science has been revived by the emergence of extended models of peer communities and governance, new technologies, education approaches, and increased enthusiasm for more open participatory science (Semjanová, 2020). As a result, citizen science is gaining ground in different scientific disciplines and domains, along with multiple associated practices (Haklay,

2015). These practices allow for a distinction within the citizen science field: the aim for scientific output or scientific outreach at the beginning of the project. According to Bonny and Ballard et al. (2009), scientific output addresses scientific articles on citizen science in peer-reviewed journals, whereas scientific outreach is more focused on the learning processes regarding science with the people involved. Examples include informal science learning, increasing scientific literacy, and/or creating more topic knowledge (Curtis, 2015). Whether the citizen science project is more focused on scientific output or outreach is based on the eventual goal of the initiative, which also determines the level of participation of the involved individual or organization.

2.1.1 Levels of participation

Citizen science projects differ in the levels of participation of involved individuals based on the researched topic and eventual goal. Participation levels, defined as '*the extent to which individuals are involved in the process of scientific research* (Shirk et al., 2012, p.4), include five categories 1) Contractual 2) Contributional 3) Collaborative 4) Co-creation 5) Collegial (Shirt et al., 2012). In the contractual project, the public participates through a mutual question or concern that researchers often would not have considered. This contributes to the expansion of original scientific research, as it shifts the interest of researchers to consider the questions and interests of the community. On the other end of the spectrum are the collegial citizen science projects, where the individual contributes fully on his own, and the voice of the expert will only be gathered for peer review or publication (Shirk et al., 2012). However, these papers mostly go unpublished in academic literature (Walker et al., 2021), which questions the actual contribution of these studies. In addition, it also raises questions to what extent this type of research still can be called citizen science, as it blurs the line between amateur and professional research (Walker et al., 2021). For the remaining types, contributional, collaborative, and co-created, their definition varies mostly on the eventual goal of the project. In contributional citizen science, the research project is set up by scientists while members of the public primarily contribute the data. In collaborative projects, the individuals assist scientists in the development of a study, as well as collecting and analyzing data for shared research goals. Often, participatory modeling is practiced in collaborative projects (Walker et al., 2021). These aspects can also be applied to co-created projects, which makes a distinction difficult. However, according to Walker et al. (2021), it is the degree of control that differentiates the two. In their study,

the degree of control refers to the control the professional scientist, the leader of the project, and the participant have in the project. Regarding collaborative projects, the professional scientist still prevails in the project, whereas in co-creation their control in the project is equal. Often, collaborative and co-created projects are seen as the pathway to achieving the potential benefits that citizen science projects carry (Haklay, 2013; Walker et al., 2021).

The preceding section discusses the diverse collaborative structures found in citizen science projects, focusing on the interaction between researchers and the general public. As evident in paragraph 2.1, the public involved in citizen science projects are not only individuals but also organizations that actively participate in such initiatives. The following paragraph will elaborate on the diverse organizations and their roles, in this study referred to as stakeholders.

2.2 The role of stakeholders

In this study, stakeholders refer to organizations contributing to a citizen science project with a vested interest, ultimately benefiting from the research activities and the data produced (Göbel et al., 2017). Understanding the involved stakeholders in citizen science projects influences the eventual success of the initiative (Skarlatidou et al., 2019). However, studies focusing on the various stakeholders involved in citizen science projects are scarce to date. One of the few is the study of Göbel et al. (2017), who conducted a stakeholder analysis of 16 citizen science projects and identified five distinct stakeholder groups that can be counted as an organization: 1) Civil society organizations, informal groups, and community members 2) Academic and research organizations 3) Government agencies and departments 4) Formal learning institutions 5) Businesses or industries. In line with this are the findings of Skarlatidou et al. (2019). In their study, they researched the involvement of stakeholders through three case studies, which led to identifying the involvement of the same five stakeholder groups as the study of Göbel et al. (2017). However, the roles and motivations behind these groups' participation in citizen science remain obscure. The study of Pettibone et al. (2017) suggests that certain stakeholder groups have the role of the project initiator and coordinator. Scientific institutions were found to be the biggest initiators in citizen science projects, followed by civil society organizations. Last, government and media organizations were responsible for a smaller amount of projects. Stakeholders having an initiating and coordinating role

in citizen science projects are in line with the findings of Göbel et al. (2017), who suggest that stakeholder groups provide a diverse contribution and are involved in various governance models within the project. Their study states that stakeholders have the role of leaders of the project, decision-makers, collectors, and/or users of the eventual data or are involved in project support. Decision-making refers to the project's design and implementation, whereas the collected data in the project might be understood and re-used by various stakeholders working on other related topics. Their interest may lie in the project's quantitative data, measurements on air quality, or light pollution for example. However, there are various other relevant data outputs that citizen science projects generate which might be an interest to stakeholders as well. Examples are data on involved participants, the project's development, programming, and gained skills. The fourth and last role discussed by Göbel et al. (2017) is the role of project supporter, which can take various forms. Here, support can be in the form of invested time, funding, expertise, or delivering equipment. While the stakeholder's role may appear district, they often have multiple roles within the project.

The previously mentioned roles were found to differentiate among different levels of participation in the citizen science project (Göbel et al., 2017). As seen in the evident paragraph (2.1.1), there are five distinct levels of participation in citizen science projects. The participation level influences the degree of control between the public and the head of the project and is often determined by the project goal. So did Göbel et al. (2017) discover that *academic and research organizations* and *civil society organizations, informal groups, and community members* are overall the most involved in citizen science projects of all levels, having various roles throughout these projects. *Businesses and industries* are the least involved of all indicated stakeholder groups. Table 1 shows stakeholder groups and their roles per participation level in citizen science, as discovered in the study of Göbel et al. (2017).

Table 1

Stakeholder roles per participation level (Göbel et al., 2017).

Stakeholder group	Participation level	Lead project	Decision making	Data collectors / users	Project support
Civil society organizations, Informal groups, community members					
	Contractual			X	X
	Contributory			X	X
	Collaborative	X	X	X	X
	Co-created	X	X	X	X
	Collegial		X	X	X
Academic / research organizatoins					
	Contractual	X	X	X	X
	Contributory	X	X	X	X
	Collaborative	X	X	X	X
	Co-created	X	X	X	X
	Collegial	X	X	X	X
Government agencies / departments					
	Contractual			X	
	Contributory	X	X	X	X
	Collaborative		X	X	X
	Co-created		X	X	X
	Collegial			X	
Formal learning institutions					
	Contractual				
	Contributory			X	X
	Collaborative		X	X	
	Co-created		X	X	X
	Collegial			X	
Industries / businesses					
	Contractual			X	
	Contributory			X	X
	Collaborative				
	Co-created		X	X	X
	Collegial				

2.3 Participation motivation

Citizen science studies often focus on the reasons why individual citizen scientists participate, but research on the organizational motives of the stakeholders involved is lacking (Pera et al., 2016). Numerous theories on motivation exist in the citizen science literature, many of which are connected to voluntary participation. According to Roy et al. (2012), this linkage is a result of institutions rebranding volunteering opportunities as citizen science activities. Consequently, literature on motivation in volunteerism is found to be highly relevant to citizen science projects. This trend is observable in major research institutions, such as NASA, which refers to their science program volunteers as 'citizen scientists' on their official website (NASA, 2023).

To answer the research question of this study, the concept of motivation in a citizen science context must first be understood. To do so, a paragraph is dedicated to motivation and citizen science (2.3.1), followed by an overview of theories on stakeholder motivation in citizen science (2.3.2). A consideration of these works will help shed light on why people and organizations are willing to be part of citizen science projects, which eventually provides a motivational framework (2.3.3) to consider further.

2.3.1 Motivation and citizen science

Motives are defined as *'goal-directed forces induced by threats or opportunities related to one's values.'* (Batson et al., 2002, p. 430). In addition, motives are the function of individual values and the nature of the given situation. For example, if an individual has a negative association between their expectation and the reality of the situation, they will probably set a goal to achieve their desired state. To achieve this, four underlying drivers are identified by Batson et al. (2002):

1. Egoism. Acting to increase own welfare.
2. Altruism. Increasing the welfare of others, apart from oneself.
3. Collectivism. Increasing the welfare of a group or collective, directly focused on the 'common good
4. Principlism. Motivated by the ultimate goal of upholding moral principles, justice for example.

Frequently, theories on motivation are applied to the citizen science context (Nov et al., 2011; Raddick et al., 2010; Roman et al., 2012; Sabu, 2020). So did Rotman et al. (2012) use the foundational drivers identified by Batson et al. (2002) to uncover motivational factors influencing the degree of participation in citizen science projects. Although the framework could explain some of the motivational premises found in the study of Rotman et al. (2012), it did not translate well to the citizen science context. This is because these types of projects are inherently complex activities, extended over a lengthy period where multiple tasks are involved. As a result, motivations change over time and some become particularly prominent at the specific point where activities and decision-making intersect. The given example indicates that not all literature on volunteering and motivation apply to citizen science research, because of the unique motivational factors linked to them (Rotman et al., 2014). Their discovered motivations differ widely due to the project's goal, setup, and length. Roy et al. (2012) emphasize respect for these wide motivations participants have in citizen science projects. This is because not all participants are open to modifying their activities to participate in these projects. As citizen science is used for professional consultancy, citizen science should be innovative to combine high-quality and useful data while still being attractive to the volunteering community. According to Roy et al. (2012), volunteers are motivated by the enjoyment of participating as well as the discovered data being practicable.

Raddick et al.'s (2010) study holds a prominent place in motivational research in the citizen science context. Their Galaxy Zoo citizen science projects asked citizens to classify galaxies. Over 200,000 volunteers made more than 100 galaxy classifications, identifying twelve distinct motivational categories. Several unique motives for the project were discovered, among these were beauty, vastness, and astronomy. Additionally, the study also revealed more general motives such as contributing, learning, discovery, community, teaching, fun, vastness, helping, and science which apply to other citizen science projects as well. Another frequently cited study in citizen science motivation research is from Nov et al. (2011, 2014). Their first conceptual model from 2011 includes the four original dimensions of Klandersmans' (1997) framework on volunteer motivation for participation but introduced the fifth dimension of intrinsic motivation. Also, when laying his framework next to Batson et al. (2002), overlapping categories can be found. Ultimately, Nov et al.'s framework aims to clarify the behavioral intention of involved participants, leading to their

contribution to citizen science projects. Below, an overview and description of the framework of Nov et al. (2014) can be found.

1) Collective motives. Associated with the motivation of the individual to join a project because of the importance they attribute to the project goal.
2) Norm-oriented motives. When the individual is motivated by the reactions of significant others, which include family, friends and colleagues.
3) Identification. When the individual identifies himself with the social group and the affiliated norms.
4) Intrinsic motives. The enjoyment of the individual that is associated with their participation in the project in studies of participation.
5) Reward motives. Benefits from participating, which varies from gaining reputation to making new friends.
    I. Community reputation benefits
    II. Social interaction benefits

The literature above elaborates on the various motives behind citizen science participation, indicating that not all literature on volunteering and motivation applies to citizen science projects. Specific theories are needed, and by embracing this complexity of motivations, citizen science projects can effectively utilize the power of their participant's contributions. However, as seen, not just individuals are participating in citizen science projects, organizations are also actively involved in these initiatives. Thus, the following paragraph will delve into stakeholder motivation theories specifically tailored to the citizen science context.

2.3.2 Stakeholder motivation in citizen science

There is no extensive research on stakeholder motivation in citizen science, resulting in only three clear examples found. Petra et al. (2016) identified three general motives of stakeholders to be involved in co-creation tasks. Their study states that citizen participants vary considerably in their ability to engage and interest in the subject, and is believed stakeholders do the same. However, their study suggests that the motivation of participation is mostly identified as intrinsic motivation,

whereas stakeholder motivation is mostly extrinsic focused in terms of long and short-term goals and specific externally derived objectives. The three motives include 1) Reputation enhancement motives, outcome-oriented attitude, related to the specific business purpose 2) Experimentation motives, related to the spark to develop feasible solutions and ignite design 3) Relationship motives, relates to building a sense of bonding in the stakeholder ecosystem.

The second study by Pedrosa et al. (2009) highlighted the motivations of stakeholders being involved in co-created innovations. According to their research, the easiest way to motivate stakeholders is to offer financial incentives to compensate for their expenses. In here, expenses are referred to as time and effort, offering knowledge and expertise, or taking over development risks. However, financial compensation does not ensure the engagement of stakeholders according to Pedrosa et al. (2009). Four additional factors were found that motivate stakeholders to engage in these types of projects: 1) Reducing risks 2) Building new relationships 3) Developing new knowledge 4) Building new capabilities.

The third discovered study on stakeholder motivation is by Geoghegan et al. (2016). They interviewed 18 stakeholders in the science, policy, and practice field. Their research drew upon literature on scientists' motives to participate, eventually incorporating motives discovered from interviewing other stakeholders. Their findings suggest that the primary motivation for stakeholders is to advance scientific knowledge. However, multiple other motivational categories were discovered. In addition, their study also suggests that the personal satisfaction of the individual was a significant motivation to participate in the citizen science project. For instance, enjoying their work, fulfilling career objectives, building on previous education, impacting people's lives, working with unpaid experts, and harnessing their enthusiasm for science and their ambition (Geoghegan et al., 2016). Below, the findings of Geoghegan et al. (2016) study on stakeholder motivation in citizen science are laid out.

1) Science contributing motive
    I. Need for open data
    II. Unrestricted work for academic funding landscape
2) Policy motive
    I. Develop of sustainable solution for monitoring

II. Fulfill specific evidence need

3) Information motive on land management and conservation
4) Educational motive
    I. Connect people with nature
5) Buy in improving motive
    I. Facilitate involvement in surveillance in a managed way
6) Awareness and engaging motive. To inform citizens on certain issues, resulting in sense of ownership, shared responsibility, concern and stewardship.
7) Partnerships and improve communication motive
    I. Engage with external audiences interested in institution
    II. Meet charitable objectives (Including education and communication)

Although existing research in this domain is limited, the previously described studies lay a foundation for understanding the diverse motivations for stakeholders to participate in citizen science projects. This research will contribute to expanding this research field, with the potential to create a deeper understanding of these various dynamics. To do so, the following paragraph will provide a structure based on the evident theories, creating a theory-based foundation which is considered further throughout this study.

2.3.3 Motivational framework

The described literature sheds light on the motivation behind individual and stakeholder participation in citizen science projects. The difficulty in understanding stakeholder motives, and organizational motives to join citizen science projects, is that personal motives are often intertwined. This is found in the study by Geoghegan et al. (2016) by emphasizing the important influence of personal satisfaction as a motive to join the project. Therefore, the diverse aspects of stakeholder motivation will be examined, considering the potential impact of personal motivation as well. Recognizing these motives may provide a better understanding of the multi-faceted nature of why stakeholders participate in citizen science. To do so, the previously described frameworks will be combined into a structure suitable for this study. The groundwork will eventually be used as a guideline, to ensure a well-provided base for the interview questions. For both motivational

categories, organizational and individual, it was important to create broad categories to allow motives to arise naturally during the interview.

Organizational motivation

The choice was made to use the study of Geoghegan et al. (2016) as a base for discovering organizational motivation. This is because it has clearly distinguished aspects, while still having room for own interpretation of the motive. However, some motives were not included in the eventual framework. The motives of “buy in” and the “information motives on land management and conservation” were found too specific and can be categorized under the broad motive of policy as well. Furthermore, the motive of “partnership and improve communication” was traded for the more general “relationship motive” from Pera et al. (2016). By doing so, it ensures that the participant of the interview is not pushed too much into a certain direction, which leaves room for their interpretation of the question. In the end, this leads to the following motives: 1) Contributing motives in terms of education, science, and/or policy 2) Awareness and engaging motives 3) Relationship motives.

Personal motivation

Klandermans (1997) voluntary motivation theory to join social movements was put in the context of citizen science by Nov et al. (2011, 2014). Because of this, the choice was made to take their framework as a base to discover personal motives. While taking the statement of Roy et al. (2012) in mind, to respect the wide motives participants may have to join the project, it was found that Nov et al. (2011, 2014) ensured an environment welcoming all answers without creating a specific direction. Because of that, this leads to the following personal motives for interview questions: 1) Collective motives 2) Intrinsic motives 3) Norm-oriented motives 4) Identification.

Previous experience in citizen science

In the study of West and Pateman (2016) 'dispositional variables' refer to non-standardized demographics that possibly influence the individuals' likelihood of participating in citizen science projects. In their study, they mentioned that the differences in skill and experience level affect

participation. This research will explore the possible influence of this demographic to identify if it affects the respondents motivation to participate in citizen science.

Table 2

Structure of motivational categories for interview questions.

Motive	Type of motives	Definition
Organizational	Contributing motive	Contributing to science, policy or education when participating
	Relationship motive	Build new relationships through the project
	Awareness and engaging motive	To inform citizens on certain issues, resulting in sense of ownership, shared responsibility, concern and stewardship
Personal	Norm-oriented motives	When the individual is motivated by the reactions of significant others, such as family, friends or colleagues
	Identification	When the individual identifies himself with the social group and the affiliated norms
	Intrinsic motives	The enjoyment of the individual that is associated with their participation in the project
	Collective motives	Associated with the motivation of the individual to join a project because of the importance they attribute to the project goal
	Previous experience	Having experience with citizen science before their involvement with the followed project of this study

3. Methodology

In the following paragraphs an explanation is given on how the research was executed. At first, the research design (3.1) will be described, followed by an explanation of the analyzed citizen science project (3.2). Furthermore, a description of the respondents (3.3) and the data collection (3.4) will be given. The methodology section concludes with the data analysis (3.5).

3.1 Research design

To identify stakeholder motives to participate in citizen science, qualitative research was conducted. This research adopted a case study approach, a method often applied to conduct research in natural and social sciences (Yin, 2003). The case study method focuses on one entity, such as an individual, organization, event, or project, which eventually can be examined in-depth and from many angles. This type of research design can be used to gain a rich picture of real-life circumstances, which eventually will help to obtain analytical insights (Yin, 2003). Also, case studies can generate or refine existing theories by identifying patterns, due to the more careful approach the study is made with (Yin, 2003). To analyze a case study in great detail, multiple sources of evidence are used. As a result, this leads to a 'chain of evidence' that can be used to answer the research questions of the study (Curtis, 2015). Various types of evidence can be used in a case study, including interviews, diaries, personal accounts, archives, observations, statistics, and questionnaires (Curtis, 2015).

This study focused on a single case, where it applied the method of observation and interviewing. According to Yin. (2003), single case studies create a deeper understanding of the explored subject, resulting in a rich description of the studied phenomenon. Given the limited amount of literature and therefore understanding of stakeholder motivation in citizen science, this research design is found applicable. In addition, Yin. (2003) discusses that single case studies are the most appropriate for research aiming to understand one individual or a group of people. As this study's focal point is on a stint group of individuals, stakeholders, this approach was considered fitting. Finally, because of the study's constrained timeframe and the scarcity of similar citizen science projects to known, conducting multiple case studies was not achievable.

To eventually answer the research question, observation and interviewing were applied. Interviews and observations are fairly used methods in qualitative studies, where they have some

explicit structure in terms of theory or method. Typically it involves systematic, interactive coding of verbal data that is complemented by other data procedures (Blandford, 2013). For the interview questions, a semi-structured approach was found a suitable method as it will explore multiple views of participants on stakeholder motivations. In addition, it will provide the opportunity to explore prepared questions while also allowing room for spontaneous questions or interactions that may occur during the interview. Second, direct non-participant observations were applied. With this observation method, the opportunity is given to get closer to the research field while retaining the position of a guest or outsider (Ciesielska et al.,2018). However, the researcher's role and identity are defined to the attendees during this method, which results in social interaction during the time present.

3.2 The analyzed project

In this case study, the focus was on a single project which was followed for five months. The project required active citizen participation, as citizens measured air quality through sensor kits and Palmes tubes. The project was enrolled throughout several areas in the north of the Netherlands when it started as a pilot in the year 2018. At its core, the project aims to address the issue of pollution, as well as to experiment with a new type of collaboration between citizens and the government. As a result, a platform, the project itself, is established where citizens, municipalities, research institutions, and other partners can develop knowledge and conduct dialogue on a healthy environment in their region. Nowadays the project has 4 measurement regions, consisting of 10 measurement groups through various areas. The project was founded by the province, making it the commissioning and funding party. Meanwhile, five project partners, stakeholders, were invited to participate in the project based on their expertise regarding air quality, sensor technology, or data analysis. The stakeholders and citizen participants come together numerous times a year to talk about their findings or participate in informational gatherings on a requested topic. These meetings are accessible to anyone who is interested, and people can join throughout the year at any time.

Co-creation method

The analyzed citizen science project adopted the co-creation level of participation throughout its duration. In the context of citizen science, co-creation refers to the public assisting in the

development of a study, as well as collecting and analyzing data for shared research goals (Walker et al., 2021). In addition, co-creation is an inclusive approach used to gather various societal actors around matters of shared concern (Kamst, 2019). A crucial aspect of this participation level is the degree of control between the participating public and the initiative taker of the project. By embracing co-creation, the project welcomed both the public and stakeholders, creating a welcoming environment for collaboration based on equal contributions and shared responsibility.

This collective decision-making and contribution could be found in the project's open access meetings, of which five types were distinguished: 1) Start-up meeting 1, creating measurement questions 2) Start-up meeting 2, creating a measurement strategy 3) Data analysis meeting after 3 months 4) Data analysis meeting after 12 months 5) Informational gatherings by requested topic. The project's decision-making is a continuous collective process, including choosing suitable research questions to identify relevant sensor locations in the area. As a result, a community within the project was built that would come up with its own goals, measurement strategy, and data analysis. All this was guided by the involved stakeholders in terms of sharing knowledge, giving advice, and eventually helping the citizens understand their measurements.

The co-creation method extends to the organizational aspects of the project as well. All stakeholders involved are arranged in three types of workgroups, communication, technical, or data science groups. While some stakeholders were in one specific workgroup, others had a seat in multiple. Within these groups, stakeholders discussed various facets. For example, they deliberate how to structure the upcoming project meeting, the functionality of the sensors, or address emails from participation with questions. Also present in these meetings was a 'community hero', this citizen is an active involved community member in the project. Often, this individual is the first point of contact for the other citizen participants regarding questions. Interestingly, the project website highlights that these individuals have the feeling of co-ownership towards the measurement network, indicating a strong bond with the project itself as well as the community. Lastly, these meetings were open to anyone interested, maintaining the equal degree of control that is a key point in the co-creation method.

3.3 Respondents

This study gathered qualitative data through citizen science meeting observations and semi-structured interviews. Table 3 gives an overview of the interviewed respondents, the role of their organization within the project, and their previous experience in citizen science. Their role is based on the information on the project's website, as well as on the obtained knowledge during the interviews. While for all institutions their role in the project was very clear, the role of the municipalities could not be specified besides being involved as a regional area in the project. The project website does not identify them as project partners on their website, and also during the interviews they could not give a clear picture of their role in the project. Answers such as 'being there for the citizens of our municipality' or 'supporting the project' were common answers. Because of this, their role states 'not specified' in Table 3.

3.3.1 Previous experience in citizen science

The characteristic of previous experience in citizen science was introduced to the interview structure to assess its potential influence on the representative's motives to participate. In the interviews, interviewees were questioned if they had any prior experience with citizen science *before* joining the current project they are involved in now. Respondent E mentioned that she worked with a citizen science approach in her thesis. In her research, she used dialogues and conversations with the citizens to gather local knowledge about the area. Because this is not in line with the definition of citizen science this study uses, her previous experience characteristic is indicated as a 'no'. In addition, respondent G previously worked for another municipality also involved in the project, where she also worked as the representative on behalf of her municipality. However, because she did not have experience in citizen science *before* this project, this study indicated her previous experience as a 'no' as well. Ultimately, four out of nine respondents were identified having prior experience in citizen science.

Table 3

Stakeholder type, role in the project and previous experience per respondent.

Stakeholder type	Role in the project	Respondent	Previous experience
Research institutions	Advice on specific terrains regarding health knowledge and research	A	Yes
	Advice, development and knowledge building on sensor measurement and calculation models	B	No
	Sharing expertise in citizen science, participation and open technology. Develop and maintain technical and social infrastructure of the project	C	Yes
Civil society organization	Advice and suggestions for technical and practical issues regarding sensors and data processing	D	No
Municipalities	Not specified	E	No
	Not specified	F	No
	Not specified	G	No
	Not specified	H	Yes
Province	Commissioning party / funder	I	Yes

3.4 Data collection

3.4.1 Data collection approaches

Project's website

The analyzed citizen science project has an actively updated website, where news updates, newly organized meetings, reports from previous undertakings, and a sensor measurement forum is constantly updated. Furthermore, the website contains general information on the project, as well as a manual for people wanting to start a measurement group. Also, the participating organizations and their role are discussed, resulting in the first data collection on the involved stakeholders.

Attendance of the project's open access meetings

Observations were made by attending the project's meetings, where the method of non-participant observation was applied. With this method the meetings and attendees are observed from a distance, as the researcher did not participate in the project or its discussions. While this may result in less detailed observation, it thus remains a reflection of reality. From November 2022 to April 2023, four meetings were attended. They are open to everyone to join, but signing up is obligated. Because the project has been enrolled in multiple areas during the last five years, the meetings did not align in time frame. As a result, one start-up meeting, one informational gathering on air quality, and two data analysis meetings were attended, all in different measurement areas. This did not allow the researcher to follow one region in the project from the start. However, it did gave the opportunity to visit different meetings, resulting in a clear overview of the project's beginnings and further development.

Semi-structured interviews

Because the involved stakeholder parties were known, purpose sampling was applied to get in touch with their representatives. By attending the meetings, the representatives were met and asked to participate in the interviews. Two interviewees were not met in person but were approached by email, which eventually led to participation in this study. Eventually, nine people were interviewed for this research who together worked for nine different involved stakeholder parties.

3.4.2 Interview design

The interview design used a semi-structured approach, as it balanced the intended theoretical concepts while allowing unanticipated themes to arise. The interview consisted of 20 questions, covering diverse question types to gather rich and comprehensive qualitative data. Open-ended questions provided interviewees with the opportunity to give their perspective on the topic, without the worry of needing to give relevant information. In addition, confirmative questions and reflective questions were integrated as well. The combination of these question types facilitated a multi-faced view of the topic, eventually offering a deeper understanding of the participants' perceptions.

To ensure internal validity throughout the study, the extent to which measurements and observations are representations of reality (LaCompte & Goetz, 1982), the interviews were held in the respondent's native language. This resulted in a Dutch interview, where the interviewees could speak freely without any concerns about translating their thoughts correctly. External validity is anticipated to be low in this study, as generalization of the results is difficult to achieve in studies with small samples (Bryman, 2016). Second, internal and external reliability is discussed. LaCompte and Goetz (1982) refer to internal reliability as the same description of phenomena held by multiple observers, and therefore arriving at the same conclusions about the observation. As this research is executed alone, the internal reliability of this study is found to be low for this reason. External reliability is ensured by preachily describing the conduction of this research. According to Clonts (1992), the degree to which a study can be replicated and get the same results is characterized by the concept of external reliability. In this study, external reliability is ensured by recording all interviews and transcript them afterwards. In addition, as the interview design is based on literature and is accessible in Appendix A and B, this study can be replicated when interested.

All interviews were conducted online in one month, each lasting approximately 40 minutes to one hour. At the beginning of the interview, the researcher introduced herself, followed by an outline of the research's scope and the subjects that were going to be discussed throughout the interview session. Subsequently, the interview design was divided into three parts. At first, questions were asked regarding the stakeholder motives from a company perspective to participate in citizen science projects. The second part aimed at gathering information on the perspective of the collaboration with other involved stakeholders. Last, questions were asked regarding the personal motivation of the interviewee to participate in citizen science throughout their workplace. The interview design of this research's semi-structured interviews can be found in Appendix I, employed for the interviews with the research institutions, civil society organization, and municipalities. Due to the province being the commissioning party of the followed citizen science project, some questions required adaptation. This interview design can be found in Appendix II. Still, the three main topics and the motives derived from theory were used as a structure, detailed in Table 4 below.

Table 4

Interview structure with definitions and example questions.

Type	Motive	Study	Definition	Example question
Organizational	Contributing motive	Geoghegan et al. (2016)	Contributing to science, policy or education when participating.	*'Can you describe how your organization uses or want to use the produced data from the project?'*
	Relationship motive	Putra et al. (2020)	Build new relationships through the project.	*'How would you describe your relationship with the other involved stakeholders in the project?'*
	Awareness and engaging motive	Geoghegan et al. (2016)	To inform citizens on certain issues, resulting in sense of ownership, shared responsibility, concern and stewardship.	*'Does your organization notice a renewed interest on air quality issues due to your participation in the citizen science project?'*
Personal	Norm-oriented motives	Nov et al. (2011, 2014)	When the individual is motivated by the reactions of significant others, such as family, friends or colleagues.	*'Do you talk with your family, friends or others about this project?'*
	Identification	Nov et al. (2011, 2014)	When the individual identifies himself with the social group and the affiliated norms.	*'Do you feel connected with themes regarding environmental issues?'*
	Intrinsic motives	Nov et al. (2011, 2014)	The enjoyment of the individual that is associated with their participation in the project.	*'Can you describe an experience or occurrence with the project that has stayed with you all this time?'*
	Collective motives	Nov et al. (2011, 2014)	Associated with the motivation of the individual to join a project because of the importance they attribute to the project goal.	*'Do you have the feeling that with your participation in this project you contribute to society? And if so, in what way?'*
	Previous experience in citizen science	West and Pateman (2016)		*'Have you previously been involved with citizen science related projects before this particular one? And if so, in what way?'*

3.5 Data analysis

After the conducted interviews, the data was analyzed to get results. This proces involved recording each interview and transcribing them afterwards. The transcription was automatically done by an online transcription tool called Amberscript. After receiving the automatic transcription, the whole interview and transcription was checked by hand afterwards to avoid misinterpretation by the program.

For the search of motivational aspects of stakeholders involved in citizen science, the method of structured coding was applied to organize the data. The first step was to code the data based on the motives outlined in the motivational framework (2.3.3). As many questions were formulated around a specific motive, the initial coding step aimed to see if the provided response aligned with the intended motive questioned. At first, general codes as ‘contribution’ or ‘awareness or 'intrinsic motivation’ were given to corresponding answers. Responses that were not a direct answer to the question but still found relevant were coded with an open label. This was also done with responses that aligned with the question, but did not correspond with organizational or stakeholder motives derived from the motivational framework. Once the coding process was completed for every interview, an in-depth analysis was conducted for the coded topic to create sob-codes. With this method, answers were further differentiated, resulting in more specific types of motivations. This refinement resulted in the development of a coding framework, wherefore the interviews were coded again to ensure consistency between the interviews. Also, this helped to establish if all codes were relevant after all. As a result, 13 different codes were identified, categorized in four overarching themes. For instance, the original motivational code of ‘advancing scientific knowledge’ was split up in the codes ‘creating more accurate models’ and ‘obtaining knowledge on air quality sensors’. Which eventually led to the theme of ‘generating knowledge’.

4. Results

In the results section, the interviews and observations will be discussed. Paragraph 4.1 will discuss the discovered stakeholder motives based on the interviews held. Second, paragraph 4.2 will reflect on observed motivations from visiting the project's meetings.

4.1 Stakeholder motives to participate

The first part of the result section will discuss the interview findings in this research, which resulted in four discovered themes: generating knowledge (4.1.1), fostering a closer relationship (4.1.2), educating and empowering the involved citizen (4.1.3) and personal motives of the representatives (4.1.4). Table 5 summarizes the discovered stakeholder motives in this study and their corresponding stakeholder groups in order of popularity. The following paragraphs will further elaborate on the discovered stakeholder motives with explanations and quotations from the respondents.

Table 5

All discovered stakeholder motives.

Motives	Mentioned by	Quotes	Total	Paragraph
Capture knowledge and experience in citizen science	Municipalities (E/G), research institution (B/C) province (I) & civil society organization (D)	*"It is a learning model for the province and the municipalities. Making citizens part of the project from the beginning, where they make their own decisions, how does this work then?*	6	4.1.1
Affiliation with the project goals	Research institution (A/ C), municipalities (E/F), civil society organization (D) and the province (I)	*"I think that what we want to achieve is a better relationship between citizens, municipalities and research organizations. What we do is bring them closer together, creating a connection between these worlds."*	6	4.1.4
Supporting citizen concerns	Municipalities (E/F/G/H)	*"In the beginning stage that was certainly an important reason to join [supporting citizens with air quality concerns], because they were asking these questions."*	4	4.1.2
Fulfillment and satisfaction from participating	Research institution (B), province (I), municipality (F)	*"When the involved citizens see that what we do is interesting, then I really have the feeling that what you do contributes to something."*	3	4.1.4

Using the project for policy	Municipalities (E/F/G)	*"If it turns out that the air quality is indeed inadequate, then we can see if we can do something about that. We are not opposed of it."*	3	4.1.1
Creating more accurate air quality models	Research institutions (A/B) and civil society organization (D)	*"More sensors have been added, by the project and by others. A bit cheaper and of lesser quality, but still, these are very important to us. We can refine our 24 hours forecast models on air quality."*	3	4.1.1
Personal beliefs and interest	Research institution (A/C), municipality (E)	*"I pointed out that I am enthusiastic about the project and wanted to be involved in taks around a healthy living environment."*	3	4.1.4
Improving topic knowledge	Province (I) and research institution (C)	*"How do you ensure that the citizen already has the knowledge to really contribute in the dialogue? You don't want them to first hear about it at the meeting, which makes them unable to ask the right questions."*	2	4.1.3
Improving data literacy	Province (I) and research institution (C)	*"Another important role we have is to support, especially the citizens. How do you ensure that they can achieve valuable research?"*	2	4.1.3
Obtaining scientific knowledge on sensors	Civil society organization (D) & Province (I)	*"For us it is most about obtaining knowledge on how well the sensors work."*	2	4.1.1
Creating a shared ownership	Research institution (C)	*"How do you give someone the instruments to develop himself in such a way that they really can contribute knowledge on government issues?*	1	4.1.3
Using the project as a policy instrument	Municipality (F)	*"We want to eventually join the Clean Air Agreement of the Dutch government."*	1	4.1.2
Being more locally involved	Research institution (A)	*"Our institution uses the motto "in the middle of society", and as a big institution that can be quite a challenge. With these kinds of projects I have the feeling that we are."*	1	4.1.2

4.1.1 Generating knowledge

The first theme that came to light was that the involved stakeholders have the motive to generate knowledge from the project. This was found in obtaining general knowledge on how to set up and work with a citizen science project, as well as gaining knowledge that can eventually be used in their own working domains. Table 6 below summarizes the discovered motives whereof additional explanation can be found in the paragraphs.

Table 6

Specified motives on "generating knowledge" per stakeholder.

Stakeholder motives	Mentioned by	Total
Capturing knowledge and experience in citizen science	Municipalities (E/G), research institution (B/C), province (I) & civil society organization (D)	6
Using the project for policy	Municipalities (E/F/G)	3
Creating more accurate models	Research institution (B/C) & civil society organization (D)	3
Obtaining knowledge on air quality sensors	Civil society organization (D)	1

Capturing knowledge and experience in citizen science

A recurrent theme revolved around the stakeholders' curiosity about the potential outcomes of the initiative. Capturing knowledge and experience consistently emerged as a common motive, resulting in this dual coding of the data. The province, stakeholder I, indicated that the project has an informative value for them: *"Another part of the project is also how do you set up such a thing? Who need to be there to create the dialogue? Which partners do you incorporate? How do you ensure that if you organize such a meeting that the citizen already has the knowledge to make a real impact in the dialogues?"*. While the province primarily aimed at capturing experiencing in establishing a citizen science project, other stakeholders showed interest in the projects potential outcomes. Their eagerness to explore is found in multiple answers: *We are still in a sort of discovering phase with the project. So it it not that we are going to make decisions based on this, we will see how it develops. For now it is nice that we are trying.",* as mentioned by municipality E. In line with this is the answers of civil society organization D *"Our institution does not do any other citizen science projects at the*

moment, so this is the only one we are involved in. For us it is really nice to see: how does this work? What can you do with it? It is also educational in that sense." Similarly, municipality G acknowledged the project's valuable learning opportunity, but also encounters some challenges: *"Like you have noticed as well, we are still searching with each other within this project. It turns out that the SODAQ sensors gives other measurements than LuftData sensors. We cannot do something with that."* Later on she mentions that the sensors still give a nice overview, but the divergence in sensors are still an issue. However, she sees this as a learning opportunity for the project: *"That is a question and interesting issue for the project and citizen science to enhance."*

Using the project for policy

The motive of using the citizen science project as a source of information for policy making was found within multiple answers given by all four interviewed municipalities. However, they all acknowledge that creating actual policy on how the data is at this moment is too difficult and also too early in the process. So did municipality E mention: *"We do not know yet what to do with the data, or how we are going to use or manage it."* However, when looking into the future of the project, they did show to anticipate on using the projects data further: *"If at some point correlations and connections can be found, based on that available information it is possible to create policy or new plans."* A complimentary answer was given by municipality G, who already had an example on how they could possibly use the local data on air quality: *"Based on the measures, maybe we can decide that in areas where those higher values are, we might not house sensitive groups anymore in the future."* A noticed concern in all municipalities and a particular reason why a lot of citizens join the citizen science project is their worry about wood stoke and the consequences for their health. In municipality F they use this information obtained from the citizen science project to start the conversation with other involved departments: *"This kind of research and the message it sends across can reinforce it. For example, we can say: okay, should we start a campaign ourselves or should we communicate more actively? It can promote that."*

Creating more accurate air quality models

While the research institutions are asked to have more of an educational role in the project, it was noticed that they had some scientific motives themselves. More specific, to derive scientific

knowledge for air quality models. Research institution A has the legal task to already measure air quality throughout the Netherlands. Based on their models they calculate how the air quality is settled for several places. *"There are numerous citizen science measurements, the ultimate goal is that these measures make our models more accurate."* While the measures of the citizen science project on particulate matter do not contribute to their calculates yet, it was mentioned that measures of nitrogen dioxide made by citizen scientists is already incorporated on their official maps. *"The citizen science project is now also measuring nitrogen dioxide, so I think that eventually those measures will end up on our maps as well."* Research institution B gave an example on how the project's data was already contributing to their work as data scientists *"We have a 'Urban Strategy' platform where we also involve the contribution of air quality, the sensors used by the citizen science project contribute to this platform."* In addition he mentioned: *"We do benefit from those sensors and we hope that people see that their data is really valuable, for science as well."* Furthermore participant B mentioned: *"the project is a first step, but our vision is more broad. This is the beginning towards a more accurate local model that is is beneficial for the citizens."*

Obtaining knowledge on air quality sensors

One stakeholder mentioned scientific motives regarding the sensors, as they cannot use the data for anything as of right now. Civil society organization D mentioned that they compare the sensors used by the citizen science project with others: *"For us it is most about obtaining knowledge on how well the sensors work."* The commissioning party, the province, also mentioned that they do not use the data. However, they are looking at how the data can become an added value to their own air quality measurements. But for now, it is most about sensors: "W*e do not do anything with the data right now, but just with the sensors and their development."*

4.1.2 Fostering a closer relationship

The second theme found in the discovered motives was that the involved stakeholders find it important that citizens concerns around air quality are being heard and taken seriously. This also aligns with the intention of the province with the project, as their goal is to facilitate the conversation between citizens and involved parties around air quality concerns. The motive to foster a closer relationship varies from having a familiar face at the citizen science project meetings, to big

institutions having an entry to connect with citizens on local issues. Table 7 summarizes the discovered motives with the corresponding stakeholder group.

Table 7

Specified motives on "fostering a closer relationship" per stakeholder.

Stakeholder motives	Mentioned by	Total
Supporting citizen concerns	Municipalties (E/F/G/H)	4
Facilitate conversation about living environment	Province (I)	1
Local involvement	Research institution (A)	1

Supporting citizen concerns

Another commonly mentioned motive was giving citizens the sense that their concerns are taken seriously. All municipalities expressed this in their interview. So did municipality F mention: *"How can we, on the basis of these measurements, give residents the feeling that they are actually being heard?"* Municipality G mentioned that she experienced residents already actively measuring air quality, because of this, they decided to inform themselves on the topic *"People really wanted to measure, because measuring is knowledge. Because of that we decided to take a look, how do you do something like this? And how do other municipalities do this?"* Citizens already measuring in their city's was also mentioned by the spokesperson for municipality H. There, residents asked the municipality to do their own measures in the neighborhood because they had concerns about the municipality's ones about the air quality. *"We were like, okay, if you want to measure then that is fine. We would like to help and see how that will develop."* Because of this movement, it was important for the municipality to show their residents that they are supported. For them that was one of the main reasons to join the citizen science project in the first place. Lastly, municipality E also mentions the importance of acknowledging the concerns of their citizens "*In the end it is citizen science, however, I do think that it helps that an alderman is also present to give some sort of presentation. That it is seen and acknowledged, some sort of additional interest, as the municipality."*

Facilitate conversation about living environment

While all eight other stakeholders were asked why and how their organization was involved in the citizen science project, the province, as the commissioning party, was asked with what vision they started this project. The answer was that the main goal of the project is to create a space to facilitate a conversation about the living environment of the citizens. "*We use citizen science to conduct this dialogue, we, as the province, see it as an instrument to do that."* He continued with examples: *"What is happening there? What are their concerns? And how can I, how can we, change something about that? How can we as the government change something about that?"*

Local involvement

Another reason found was that one research institution had the feeling could relate more to the citizens and the problems in their living areas on a local level. So did research institution A mention that: *"As a big institution it is a bit of a challenge to be in touch with everything that is happening locally. With this initiative, we are in more of a direct contact with the citizens, we get access to what is happening on a local level. That is very useful for us. Also to get direct feedback on the sensors that are being used. Do they work? What kind of issues are encountered? What questions do the citizens have? This, so we know that as well."*

4.1.3 Educating and empowering the involved citizen

The third discovered theme was found in the answers of the commissioning party, the province, and the research institution they work most closely with. They both acknowledge educating and empowering the citizen is a part of the citizen science project as well. In here, education regarding air quality is a given motive, but also educating the citizen in doing proper research. This serves to the purpose of empowering them to actively engage in air quality conversations regarding issues or their own concerns. Table 8 gives an overview of the given motives with their corresponding stakeholder.

Table 8

Specified motives on "educating and empowering the involved citizen" per stakeholder.

Stakeholder motives	Mentioned by	Total

Improving topic knowledge	Province (I) & research institution (C)	2
Improving data literacy	Province (I) & research institution (C)	2
Creating a shared ownership	Research institution (C)	1

Improving topic knowledge

The commissioning party of the project, the province, mentioned that the aim of the project is to conduct a dialogue about a healthy living environment. In here, the motive was mostly found regarding educating the citizen to become a valuable asset in the dialogue: *"How do you prepare your interlocutor to an actual interlocutor? That translates towards the design of the citizen science project as well. That at first you educate someone about air quality. What do you do with that? What can you measure with this sensor? What do we measure with other sensors? What is your personal question? How can you research that? … This comes back in all aspects of the project. How do you give someone the instruments to develop himself in such a way that he really can contribute knowledge on government issues?",* as said by province I. This is done with the help from experts and professionals, who were asked to become partners in the project based on their expertise. They have a supporting role regarding knowledge on the hardware of the sensors, as well as the topic of air quality and data support. Research institution C mentions that they already see the difference in topic knowledge overtime: *"Citizens build up knowledge about air quality in different ways, also in every meeting. I hear more and more that when I talk with them they say: you shouldn't measure it this way, but like this."*

Improving data literacy

Research institution C finds it important that besides learning about air quality and creating a shared ownership, they also improve their data literacy: "*That is an important aspect. That the citizens do not only obtain more knowledge about air quality, but also about data literacy, something that becomes more important in our society."* This translates in learning citizens how to improve their research skills: "H*ow do you ensure that they can conduct a proper research? How do you ensure that they can eventually answer their measurement question? It is not my research, but the research of the citizens that are consciously active with their living environment."* That data literacy is

improved is also noticed by the province, respondent I: *"I see that the dialogue with the involved citizens has changed. It's more about their concern combined with the interpretation of the data."*

Creating a shared ownership

Research institution C has a strong vision about the citizen science project: *"How can you use data, open technology, to increase ownership about your own living environment?"* The data that is referred to is the use of sensors to measure air quality by citizens, also called citizen sensing. Research institution C actively works with this specific devision of citizen science used in this project: *"One of the most important things with this way of working is because you enable residents to measure their own living environment, they also acquire an equal knowledge position."* That this form of citizen science is working can be found in the answer given by respondent I, the province: *"I do see that the dialogue with the people we work with has changed. Now it is more about their concern, while taking the data in consideration and what that could possibly mean."* This shift in behavior is desired in the project, as research institution C mentions "*How do you ensure that you have not only built up knowledge with each other, but that you can also take this to the next level? That not just an individual walks into their municipality talking about their concerns, but created a social environment that has the power to undertake action? To conduct a conversation with their municipality or other involved parties, saying: "we have gathered this information and we want changes.""*

4.1.4 Personal motives of the representatives

As evidently seen, stakeholder and personal motives are often intertwined. Also in this study, personal motives were discovered. During the interviews, personal beliefs, alignement with the project goals and their sense of fulfillment derived from participation was discovered. Last, the potential influence of previous experience in citizen science will be explored (4.2.4.1). Per stakeholder group, one spokesperson took part in the interviews, indicated with the corresponding stakeholder letter.

Table 10

Specified motives on "personal motives of the representatives" per stakeholder.

Personal motives of representatives	Mentioned by	Total
Affiliation with the project goals	Research institution (A/C), municipalities (E/F), civil society organization (D) and the province (I)	6
Fulfillment and satisfaction from participating	Research institution (B), province (I), municipality (F)	3
Personal beliefs and interest	Research institution (A/C), municipality (E)	3

Affiliation with the project goals

Several respondents indicated a strong belief in the project's objectives and the potential impact they can make. For instance, the project continued because the representative from the province (stakeholder I) wondered why it wasn't: "*I began doing the project because it was on hold for a while. Something in me thought: it cannot just lay there. That is because I think it is very innovative, the way of working together and just the whole development the project has gone through."* In here, participant I is talking about that the project started out as a pilot, which eventually developed in a project in several regions, and demonstrates how respondent I recognized the projects' innovative nature and believed in its approach. Other participants gave similar answers fitting this motivation, as they tried to enhance public understanding and creating awareness. So did the representative from municipality F mention *"You contribute that people feel heard, and you make things insightful for them in a time where a lot of people are skeptical against government instances. That is something you can offer with citizen science. Making it more tangible instead of reading some numbers online based on measurements that a lot of people do not understand."* In line with this was the answer given by the interviewee from research institution C, who mentioned how important it is for her to create these data analysis meetings with stakeholders and citizens. This, as it creates an opportunity to have a conversation with each other: *"Only handing people the data is not enough I think, like just a report, or only a platform. But discovering more methods to search for answers. What does this mean for me? What can I do with this?"* The desire to enhance public understanding on the impact of air quality is also mentioned by the representative of civil society organization D: "*When I give a presentation for the citizen science project, I always mention the smoke from wood*

stoves. That is one personal goal of mine, to let people think about the damage they do to the environment when stoking wood.". Their affiliation with environmental issues, air quality in this particular project, is found to be a common motive for the involved participants: *"I think that themes as clean air quality and noise are very important themes regarding to health and well-being. If I am correct, clean air is about four procent of the total disease burden, so we are really talking about important topics. You might not see it, but it is there. It is good to become aware of that and also working on creating awareness for these topics."* as said by the respondent from municipality E.

Fulfillment and satisfaction from participating

Another point of view that came back in the answers of three stakeholders was the concept of satisfaction from their participation, which makes it worth it to be involved in the project. When asked if representative from the province (stakeholder I) could recall a special or impactful moment while working for the citizen science project, he mentioned *"At one particular gathering where I saw: okay, it works what we came up with, what we do succeeds."* After seeing all these different stakeholders together in such a meeting, he wondered if this will still works on a regional level so the project will stay affordable *"Does it still work then? Can the resident still ask his local question in the conversation? Because of the design our partner came up with, having working sessions in the project with professionals who bring knowledge to the table, I thought: it works, and I was proud of that."* Satisfaction with the project itself is also mentioned by the representative from research institution B *"If it continues, I would certainly be happy to continue working on it."* In addition he added: "*I think it is a nice initiative and I think that maybe other provinces are looking at this like: hey, this is interesting, maybe we should develop something like this as well",* which indicates that the respondent finds the work for he does for the project valuable. For the interviewee of municipality F the satisfaction she receives from the project is that she learns new things. This in the form of own research on air quality, but also at the meetings given by the involved stakeholders for the citizen science project *"At the presentation they said that you wouldn't find a sensor measuring particular matter next to the freeway, because that are complete different substances that you measure then. Those insights made me think: I really learned a lot from it. That also triggered me to become part of it as well."* Lastly, the the representative from municipality F mentioned that she values the reaction of citizens towards her attendance at the project's meetings: *"They come in and say: how great to*

see you! How nice that the municipality is involved as well! That gives me a good feeling, that is also why you do it.”, indicating that she got a feeling of fulfillment derived as her contribution is valued.

Personal beliefs and interest

For four out of nine respondents, their affiliation with the project matter or citizen science in general was a reason to participate. So did the representative from research institution C began working at her current workplace because it aligns with her beliefs: "*I started working here because I really believe in the ownership of people. I saw that concept back in the projects that this institution does.* This answer shows a different workplace motive, participant C really choose to have these kind of projects as her work. This is also mentioned by the respondent from research institution A, who worked with citizen science before: *"I already did this in my free time, because of that it made me think like: oh this is such fun, I would like to have a job in this."* When asked if she could explain this a bit more in depth, she answered: *"I really liked that you measure things yourself and think together in such a project about a certain subject. Climate change for example and how that may affect your neighborhood. Especially the participation part was something I liked very much. Because of that I started to look for a job in this field."* Furthermore she mentioned: *"It was not that I had to get a job in citizen science, but I searched for it. I was really happy when I found one."* Having interest in citizen science or in the subject it targets was also found in the interview with the representative from municipality E. She mentioned that she has a great interest in subjects that apply to the concept of a healthy living environment: *”I wanted tasks which corresponded around this subject. When two people left the workplace, there was a lot of work to choose from. The citizen science project is something that I picked to do."*

4.1.4.2 Previous experience in citizen science

The characteristic of previous experience in citizen science was added to the interview question to see if this had an influence on the representatives personal motives to participate. This question anticipated if the interviewee had previous experience in citizen science before participating in the citizen science project this research followed. In table 13 the deviation between the respondents answers can be found.

Table 11

Experience in citizen science.

Previous experience in citizen science	Total
No experience in citizen science	5
Experience in citizen science	4

No experience in citizen science

Not all respondents had previous experience with citizen science in general. Respondent D from the civil society organization mentioned: *"I have heard about it before, but I cannot remember I previously did something with it."* Municipality representative F mentioned that she only got involved because of her workplace "*No, I have never been into it. Maybe because I am one of these people who thinks: I want to spend my time on other things."* When asked why she thinks that, she came up with a possible explanation: *"In the city that I am from, neighborhood platforms or citizen work groups were not a thing. Because of that, I think that you quickly become more distant to these kind of initiatives."* The interview from research institution B did also not have previous experience in citizen science before his workplace, however, he found that this experience made him look differently against it: *"What it brings to me is that the next time I will look differently to these kind of initiatives. That I think: this has enrichment qualities instead of this is going to be difficult, or it is going to be a hassle."* The same type of answers was found when talking with the respondent from municipality F *"We are also taking part in noise research as part of this project. At first I was a bit skeptical about it, but it thought let's just try it. It might be that that won me over."*

Experience in citizen science

For five respondents this project was the first time they have come in contact with citizen science, the other four respondents did have experience in this field. The representative from research institution C mentioned: *"Yes, citizen science as in doing bird counting or taking monsters out of water for example. Working with sensors, citizen sensing, is something I knew less about."* Interviewee A (research institution A) indicated that she worked with sensors before, but not in such a setting as the citizen science project she is involved in now through her work organization. *"I have*

already been involved in citizen science for three years now. I do this in my free time, I was participating in a project in Utrecht which was called 'meet je stad.' We measured temperature and build our own sensors. That is very different from this project, because there isn't an official organization financing this." That the followed project is quite rare in its form is also indicated by the province's respondent (stakeholder I), who had experience in working with citizen science regarding to water quality: *"I measured things myself and I then sent it out."* When asked about if that project also had a stakeholder community he answered: *"That is the unique thing about this citizen science project, building such a strong community base that also is being facilitated."* The interviewee from municipality H goes a long way back with citizen science: "*In 2006 we did a project with palmes tubes ourselves, we hang them up on around 20 locations for a couple of months. Our goal was that we could answer our research question, which was to see if we could implement natural gas busses in that area.*"

4.2 Reflections on discovered motivations

The observations provided the opportunity to reflect on three of the discovered stakeholder motivations during the interviews. One of the dominant motives, capturing knowledge and experience in citizen science (4.2.1), was observed to create an imbalance between the stakeholder's explorative approach and the answer-seeking attitude of participants. Second, interviews gave insight into the research institutions' plans with the utilized data, where observations show tangible results from (4.2.2). Lastly, the efficiency of improving data literacy is questioned in paragraph 4.2.3, as the observations highlight a potential mismatch in their applied method.

4.2.1 Capturing knowledge and experience in citizen science

As seen, capturing knowledge and experience in citizen science is one of the two dominant motives derived from the interviews. This organizational motive expresses the stakeholder's curiosity about the project itself and the possibilities it obtains. Several stakeholders acknowledged that the project is a valuable learning experience, and their interest is more in exploring the project than in the actual data outcomes. The attended meetings confirmed the stakeholder's explorative approach, as the project's meetings were discovered to be slightly chaotic at times. This chaotic feeling was mostly caused by an observed imbalance between the stakeholders' and citizens' expectations of the project. During the meetings, it was continuously emphasized that the project is research on its own, as the initiative explores the potential that the project can bring. Citizens were observed to lack awareness of this aspect at times, as some of them mentioned they were participating in the project because of their belief that the project could change regarding air quality issues. The citizens had the feeling that the project outcomes could potentially impact policy, something that is not feasible yet according to the interviews with the municipalities. The imbalance of expectations regarding the project impact between the stakeholders and the citizens highlights the need for expectation management improvement.

4.2.2 Creating more accurate air quality models

While the explorative attitude towards the project is a predominant motive to participate, research institutions were discovered to have actual clear goals with the project. Both research organizations

expressed in their interviews that the data obtained from the project is already been used in their air quality platforms. One of these platforms is the 'Urban Strategy' platform, which was demonstrated to the citizens during a data analysis meeting. This platform shows the air quality status and gives predictions, just like weather forecasts. While the citizen science project continuously emphasizes that it is a project for and by the citizens and their research questions, this platform introduction still sheds light on the organization's gain from participating. Moreover, the research institutions emphasized the contributing factor the measurements of the citizens play in this platform, as it will give more detailed information about the air quality in a certain region. Citizens were observed to react enthusiastically towards this platform and asked multiple questions about the functionality and future aspects. This example emphasizes the benefits the research institutions obtain from their collaboration.

4.2.3 Improving data literacy

A third organizational motivation discovered in the interviews is the motive to improve topic knowledge and data literacy of the citizens. Eventually, this will contribute to the project's overarching goal, as the predominant motive to set up this initiative is to conduct a dialogue about a healthy living environment. Through this improved knowledge and data literacy, the citizens will be empowered, resulting in a more equal position between them and other stakeholders. To achieve this, several meetings on air quality and health and data analysis meetings are organized for the citizens to build up knowledge. It is interesting how this intention is applied in the meetings, as it was observed that the research institutions only provide presentations on the topics. The data analysis presentations obtained actual data from the citizens, wherefore Power BI is used to show prepared graphics and visualizations. Questions from the citizens were made visible through the program, leading to enthusiastic responses about this software. However, the question arises if citizens obtained knowledge of data literacy through this presentation. Citizens were not actively working with the data, but listening to the research institution showing the possibilities of the program with the participant's data. Although it was expressed that all data is openly accessible on the project's website, there was no impression that citizens had worked with the data before the presentation.

5. Discussion and Conclusion

5.1 Discussion

This research aims to uncover motives that possibly influence the stakeholder's motivation to participate in co-created citizen science projects. In order to generate a deeper understanding of this concept, organizational and personal motives were questioned. This single case study research explored an active and professional set-up co-created citizen science project, where knowledgeable parties collaborate with citizens to create a dialogue about air quality. Eventually, this led to the following research question: *What are the motives of stakeholders to participate in citizen science projects?*

The observations and the interviews provided complementary insight into the project dynamics. While observations allowed capturing real-time interactions and implementation, the interviews allowed the stakeholders to express their beliefs, intentions, and thoughts on the analyzed project. Together, these two methods provide a well-rounded perspective on stakeholder motivation.
The four discovered themes: 1) Generating knowledge 2) Fostering a closer relationship 3) Educating and empowering the involved citizen 4) Personal motives of the representatives, captures distinct aspects of stakeholder engagement and shed light on their underlying motivations to participate. So does the theme 'generating knowledge' highlight the stakeholders' desire to gather valuable insights, information, and experience from their participation in the citizen science project. The second theme showcases the interest of stakeholders to build stronger connections among the participants and various organizations, resulting in the effort to create meaningful dialogues around citizen concerns and issues around air quality. The third theme, educating and empowering the involved citizen, emphasizes the stakeholder's commitment to enhance the participant's skills and knowledge which eventually will contribute to active and meaningful participation. Lastly, the personal motives of the representatives provide an individual perspective, as it acknowledges that each representative brings their values, beliefs, and interests while participating in the project. Collectively, these themes illustrate that stakeholders are motivated by a combination of curiosity, data collection, shared learning, connection-making making and personal driving factors.

The top two motives highlight the intertwinement between exploring the project's objectives and personal beliefs. *Capturing knowledge and experience in citizen science* was discovered to be a predominant motive for stakeholders to participate. Various stakeholders revealed an eagerness to explore the initiative's potential, as well as to gain a deeper understanding of participating in citizen science in general. For most of them, this project was the first time they participated in such an initiative, making this result not unexpected. In addition, because the project itself is presented as a research initiative, this could also be an influence on this discovered motive. While all stakeholders are attentive and open to this aspect, participants were observed to occasionally lack awareness of this factor, resulting in an imbalance in their approach towards the project. As citizens were looking for answers to their concerns, some stakeholders used the project's explorative approach to discover its potential regarding their work domain. Two discovered motives gave insight into these plans. The motives of *creating more accurate air quality models* or *using the project for policy* all propose intentions how the data of the project could be used in the future. For the motive of *creating more accurate air quality models,* observations show that this is already slightly in motion. The interviews gave the impression that the stakeholders see the project as an opportunity to enhance their air quality platforms. They expressed that the citizen science projects provide local data, which can be integrated into their models for more accurate air quality predictions. The attended meeting showcased the development of such a platform, as a research institution presented its model to the attendees. This observation shows tangible evidence of the institutions' genuine interest in enhancing their scientific platforms through the project.

The second motive, *affiliation with the project goals,* shows the respondent's personal belief in the project's goal and objectives. The overarching goal of the project is to give citizens a platform to engage in conversations about a healthy living environment. By participating in the project, citizens will obtain a more equal knowledge position, as they acquire firsthand data and are educated on related subject matters. This sentiment is also expressed by the municipality, as they reflect how citizen science can serve as a bridge between knowledgeable parties and the general public. In her interview, she expressed her noticed skepticism from citizens towards several knowledgeable institutions, and sees citizen science as a solution to present tangible insights and make challenging topics as air quality more accessible. Moreover, the research institution acknowledges the relevance of conversations between stakeholders and citizens, as she emphasizes the importance of organized

meetings. According to her, handing out air quality data is not enough to enhance the understanding of the general public on this topic. With direct citizen participation in data collection and analysis, she thinks the project fosters meaningful engagement and empowerment. However, the observations show that the method of presentations is applied to educate on data literacy, and questions if this is the most efficient method to do so. As the goal of the project is to give citizens a more equal position in environmental conversations, education on conducting proper research is an important factor. Creating interactive data analysis meetings, where citizens work with their data on their computers, may contribute to this. Also, while for research institutions it may be a daily task to work with Power BI, using this software might give an unrealistic picture of what citizens will learn during their participation. Admits these considerations, the representatives responses not only aligns with the overarching goal of the project, but also showcase a commitment to one of the project's objectives: enhancing the public understanding of air quality. So did one representative express her belief in the project's potential to bring broader societal awareness on the impact of air quality on community health, as she mentioned the importance and impact of clean air on well-being. Notably, the representative from the civil society organization exemplifies this sentiment, as he emphasizes that it is his personal goal to enhance the understanding of woodsmoke on the environment. This example highlights a genuine commitment to the issue, as his beliefs align with one of the project objectives. Collectively, these personal intentions, beliefs, and motivations showcase their commitment to advancing the citizen science initiative.

The last topic discussed is the project's co-creation approach, a level of participation where individuals assist in the development of a study by collecting and analyzing data for shared research goals (Walker et al., 2021). Although the project's measurement questions, strategies, and further development of the study are collectively decided by participating citizens and stakeholders, it is unsure how this collective decision-making continues after the community question is answered. This concern is strengthened by the province being the only funding party of the initiative, as the future of the project is dependent on their decision to continue. This conflicts with the equal degree of control factor between the public and the project initiative taker in this level of engagement.

5.2 Theoretical and practical contribution

Theoretical contribution

Two scientific contributions were made with this research. First, this research extends the literature on stakeholder motivation in citizen science, as existing literature uses theories and concepts derived from either citizens or scientists. The results section gives a distinct overview of the motives per stakeholder, resulting in valuable insights into specific motivations for the participating organizations. Second, limited studies on motivation in citizen science consider the variable of 'previous experience'. While none of the respondents explicitly indicated that their previous experience influenced their participation in this project, a perspective change was discovered by two respondents after their experience with the analyzed project. One respondent mentioned that because of her gained experience, it might have pulled her over the line to participate in another similar citizen science project. Another respondent mentioned that because of his experience, he created a more positive view of participating in citizen science projects in the future. Because of this, it is an aspect to consider in future research as a possible influence on personal motivation to participate.

Practical contribution

The analyzed project has a vested interest in the outcome of this research for their study on the impact of the project. This study reflects on their initiative, resulting in an extensive overview of their stakeholder's motives to participate. Second, this study might be interesting for new citizen science projects wanting to involve stakeholders. Understanding stakeholder motivations can help future projects tailor better engagement strategies for the stakeholders they are willing to attract. As the themes highlight that stakeholders are motivated by a blend of curiosity, data collection, shared learning, connection-making, and personal driving factors, these aspects could be considered when designing a similar initiative. Furthermore, the two predominant motivations discovered highlight the fusion between organizational and personal driving factors for participation. These aspects display that active and committed participation from the organization and their representative enhances the citizen science initiative, resulting in an environment of mutual commitment.

5.3 Recommendations for future citizen science projects

Expectation management

Future citizen science projects should communicate the project's goal clearly to the participants from the beginning. As this study discovered an imbalance between the stakeholders' and participants' knowledge of this matter, expectation management should be a point of thought. Researcher observations noticed individuals willing to participate in the project, thinking they could change policy. As the overarching goal is to create a dialogue about air quality in the living environment, as well as an experiment to do so, this belief of the participants often led to frustration. A recommendation for future citizen science projects would be to clearly emphasize the project's goal and potential outcomes to limit the number of participants dropping out or losing interest eventually.

Regular physical meetings

Several stakeholders emphasized that the feeling of actual contribution to the project is the most present during the physical meetings with citizens. Talking with the participants and sharing knowledge is often found to be 'inspiring' and leads to enjoyment for the stakeholders. This was commented on by stakeholders during the interviews, as well as observed during the meetings. When the gatherings ended, several participants stayed to talk to each other, but mostly to ask questions or gather a conversation with the stakeholders present. A recommendation for future citizen science projects would be to have regular physical meetings with all people involved, as it is found to increase mutual enthusiasm.

Education strategies

Educating the citizens to empower their position in air quality conversations is expressed to be important by several participating stakeholders, as it contributes to the overarching goal of the project. This viewpoint extends beyond the analyzed project, as citizen science initiatives that adopt the co-creation approach also prioritize this equal position between citizens and scientists. While this research observed that the analyzed project relied on presentations to enhance topic knowledge and data literacy, this study questions if this is the most efficient method. While presentations are a prevailing method for education, this study raises questions about their effectiveness, especially

when it comes to more advanced tools such as Power BI. Future citizen science projects could consider offering active data courses that educate participants on how to work with these types of programs. These courses can empower citizens with skills, resulting in more meaningful contributions. This approach would be more in line with the stakeholder's desire for citizens to conduct proper research, which eventually contributes to the overarching goal of creating an equal knowledge position. A recommendation for future citizen science projects is to prioritize an effective education strategy that empowers citizens while considering their abilities and the time they are willing to invest.

5.4 Limitations and future research

This research concurred with several limitations in the process, which will be discussed below. First, citizen science projects frequently have multiple stakeholders participating. While this study aimed at including a broad spectrum of various involved organizations, it does not encompass all identified stakeholder groups in the theoretical framework. Business and primary learning institutions were not part of the analyzed project, resulting in a possibility of incomplete stakeholder motivation.

The limited number of active citizen science projects on the scale of the analyzed project is a limitation. Because of this, the study was narrowed to a single case study, which limits the generalizability of the findings to other contexts. The discovered motivations and observed dynamics might not be representative of other citizen science initiatives. Future research should compare different citizen science projects with comparable involved stakeholders to provide a more well-found conclusion on stakeholder motivation.

Certain participating organizations had multiple individuals involved in the project. This research interviewed the representatives who demonstrated the highest level of involvement, resulting in one viewpoint of their organizations' motivation to participate. This narrow view limits the richness and complexity of perspectives, or results in the possibility of underrepresentation of some motivations. Future research should interview multiple representatives involved in the same organization, as it provides the potential for a more comprehensive understanding of stakeholder motivation.

The qualitative nature of this research, applying the method of observations and interviews, has the potential to bring subjectivity into the data analysis. Interpretation bias and subjectivity of

the researcher might influence the identification of the motivations discovered, as well as the identification of the themes. This may affect the accuracy and objectivity of the findings.

Last, this study relied on self-reported information through interviews, which could introduce social bias as the respondents may have felt they had to give socially desirable answers in favor of the project. While this study emphasized that their answers would be processed anonymously, the small sample size might have influenced their answers. Respondents might have had concerns that their answers would be identified by their colleagues in the project.

5.5 Conclusion

This study provided an in-depth understanding of the complex interplay of stakeholder motivation to participate in citizen science, resulting in organizational and personal motives discovered. In total, 13 motivations were discovered, categorized in four themes: 1) Generating knowledge 2) Fostering a closer relationship 3) Educating and empowering the involved citizen 4) Personal motives of the representatives. Collectively, these motives illustrate that the participating stakeholders are motivated by a combination of curiosity, data collection, shared learning, connection-making, and personal driving factors. The two dominant motives discovered in this study are capturing knowledge and experience in citizen science and affiliation with the project goals. The diverse group of stakeholders involved in this research, recognizing these dual motivations, highlights the intertwinement between organizational and personal motivation for stakeholder participation. The motive of capturing knowledge and experience in citizen science is in line with the purpose of the analyzed project, as it is also an experiment on how to set up such an initiative. However, several motives shed light on the stakeholder's plans with the project's data, as policy-making and advancing scientific developments are mentioned. These two examples highlight the stakeholder's belief in the potential of the citizen science project. Second, the personal motives of the representatives indicate their eagerness and passion for enhancing public understanding and awareness of air quality. It came to light that certain representatives used their position in the project to introduce subjects of personal matters, such as woodsmoke, aiming to bring awareness to this issue. Overall, this shared belief in the project's objectives, its explorative approach, and the potential impact on public understanding emphasizes the stakeholders' enthusiastic involvement and personal commitment. This active engagement showcases their curiosity about the project possibilities, potentially enriching

their professional domains, as well as their personal desire to contribute to the public understanding of air quality issues. These dynamics highlight the intertwinement of shared project objectives with individual values, resulting in an environment where the stakeholder and its representative are mutually committed.

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Appendix I - Interview questions research institutions, civil society organization and municipalities

1. Institutionele motieven - bijdragen aan de maatschappij

1.1 Wat maakt het dat X betrokken is bij het burgerwetenschap project?

1.2 Hoe zou u de rol van X omschrijven met betrekking tot het burgerwetenschap project?

> Aanvullend / ondersteunend / verbeterend etc…

1.3 Kunt u vertellen vanuit waar deze samenwerking is ontstaan?

1.4 Kunt u vertellen op welke manier X de geproduceerde data gebruikt van het burgerwetenschap project?

> Of wil gaan gebruiken?

1.5 Zijn er hierbinnen enkele belemmeringen of uitdagingen?

B. Institutionele motieven - betrokkenheid

2.1 Binnen het burgerwetenschap projectwerken verschillende betrokken partners samen, hoe zou u de relatie met deze instanties omschrijven?

2.2 Wordt er veel samengewerkt met andere instanties? Hoe gaat dit in zijn werking?

2.2 Wat zou u als eventueel verbeterpunt benoemen voor de samenwerking tussen de verschillende betrokken instanties?

2.3 Wat zou u als krachtig punt van deze samenwerking omschrijven?

2.4 Welke instantie zou volgens u een vernieuwde bijdrage kunnen leveren aan burgerwetenschap projecten die op dit moment nog niet betrokken is?

2.5 Merkt X een vernieuwde interesse rondom het thema luchtkwaliteit door de samenwerking met het burgerwetenschap project?

> Zo ja, op welke manier uit zich dit?

2.6 Wat is de kijk van X op de medewerking van burgers in wetenschap?

3. Persoonlijke motieven

3.1 Bent u al eens eerder in aanraking gekomen met burgerwetenschap? Op welke manier was dit?

3.2 Wat was voor u de reden(en) om mee te werken aan het burgerwetenschap project?

> Welke van deze redenen zou u benoemen als het meest belangrijk? Waarom?

3.3 Door welke ervaring / moment bent u betrokken gebleven bij Hollandse Luchten?

> Wat zou een reden zijn om nog meer betrokken te raken?

3.4 Voelt u zich verbonden met dit soort projecten met milieu thema's zoals luchtkwaliteit? Zo ja, kunt u dit verder toelichten?

> Of voelt u zich bijvoorbeeld verbonden met andere betrokkenen, zowel individuen als andere instanties, bij het burgerwetenschap project?

3.5 Heeft uw betrokkenheid bij het burgerwetenschap project ervoor gezorgd dat uw betrokken bent geraakt bij soortgelijke initiatieven?

3.6 Praat u met uw naaste omgeving over burgerwetenschap?

> Waarover praat u? En op welke manier wordt hierop gereageerd?

3.7 Heeft u het gevoel dat u met uw medewerking aan het burgerwetenschap project iets bijdraagt aan de maatschappij? Op wat voor manier?

> Heeft het uw mening over burgerwetenschap veranderd? (Leg verder uit)

Appendix II - Interview questions province

1. Institutionele motieven - bijdragen aan de maatschappij

1.1 Kunt u vertellen wat de visie was/is van de Provincie met het burgerwetenschap project?

1.2 Kunt u vertellen wat de rol is van de Provincie met betrekking tot het burgerwetenschap project?

> Aanvullend / ondersteunend / verbeterend etc…

1.3 Kunt u een voorbeeld geven hoe dit in zijn werking gaat?

1.4 Gebruikt de Provincie de geproduceerde data van het burgerwetenschap project? Zo ja, op wat voor manier?

> Of wil gaan gebruiken?

1.5 Bevinden zich hierbinnen nog enkele belemmeringen of uitdagingen?

B. Institutionele motieven - betrokkenheid

2.1 Binnen het burgerwetenschap project werken verschillende betrokken partners samen, hoe zou u de relatie van de Provincie met de andere betrokken instanties omschrijven?

2.2 Hoe gaat deze samenwerking in zijn werking?

2.2 Wat zou u als eventueel verbeterpunt benoemen voor de samenwerking tussen de verschillende betrokken instanties?

2.3 Wat zou u als krachtig punt van deze samenwerking omschrijven?

2.4 Welke instantie zou volgens u een vernieuwde bijdrage kunnen leveren aan het burgerwetenschap project die op dit moment nog niet betrokken is?

2.5 Merkt de Provincie een vernieuwde interesse rondom het thema luchtkwaliteit door het starten van het burgerwetenschap project?

> Zo ja, op welke manier uit zich dit?

2.6 Wat is de kijk van de Provincie op de medewerking van burgers in wetenschap?

3. Persoonlijke motieven

3.1 Bent u voor uw medewerking aan het burgerwetenschap project al eens eerder in aanraking gekomen met burgerwetenschap? Op welke manier was dit?

3.2 Wat was voor u een persoonlijke reden(en) om mee te werken aan het burgerwetenschap project?

> Welke van deze redenen zou u benoemen als het meest belangrijk? Waarom?

3.3 Heeft u een ervaring / moment die u erg is bijgebleven tijdens u medewerking aan Hollandse Luchten?

> Waarom vond u dit zo opmerkelijk? Wat maakte dit los?

3.4 Voelt u zich verbonden met dit soort projecten met thema's rondom klimaat zoals bijvoorbeeld luchtkwaliteit? Zo ja, kunt u dit verder toelichten?

> Of voelt u zich bijvoorbeeld verbonden met andere betrokkenen, zowel individuen als andere instanties, bij het burgerwetenschap project?

3.5 Heeft uw betrokkenheid bij het burgerwetenschap project ervoor gezorgd dat uw betrokken bent geraakt bij soortgelijke initiatieven?

3.6 Praat u met uw naaste omgeving over burgerwetenschap?

> Waarover praat u? En op welke manier wordt hierop gereageerd?

3.7 Heeft u het gevoel dat u met uw medewerking aan het burgerwetenschap project iets bijdraagt aan de maatschappij? Op wat voor manier?

> Heeft het uw mening over burgerwetenschap veranderd? (Leg verder uit)