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Executive Summary

Context of the evaluation of the empowerment potential

In this report the methodological support team on engagement and empowerment presents the evaluation of empowerment activities within CITI-SENSE. This project has been very complex and difficult, but was also a project of great learning. The project had to operate on the interface between expertise on advanced measurement and Information Technology (IT) on the one hand and expertise about engagement and empowerment of citizens on the other. It had to do this in the context of improving people's engagement with environmental issues of consequence, and increasing their power to be active participants in improving environment and health. This needed to be applied in the practical context of local case studies called Empowerment Initiatives (EIs). In practice however, most partners involved in the project started from technology driven model. What made it even more difficult was the fact that the local empowerment initiatives were carried out by teams which consisted principally of physical scientists, exposure assessment experts, experts in measurements, etc. – teams with the expertise necessary for testing and managing the use of static and personal sensors – and CITI-SENSE also asked these EI teams to do the practical work of engagement with citizens to support empowerment.

When it became clear that many of the sensors were not performing as had been hoped for and expected, this approach needed to be and was adapted. Nonetheless, the technological difficulties with the reliability of sensors and the quality of data stayed on the forefront for a long time, together with a preoccupation with resolving those difficulties. Over time the CITI-SENSE-project developed alternative and/or complementary products could be options for engagement and empowerment. Nevertheless this tension, arising because engagement and empowerment were (considered) dependent on the good functioning of the technology, became one of the key motives of CITI-SENSE. The technology did not function as had been hoped for and expected, and although big gains were made in its development, it left the engagement and empowerment aspects of CITI-SENSE with three major difficulties which impacted seriously on the engagement and empowerment activities:

1. The work of engagement and empowerment could not go ahead as originally anticipated, even though substantial progress was made on the engagement aspects later on in the project, and the work on empowerment remained limited due to the long delays in getting a citizens' observatory operational.
2. Those delays related to technology sucked resource and attention, not only from the teams with responsibility for sensor and other infrastructure development, but also from the Empowerment Initiative teams and from the methodological support team on engagement and empowerment itself.
3. It seriously damaged the work on engagement and empowerment, as the methodological development could not always be linked as envisaged with practical applications.

To solve this situation, it was essential to have a project strong on interdisciplinary collaboration and open to learning. In the end, various alternative ideas were worked out into additional CITI-SENSE-products which were used with and by citizens. For example:

- The development of the smart-phone app (the CityAir app) was developed to enable citizens to record their perceptions of air quality at a specific place and moment in time, and to have these results displayed visually as location-specific color-coded results on a map.
- The development of the perceptions questionnaire to capture the perceptions of air quality that were expected to vary over much longer timescales.
- In parallel, the team of the school empowerment initiatives developed some creative approaches to their work of engagement and empowerment, as the schools shifted their

focus of the work to building environmental issues into the curriculum with the help of the project (for instance by working with off-the-shelf sensors).

The Empowerment Initiative team working on maintained public spaces in one city (Vitoria-Gasteiz in the Basque Country of Northern Spain) had from the outset designed their work to include e.g. perception monitoring as well as 'objective' measures of soundscape and thermal environment; and so their work was relatively protected from the long-lasting difficulties with sensors that affected other teams, especially on outdoor air.

For many of the local empowerment teams on air quality in the eight participating cities, CITI-SENSE also involved getting to know and understand much better the local policy context in which they were doing their scientific work – the possibilities for change and the barriers to it. This led to some reflection about what might be considered an ideology underlying the use of citizen science and citizens' observatories which perhaps needs to be made more transparent and examined more critically. The original viewpoint that the Empowerment Initiatives (or the CITI-SENSE-project in general) would influence policy-making or decision-making for the better, mainly by engaging people in taking measurements, was challenges. Although the assumptions that:

- the additional knowledge (gained from sensor measurements that were considered usable and useful) would lead to better decisions, and;
- the additional engagement of citizens, NGOs etc., in gathering and/or understanding these measurements, would lead to better methods of decision making,

…might seem to be plausible at first sight, they were not at all obvious. Unfortunately, we did not get the chance to find out the full potential within the project, so we have to be cautious when drawing final conclusions. However, the story of these dimensions of learning – all of which were happening in parallel, but with different intensities at different times – was definitely another important and meaningful way of looking at the project (which might be useful for similar initiatives in the future).

User-evaluation of the empowerment potential of the CITI-SENSE-tools

The way in which empowerment would be defined seems to be very important for the development of these technologies. One main concern is that the tools might only enable individuals to better adapt to a fundamentally unfair situation, without addressing the conditions that produce this unfairness in the first place (Pettit, 2012). Within the CITI-SENSE-project, a potential risk of – unconsciously – developing counterproductive tools was found, especially if the empowerment goals would be defined in terms of having the "power-to-choose". But even with more appropriate definitions of empowerment, challenging situations might occur. Although the tool-developers and scientists might have the best intentions, the tools may become *"a Siren's song seducing us to make poor choices"* (Cuff et al, 2008). This means that – no matter how empowerment is defined exactly – the newly available technologies can always have both empowering and disempowering effects (for instance strongly depending for which purposes the output of the tools would be used). Examples of the possible negative consequences are:

First of all, people might be seduced to make poor chooses in terms of real empowerment, even although they might seem to be reasonable choices at first sight.

- The possibility to take an alternative route might give the wrong message. This choice would only re-enforce the status-quo: people who are giving the good example will be punished (by making them walk or cycle longer distances in an attempt to avoid AQ-hotspots).
- When there are no alternative routes available, people might also decide to stay inside. Once again this will rather be a doubtful way of only enabling (vulnerable) people to adapt better to fundamentally unfair situations. And sometimes there will be no other option then leaving the house (e.g. to bring the children to school, to go to work, etc.).

- Deciding to stay indoors might even be more problematic, because air pollution does not stop at people's doorsteps. Indoor air often seems to be more polluted than outdoor air, this might also be a poor choice. In 2007 the European Scientific Committee on Health and Environmental Risks (SCHER) recommended *"that any studies to correlate outdoor air concentration with health effects need to consider the impact of indoor exposure".*
- Similarly, it can also be questioned if the choice to wear a mask when people go outdoors would empower people. Although it can indeed contribute to your health, this poor choice is giving the same wrong message to polluters.
- Moving houses because of bad air quality can also be a poor choice for different reasons. It might for instance re-enforce urban sprawl, and therefore increase the AQ-problems. People who don't have the financial means to move away, will stay behind in communities that might become even more vulnerable.
- Using these tools to estimate property values was also explicitly mentioned. This means that in a worst case scenario, the tools can re-enforce "gentrified sustainability", "environmental gentrification" and "smart segregation" (instead of smart growth) due to unrestricted market processes that lead to changing housing prices based on the AQ-data that is made available. Again, for those who are left behind it will probably cause feeling of frustration.
- Although not fully comparable with the Empowerment Initiatives (EIs) about outdoor air quality, similar challenges might occur in the school case studies, for instance when parents would start to select the most appropriate school for their children in relation the AQ-levels that were measured.

Secondly, there might also occur frustrating situations when there are no real alternatives available for the informed citizens, or if they are not aware of how they can deal with the issue:

- When citizens are made more aware of AQ-problems while they don't have alternatives to solve them, this can often lead to frustrating feelings of "learned helplessness".
- When citizens are intensively made more aware of AQ-problems without making it equally clear to them how they might be dealt with, this can also lead to frustrating feelings of "learned helplessness".

Besides the risks of making poor choices, there are also other ethical limitations regarding "individual choice" in terms of a person's choice to refuse being held responsible for his/her contribution to the problem of air pollution. The very interesting debates on Odum's/Kahn's "tyranny of small decisions" and Hardin's "tragedy of the commons" can be seen as an interesting starting point for this debate. And there might also occur problematic situations when valuable information (e.g. AQ-data) would be gathered, but then it is not acted upon:

- There might be situations in which polluters and/or local authorities will try push away their (complicated) tasks and responsibilities to the level of individual citizens who will then have to help themselves (as part of an "empowerment as freedom to choose"-approach-.
- The inactivity of authorities can force individuals to become activists, because responsibilities for solving AQ-problems are shifted towards them. The potential risks of being treathened by opponents might also increase then, especially when stakes are high.

Other challenges that were mentioned:

- On a more general level, privacy and data security were also addressed as concerns (at least by some of the participants).
- The potential risk of creating "hysteria", for example when alerts about air quality are send out to individuals and/or schools (especially when risk communication is not been taken into account).

Finally, besides all these challenges mentioned above, also the idea that empowerment would follow rather automatically from the collection of new data about air quality was questioned by some of the participants.

Often, participants were not fully aware of the possible negative side-effects. Therefore, the societal challenges have to be acknowledged by all scientists involved in these kinds of projects, whether these are participatory (citizen science) projects or projects that mainly focus on the development of the technology itself. Also the ethical debates about the tools or the topic of air quality in general should not be avoided. Both positive and potentially negative outcomes should be discussed openly with citizens, right from the start. If not, there is indeed a real danger that these new technologies might become contested, as it was emphasized by the European Commission:

> *"[…] There are many examples in which the outcomes of research have been contested in society, because societal impacts and ethical aspects have not adequately been taken into consideration in the development of innovation. In many cases, the related research funding was wasted. On the other hand, there are many cases in which the successful and early consideration of societal needs has brought up innovation which were particular successful, also in economic terms" (European Commission, 2013a).*

Answering the question if all these risks for (potentially) negative outcomes should withhold us from making detailed AQ-measurements is more difficult. Taking into account the goals for Responsible Research & Innovation, the potential risks should not be underestimated. But these data can also be used very positively to solve (local) AQ-problems. Besides that, inactivity would also contribute to the remain of the status-quo (e.g. no empowerment achieved). However, the processes, the activities and the ways in which goals are set should be selected very carefully and the results or final outcomes should be evaluated and communicated appropriately. Tools which aim to support empowerment should be co-developed carefully together with the target-groups (e.g. co-design).

User-evaluation of the overall outcomes of the project

Evaluating outcomes and impact of research in terms of empowerment can be very challenging. Societal impact is much harder to measure than pure scientific impact, societal impact can often take many years to become apparent, and the routes through which research can influence individual behavior or inform social policy are often very diffuse. Within the timeframe of this project, it was not possible to evaluate all kinds of outcomes, especially not the outcomes that might require more time to occur. The user-evaluation is therefore limited to the first (intermediary) outcomes and possible impacts of the project. Although it is important not to overestimate the impact of the CITI-SENSE-project, it would also be a missed opportunity if the overall impact of the project would be seriously underestimated. Following indications regarding outcomes were found:

- Gain of scientific knowledge: not only scientific knowledge about air pollution, but also other relevant knowledge (for instance about these kind of new technologies in general);
- Learning of new skills (for example regarding the use of these technologies);
- Awareness-raising amongst the wider public (which was also be increased as a result of media attention for the project);
- First (preliminary) indications of behavioral changes, although these were often still rather small practical changes in behaviors (but which might be seen as a first step towards more sustainable behavioral changes in the long run);
- Increased networking (with other interested people involved, with scientists, authorities…), and first indications that there is definitely a potential to start up these kinds of Citizens' Observatories;

- Increased feelings of having a purpose from now on (e.g. in terms of convincing other people to become more environment-friendly);
- Increased (preliminary) feelings of empowerment, although at the same time other participants also warned about possible negative feelings of disempowerment if other's would not be interested in their concerns);
- First (preliminary) indications of "giving people voice" (e.g. through the CityAir-app and Long Perception Questionnaire in which participants might share their concerns and ideas);
- Increased communication between different stakeholders (while also authorities mentioned that an increase in communication would be beneficial from their perspective);
- An increase in the personal activities of volunteers (with the aim to influence administrative decisions and processes).

Points of attention that were raised, are:

- The need to be aware of possible solutions, as being aware of possible solutions is an important step in order to enable people to take more concrete action (which also shows that there is still room for improvement for tools in terms of being more solution-oriented);
- The importance of engaging people in these kind of activities in order to raise awareness;
- The fact that giving voice to citizens in decision-making is definitely not enough (because a lack of interest amongst other citizens and/or authorities or the unwillingness to listen and to actively search for possible solutions might actually also contribute to feelings of frustration and disempowerment).

Not all of the expected outcomes – for instance changes in participants behaviors – will necessarily contribute to empowerment. As argued before, some of them might actually be disempowering too if they mainly enable people to adapt better to fundamentally unfair situations (even if this can contribute in a positive way to the health of the participants for the moment).

Recommendations for similar projects in the future

For (research) organizations who are planning to start a similar project in the (nearby) future, the following recommendations can be made (based on our experiences and on the evaluation of the project and the tools by participants involved):

1. Put the principles of "co-design" and "co-development" at the core of these projects.
2. Make sure right from the start that all consortium-partners are aware of the best-practices that need to be shared in order to maximize success.
3. Set up your project in such a way that it can become a real "learning organization".
4. Make sure that every project-partner takes care of "expectation management".
5. Take into account possible barriers for implementation which can reduce the outcomes and final impact of the project.
6. Make sure that the EU-goals for "Responsible Research & Innovation" (RRI) are taken seriously by all project-partners involved.
7. Double-check also during the research process if all project goals are still really shared.
8. Double-check regularly if the consortium is really balanced enough to deliver on all the necessary aspects of this research (including the social aspects).

Particular recommendations for the EU are:

1. Put the principles of "co-design" and "co-development" at the core of these projects.
2. Make sure that every project-proposal takes care of "expectation management".

Table of contents

1. Introduction

1.1 Aims and structure of the present report

In this report the methodological support team on engagement and empowerment (WP5) presents the evaluation of empowerment activities within CITI-SENSE. It is the final report of the methodological support team on engagement and empowerment. As indicated above, within CITI-SENSE this support team had the role and responsibility of:

- providing guidance to the project as a whole on engagement and empowerment issues, in the light of parallel developments in technology and infrastructure, and;
- being the focus of learning about engagement and empowerment within the CITI-SENSE-project, as a resource for future citizen observatory projects.

Previous reports from this team have recorded progress towards these objectives as follows:

1. The first report (2013) contained a structured review of scientific literature on engagement and empowerment (D5.1);
2. The second report (2013) contained a detailed protocol for the engagement and empowerment activities of the Empowerment Initiative teams; as will be explained further, below, actual implementation of engagement and empowerment was via these teams; they were the "user interface" between CITI-SENSE and the wider public, whether citizens or citizens' groups or NGOs or Local Authorities or policy makers (D5.2);
3. The third report (2015), reported on the growth of collaboration between the methodological support team on engagement and empowerment and the Empowerment Initiative teams (D5.3);
4. The fourth report (2016), reports on a specific initiative in Scotland to understand more widely the willingness of citizens' environmental organisations to engage with the concept of a citizens' observatory in support of their activities (D5.4).

While referring as needed to these earlier achievements, the main aim of this final report is to present and discuss new material on the empowerment potential evaluation.

1.2 Structure and content of this report

Chapter 2 aims to explain how the project as a whole developed: what was the overall vision, especially in relation to engagement and empowerment, and what happened subsequently. Chapter 3 presents the results of the user-evaluation of the CITI-SENSE-tools (or the Citizens' Observatories in more general), thereby strongly focussing on the social acceptability and on the practical acceptability of the tools, always taking into account the viewpoint of empowerment. Chapter 4 will present the user-evaluation of the intermediary outcomes of the Empowerment Initiatives (EIs) as how these were perceived by the participants. Chapter 5 aims to explain how the experts – the location officers in the local Empowerment Initiatives – looked at the project. Finally, chapter 6 will summarize the most important conclusions, including the lessons learned and recommendations for similar projects in the future.

2. Context for this empowerment potential evaluation

2.1 Background and overall aim of the present report

2.1.1 Background

As will become clear, CITI-SENSE has been a complex and difficult project, but also a project of great learning. It has operated on the interface between (i) expertise on advanced measurement and IT technology and (ii) expertise about engagement and empowerment of citizens. It has done this in the context of improving people's engagement with environmental issues of consequence, and increasing their power to be active participants in improving environment and health. This was applied in the practical context of local case studies called Empowerment Initiatives, and involved:

a. Development of a project designed to use modern technology in support of the engagement and subsequent empowerment of citizens within Empowerment Initiatives in three different contexts:
    i. Outdoor air quality in 8 European cities
    ii. Maintained public spaces in a 9th city;
    iii. Indoor environment in schools in initially 4, eventually 5, of the 8 cities where outdoor air quality was also being studied.
b. Consequent development, in support of that integrated vision, of:
    i. Measurement technology and associated IT infrastructure;
    ii. Methods for engagement and empowerment of citizens, and for evaluating the effectiveness of engagement and empowerment;
c. Co-operating across disciplines, e.g. exposure assessment, technology, IT and social sciences, including in how to deal with unexpected delays in having available measurement methods of the anticipated high quality
d. Re-working of methods, both technological and social scientific methods, as part of re-visioning the project in the light of those delays
e. Implementing revised plans which give interesting and useful gains, both in terms of technology / infrastructure and engagement / empowerment, though to a less integrated degree than originally anticipated.

Much of this story is written up in detailed reports that can be found on the website:
http://co.citi-sense.eu/TheProject/Deliverables.aspx
One of these, the final report on Dissemination and Training, will summarise, in language accessible to the general reader, key lessons from across the project as a whole.

2.1.2 Aims and structure of this chapter

To give context to this new material, and to explain the extent to which activities/work aiming at engagement and empowerment and research on engagement and empowerment, were implemented in CITI-SENSE, this chapter aims to explain how the project as a whole developed: what was the overall vision, especially in relation to engagement and empowerment, and what happened subsequently. Within this framework the present chapter highlights two key contextual aspects of the engagement and empowerment work of CITI-SENSE.

First, there is the relationship between technology, engagement and empowerment in CITI-SENSE. The original vision was one where technology was supposed to make it easy for citizens to engage with measuring and measurements of the physical environment and with one another in carrying out and discussing such measurements; this supposedly would lead to empowerment of citizens and improved methods of decision making. In practice however, this technology driven model needed to be and was

adapted, as it became clear that many of the sensors were not performing as had been hoped for and expected. The Chapter describes not only how the difficulties (with the reliability of sensors and the quality of data they provided, and together with a preoccupation with resolving those difficulties) impacted on CITI-SENSE work on engagement and empowerment; it describes also ways in which, over time, CITI-SENSE developed alternative and/or complementary products could be options for engagement and empowerment.

Secondly, there is the story of CITI-SENSE as a project of interdisciplinary collaboration on engagement and empowerment. This followed from the fact that (a) the local empowerment initiatives were carried out by teams which consisted principally of physical scientists, exposure assessment experts, experts in measurements, and so on – teams with the expertise necessary for testing and managing the use of static and personal sensors; and (b) CITI-SENSE asked these EI teams also to do the practical work of engagement with citizens to support empowerment: for example, (i) to scope out who are the stakeholders in that city with an interest in outdoor air pollution or indoor environment in schools; (ii) to make contact with individual citizens and with citizens' organisations, e.g. NGOs; (iii) to make contact with policy makers in cities; (iv) to work out who is involved in making decisions about outdoor air quality and/or quality of the environment in schools.

This led to a project wherewith success required interdisciplinary collaboration and negotiation, and continuous learning. This in turn became a major theme of CITI-SENSE and, in the context of engagement and empowerment was needed in at least three dimensions:

a. Between the methodological support team on engagement and empowerment and the teams involved in the three public-facing Empowerment Initiatives: the team of city empowerment initiatives , the team of public space empowerment initiative and the team of school empowerment initiatives; and
b. Within the methodological support team on engagement and empowerment itself;
c. Between the Empowerment Initiative teams and the general public.

Within each of these dimensions there were achievements and missed opportunities. This is summarised in more detail in the final major Section of the present Chapter.

2.2 The relationship between technology, engagement and empowerment in CITI-SENSE.

2.2.1 Original call for proposals: possibilities and built-in risks

It is instructive to refer back to the original call:

ENV.2012.6.5-1 Developing community-based environmental monitoring and information systems using innovative and novel earth observation applications - FP7-
New and innovative environmental monitoring and information capabilities can enable effective participation by citizens in environmental stewardship, based on broad stakeholder and user involvement in support of both community and policy priorities. The objective is to develop 'citizens' observatories' using innovative earth observation technologies. These 'citizens' observatories' should include community-based environmental monitoring, data collection, interpretation and information delivery systems. This will require the development of highly innovative monitoring technologies, (e.g. low-cost reliable micro-sensors), which can be embedded into large numbers of instruments, including highly portable devices. Citizens should be able to effortlessly collect environmental data on a range of parameters, automatically transmit this data to suitable data repositories and exchange their knowledge and experience within a citizens' observatory framework, (e.g. using smart phone

applications), thereby enabling citizenship co-participation in community decision making and co-operative planning. Advanced data management strategies, based on open ecollaboration, should enable the sharing of data and information, whilst addressing questions of privacy, data standards, quality and reliability. Suitable pilot case studies and acceptance activities should be included to test, demonstrate and validate: the concept of 'citizens' observatories'; the direct transfer of environmental knowledge for policy, industrial, research and societal use; the possibilities for a comprehensive implementation and application of the technology. Possible examples of pilot case studies could include: civil protection agencies and wide-scale flooding; estimation of personal exposure within various microenvironments (health sector); air quality and noise levels; the identification of flora, birds and wildlife, their habitats and migration paths; the surveillance of invasive alien species and their pathways of introduction and spread; illegal dumping of hazardous materials, etc.

Expected impact: *Empowerment of citizens and citizen's associations, allowing them to contribute to environmental governance processes in the domains of transparency, knowledge management, accountability and responsiveness. The provision of models for decisionmakers, facilitating connections to governance and global policy objectives.*

Here the ultimate benefits ('*expected impact*') envisaged were clearly aiming at empowerment in governance. However, the *means to those impacts* was described in terms of developments in technology – sensors and associated IT. For example:

"*The objective is to develop 'citizens' observatories' using innovative earth observation technologies. These citizens' observatories should include community-based environmental monitoring, data collection, interpretation and information delivery systems. This will require the development of highly innovative monitoring technologies (e.g. low-cost reliable micro-sensors)…*".

And finally, the means (engagement through technology) and the end (empowerment) were intended to join up seamlessly:

"*Citizens should be able to effortlessly collect environmental data… automatically transmit [it]… and exchange their knowledge and experience… thereby enabling citizenship co-participation in decision making and community planning*".

This is a clear framework for a way forward, but it contains within it a major risk. As envisaged in the call, the project's ambitions regarding empowerment were dependent on using new technology. This technology was to develop citizens' observatories, i.e. communities that share technological solutions, information products and services and community participatory methods, to complement established environmental data and information systems and to improve local environmental decision making. These citizens' observatories require engagement for them to function and in turn enable empowerment because of the data they provide, and the products of the data, and opportunity for citizens to share experience about it and so to be empowered by participating in the use of the technology and data.

But what if the 'community-based environmental monitoring, data collection, interpretation and information delivery systems' didn't function as hoped for and expected? What then for engagement in the work of the citizens' observatories, and empowerment through using it? There was no provision in the call for an alternative strategy for engagement and empowerment. However, the risk in depending so closely on sensors and IT infrastructure was identified during proposal development and some mitigating possibilities included in the proposal and resultant Description of Work.

2.2.2 The effect of long delays in having sensors and platforms of expected high quality

Nevertheless this tension, arising because engagement and empowerment were (considered) dependent on the good functioning of the technology, became one of the key *motives* of CITI-SENSE. The technology didn't function as had been hoped for and expected; and although big gains were made in its development, it left the engagement and empowerment aspects of CITI-SENSE with three major difficulties which impacted seriously on the engagement and empowerment activities of the various teams (air quality in cities; maintained public spaces; and indoor environment in schools), and on the methodological support work on engagement and empowerment also:

i. The work of engagement and empowerment could not go ahead as originally anticipated; and while substantial progress was made on the engagement aspects, the work on empowerment and empowerment evaluation described in later chapters of this report, remained seriously limited by the long delays in getting a citizens' observatory operational as originally envisaged and indeed eventually were based on aspects not originally envisaged as central to the citizens' observatories as it was expected to function.

ii. Those delays related to technology sucked resource and attention not only from the teams with responsibility for sensor and other infrastructure development, but also from the Empowerment Initiative teams and from the methodological support team on engagement and empowerment itself.

iii. It seriously damaged the work on engagement and empowerment:
    - Methodological development could not be linked as envisaged with practical applications;
    - Where practical engagement did go ahead in anticipation of workable sensors being available soon, that work was complicated and sometimes compromised by the on-going lack of dependable sensors. This affected the work of the outdoor air empowerment initiative especially, and also that of indoor environment in schools, to the extent that some teams withdrew from practical engagement with stakeholders (citizens, citizens' groups (NGOs, cyclists, people with asthma, people in schools)) until such time as they could be confident that any promises about sensors could and would be fulfilled – and this was not until the final year.

2.2.3 What CITI-SENSE did to overcome this difficulty

It wasn't all bad news, however, because CITI-SENSE as an integrated project began to develop other routes to engagement and empowerment. This happened slowly at first, but with an increasing sense of urgency, as hopes for high-quality measurements from the available sensors and platforms remained unfulfilled. There was progress on these issues (which is recorded in related reports that can be read on the website: http://co.citi-sense.eu/TheProject/Deliverables.aspx, but as some of these problems got resolved, others became apparent, and the overall difficulty – that the sensors around which several of the Empowerment Initiative teams had built their hopes and work-plans were not performing at the level which had been expected – has persisted much longer than had been anticipated.

Initiatives to develop also other approaches/methods/techniques, some as alternatives to the sensors which had been seen as essential, some to complement them, came from several different parts of the project. Already in Bilbao in May 2014 (M20 of the project) the methodological support team on engagement and empowerment, with support of the project leadership, devoted its entire plenary session to having the project as a whole 'brainstorm' on the question: "What will we do?" and "How will we progress engagement and empowerment, if the sensors don't get any better?". This was done particularly in the context of air quality in cities, where engagement and empowerment were

considered to be most dependent on data quality from sensors, and which involved the largest number of cities. The outcome was interesting, in that people got to think about what could usefully be done with sensor data which previously they considered inadequate.

- Suggestions included comparing trends over time, or (in a qualitative way) identifying areas of sustained higher pollution, or 'fusing' new sensor data with existing air quality data in the same cities to produce maps which are or may be more informative than would be produced by the city data alone.
- Other suggestions, included gathering 'softer' data, and in particular data on citizens' perceptions of air quality.

Over time, these various ideas were worked into 'products' of CITI-SENSE which were used with and by citizens. For example, in due course a smart-phone app (the City-Air app) was developed to enable citizens to record (repeatedly, on different days) their perceptions of air quality 'now', wherever they were; and to have these results displayed visually as location-specific colour-coded results on a map. A questionnaire was developed and administered (once per person) to capture perceptions of air quality that were expected to vary over much longer timescales. While the development of both the app and the questionnaire was largely by and within the project team, there was a co-design dimension whereby citizens in some of the participating cities contributed to the developments by giving feedback on earlier versions of both perception methods. Later, the potential for empowerment of these and other products was evaluated; results of that evaluation are presented in the present report.

In a parallel initiative, the team of school empowerment initiatives developed some creative approaches to their work of engagement and empowerment. In all locations, the schools shifted the focus of the work from measuring and as a result improving the indoor environment in schools, to building environmental issues into the curriculum, with the help of the project. This change in direction of the Empowerment Initiative in schools meant that what got measured became less important; the key thing was that *something* got measured sufficiently reliably that schools (pupils, staff) could use it for learning and teaching. On that basis, the teams for empowerment initiatives in schools bought and used off-the-shelf sensors which enabled them, and the participating schools, to work together on environmental measurements. In addition, in one of the participating cities (Ljubljana), school students developed apps for citizen science – developments which won them international recognition. In ways such as these the CITI-SENSE teams found ways round the difficulties for engagement and empowerment caused by long delays in having the originally envisaged sensors available and working to high standard.

Finally, the Empowerment Initiative team working on maintained public spaces in one city (Vitoria-Gasteiz in the Basque Country of Northern Spain) had from the outset designed their work to include e.g. perception monitoring as well as 'objective' measures of soundscape and thermal environment; and so their work was relatively protected from the long-lasting difficulties with sensors that affected other teams, especially on outdoor air.

2.2.4 Chronological summary

While the above themes indicate some ongoing themes in how engagement and empowerment work developed in CITI-SENSE, they give only a limited picture of how these issues developed in practice over the course of the project. For that, a chronological perspective is helpful. Briefly, then, with hindsight it is possible, from the viewpoint of the inter-relationship of technology, engagement and empowerment, to look on the project as in involving three main phases, written here with clear boundaries but in practice of course with blurred ones:

1. The First Phase: The first 18 months (M1-M18): settling into implementing the original vision;

a. In the beginning, there was what seemed to be justifiable trust that good quality sensors would become available in good time to provide data that local stakeholders would find really useful; i.e. that for each Empowerment Initiative we would get in place the engagement necessary to make a citizens' observatory viable and then learn what we could about empowerment based on the experience of using it.
b. Multiple linked or parallel streams of work were carried out within this framework, including (i) development of sensors and platforms; (ii) development of IT infrastructure for accepting, organising and eventually giving access to the measurement data; (iii) beginning development of how to translate measured data into meaningful products; (iv) review of methods and subsequent development of a protocol for engagement and empowerment within the project; (v) an empowerment reflection questionnaire was launched among Empowerment Initiative location officers in order to start reflection on the empowerment perspective (vi) development of further IT infrastructure (e.g. website) for public-facing aspects of the citizens' observatory; (vii) actual engagement, and field testing of methods, by the teams involved with air quality in cities, with public spaces; and with indoor environment in schools. Throughout all of this there was both overall co-ordination and multiple bi-lateral links as needed between streams of activity.
c. Field trials showed that problems with the sensors and platforms persisted – with reliability of the equipment and/or with quality of at least some of the hoped-for measurements. The time when the original vision for the project could be implemented on a full scale got deferred repeatedly. The impact of delays was magnified by a persistent perception that the problems were close to being solved. (To a great extent they were solved; but, repeatedly, new ones came to the surface.)
d. Planning continued for quite a while on the assumption that this original vision would come good in time enough to try out engagement and empowerment as originally envisaged, even if for a shorter period of time than envisaged originally; though increasingly the need for alternatives was being recognised by various groups within the project including, for example, D5.2, the detailed protocol for engagement and empowerment developed by the WP5 team.

2. The Second Phase: The middle 15 months (M19-M33): Closer collaboration but increasing realisation that the original vision, of engagement and empowerment based on new good quality sensor data, wasn't working; and development of alternatives
   e. As the difficulties persisted, various groups in CITI-SENSE began to realise that an alternative strategy for engagement and empowerment was needed, and began to develop ideas an plans for what this might look like. Thus, at Bilbao in May 2014 (M20 of CITI-SENSE), the methodological support team on engagement and empowerment already engaged the project as whole in thinking through what engagement and empowerment was possible, especially for the EI on air quality, even if sensors and platforms were not improved. This included visualisation aspects, linking with existing data, and the capturing of citizens' perceptions.
   f. In parallel developments, the teams of public space empowerment initiative and of school environment empowerment initiative began also to develop methods which did not depend on the air quality sensors which were proving controversial. These initiatives were sometimes in close collaboration with the methodological support team on engagement and empowerment, sometimes working relatively independently.
   g. There followed a period of intensive collaboration and joint working between various project teams to develop together the means to implement these alternative or complementary approaches. Over time this set of complementary and/or alternative strategies came to be known as 'Plan B'. This was not a formal alternative plan, rather an informal name for the increasingly varied set of options aimed at answering in practice the question: What can we

do, by way of engagement and empowerment, if eventually we need to work with sensors of limited precision, accuracy and/or reliability?

3. The Third Phase: The final 15 months (M34-48): Wide-spread adoption and implementation of alternatives to the original sensor data ('Plan B')
   h. With about 15 months to go, this collection of alternative and complementary methods was adopted as the official mainstream direction of CITI-SENSE, although work continued in parallel with development of sensors and other IT-infrastructure. Co-design with intended users was incorporated as well as possible into the development of a range of alternative or complementary CITI-SENSE 'products' – the scope for this was limited by the now relatively short timescale to completion.
   i. Methods for the evaluation of empowerment potential were developed by the methodological support team for engagement and empowerment. These methods related both to the originally envisaged sensors, which at last were becoming operational, and the newer alternative or complementary 'products' of the project, respectively not dependent or less dependent on the performance of the sensors.
   j. Within this framework there was a varied programme of engagement and empowerment carried out by the Empowerment Initiative teams. With support from and direct participation by the methodological support team for engagement and empowerment they also carried out the project's evaluation of the empowerment potential of the products of CITI-SENSE.
   k. Methods for and results from that evaluation of empowerment potential are reported in later Chapters of this Report.

2.3 CITI-SENSE as a project of interdisciplinary collaboration

2.3.1 The context where interdisciplinary collaboration and learning was required

The teams for the many local Empowerment Initiatives included teams in 8 cities for outdoor air pollution, a team in on city for public spaces and teams in 4 cities for the empowerment initiative in schools. These teams varied in the expertise which they brought to the project. As noted earlier, many of them were principally 'technical' teams with expertise in e.g. measurement of air pollution. They varied in the strength and depth of their existing relationships with stakeholders. Some teams included exposure or health scientists who already had strong links with policy makers and/or citizens in their local participating city; other teams didn't. Generally, they did not include people with formal training in social scientific methods.

Nevertheless these local Empowerment Initiative teams were the main point of contact of CITI-SENSE with local stakeholders and policy makers. Also, supported by the methodological team for engagement and empowerment, these local Empowerment Initiative teams were the main means by which the engagement and empowerment methodology of CITI-SENSE was implemented. Some of the local teams included people with a natural flair for and experience of working with citizen groups, policy makers, etc.. Others didn't have that experience and felt very incompetent about doing engagement and empowerment work: it was very different from what they were used to doing, and so they generally felt very anxious and out-of-their-depth. For this arrangement to succeed, it was essential to have a project strong on interdisciplinary collaboration and open to learning.

2.3.2 How the interdisciplinary collaboration was organised

Some of the Empowerment Initiative teams wanted the local engagement and empowerment work to be done primarily by the methodological support team for engagement and empowerment, with the local Empowerment Initiative team facilitating. But this was not workable, for two reasons:

i. Successful engagement and empowerment depend hugely on knowledge of the local situation and culture; and for many of the participating cities, the methodological support team for engagement and empowerment did not have people in it with sufficient local knowledge, including language and dialect, to do the actual work of engagement and empowerment locally.

ii. The methodological support team for engagement and empowerment didn't have the resources in terms of time to do the detailed work across the many Empowerment Initiatives. And even if the support team did have the time and funding, it was not workable for them to learn enough about the local language and culture across all the participating cities to be able to lead effectively on local engagement and empowerment in the Empowerment Initiatives.

So CITI-SENSE worked with the model of implementation via the local Empowerment Initiative teams, with support from the methodological support team for engagement and empowerment. Several complementary organisational structures were put in place to facilitate this:

- Right from proposal preparation onwards, there were discussions at project meetings, followed up by bi-lateral discussions, to get some shared vision of what was needed and how it would happen.
- Early in the project we put in place an arrangement whereby each of the 13 local Empowerment Initiative teams had one principal point of contact within the methodological support team for engagement and empowerment (implying that many in the support team were supporting more than one Empowerment Initiative team).
- In due course the methodological support team for engagement and empowerment established regular fortnightly TeleConferences, with agenda and detailed minutes, where initially leaders of Empowerment Initiative collaboration groups participated. Later the leaders of the local Empowerment Initiative teams (the Location Officers) all were invited; some participated regularly, others occasionally.
- There were joint meeting sessions during the major CITI-SENSE project meetings, i.e. Prague (2012), Cambridge (2013), Belgrade (2013), Bilbao (2014), Barcelona (2015) and finally Prague again (2016). In addition there were two special collaboration workshops (Barcelona, 2014; Oslo, 2014), and an empowerment evaluation training meeting (Oslo, 2016).
- Finally, there were in addition several joint working groups, some also with participants from other support teams of CITI-SENSE (e.g. on products of the project), through 2015-6, as CITI-SENSE extended its range of ways of engaging and empowering citizens.

Learning and interdisciplinary collaboration happened on multiple levels:

a. So within this framework (whereby for CITI-SENSE the issues of engagement and empowerment were implemented by the Empowerment Initiative teams, who generally were without specialist social scientific knowledge, supported by the methodological support team for engagement and empowerment), learning and interdisciplinary collaboration was happening at three levels: between the methodological support team for engagement and empowerment and the teams involved in the three public-facing Empowerment Initiatives:
   i. the team of city empowerment initiatives,
   ii. the team of public space empowerment initiative and
   iii. the team of school empowerment initiatives.

b. Within the methodological support team on engagement and empowerment itself.
c. Between the Empowerment Initiative teamsand the general public.

We consider each of these now in more detail.

a. *Between the methodological support team for engagement and empowerment and the teams involved in the three public-facing Empowerment Initiatives*

Central to the CITI-SENSE work on engagement and empowerment, there was intentional and sustained learning between local Empowerment Initiative teams and the methodological support team for engagement and empowerment on how to collaborate effectively so that the local Empowerment Initiative teams, and consequently the CITI-SENSE project, could engage effectively with stakeholders locally and implement a methodology that allowed tracking of the effectiveness of CITI-SENSE as project of engagement and empowerment.

Informal and formal methods for engagement and empowerment

To understand what worked well and what was difficult in establishing on-going learning and interdisciplinary collaboration, it is useful to distinguish between

i. dealing informally (though perhaps effectively) with people and with 'people' issues – in the present context, working with citizens, citizens' groups, policy makers, the media and others on the engagement and empowerment aspects of CITI-SENSE; and
ii. formal use social scientific expertise and methods, i.e. the science that deals with social and societal aspects, relations and processes – in the present context, the science that makes "dealing with people issues" systematic and rigorous.

An example from another context may help illustrate the difference. In statistics there are corresponding issues of formal and informal methods. When we see a scatter-plot, we can draw a line through it, by eye; and generally it won't be a bad summary of the data. However, there are formal methods for fitting a line, which take into account e.g. possible differences in the precision of the individual data points. Generally the formal methods and the informal ones give fairly similar answers; i.e. generally the lines we draw by eye are quite good. But (i) they will differ from one another for no good reason other than that different people have drawn them; and (ii) sometimes they will be misleading, when there are unusual aspects to the data. Consequently the informal methods, even though often effective, lack credibility, and in particular lack scientific credibility.

CITI-SENSE was a bit like that in terms of engagement, empowerment and social scientific methods. Initially, the local empowerment teams either dealt with 'people issues'/engagement and empowerment informally, building on existing relationships and experience in earlier projects, or they gave priority to technical issues. The methodological support team for engagement and empowerment, looked to bring more rigour to this work. It was well aware of the challenges and introduced the idea of CITI-SENSE being a "learning organization" at an early stage of the project, to give a framework to the transition from informal to formal methods. And indeed the underlying tension between (i) continuing to use informal methods which often were good at implementing what need to be done but weak at tracking what happened and (ii) the adoption of more formal ones, which improved implementation and provided tracking data, did change markedly over time.

How CITI-SENSE moved from informal to formal methods

Having the local Empowerment Initiative teams deal with engagement and empowerment using informal methods, i.e. building on the relationships and kinds of experiences that some had already gained through other projects, allowed the work to get started, and to happen in a way that the local teams could understand and consequently could adapt as the limitations of informal methods became

more clear. This allowed many useful things to happen, getting local stakeholders enthused about CITI-SENSE, including by use of local websites, and willing to help with the later fieldwork. On the other hand, the informal methods had some significant limitations also. Getting started early, in an un-coordinated way, meant that local stakeholders' expectations were raised; and this caused problems when these expectations could not be fulfilled because of difficulties with the sensors. Eventually the delays became an embarrassment to many of the local empowerment initiative teams, in their connections with local stakeholders.

The methodological support team accepted this diversity of early approaches to engagement but tried to bring coherence to it, by asking the local engagement teams to take a more formal and systematic approach to scoping who are the stakeholders in the Empowerment Initiative, what are their needs and expectations, etc. Formal social scientific methods about engagement and empowerment (which at least some of the methodological support team for engagement and empowerment knew well) capture the experience and lessons of similar projects and participatory approaches.

For CITI-SENSE, this wider experience was captured systematically initially in the first methodological support report on engagement and empowerment report, a detailed literature review of social scientific methods and their application in relation to citizen science. It was developed further in the second methodological support report for engagement and empowerment, a comprehensive manual of how engagement and empowerment might be implemented systematically in the various local Empowerment Initiatives of CITI-SENSE. While some of the local engagement teams recognised the usefulness of this manual, both in terms of the range of issues it covered and the guidance on implementation of each of these, others used it at most only a little. To some extent this reflected time constraints and an on-going focus on testing static sensors and platforms. But it also highlighted the difficulties in linking up extensive formal expertise with the local teams' existing experience in a way that the EI teams found helpful rather than intimidating and undermining of what they thought they already knew. If earlier and more systematic use of these formal methods had proved possible then some work that already went well could have gone even better (and monitored and evaluated more robustly), and some things that later proved problematic could have been avoided; it would certainly have led to better tracking of what was done and what was being learnt.

And learning did happen. After an initial reluctance to engage with formal methods (and some in the Empowerment Initiative teams engaged well with these from the outset), the combination of (i) greater experience of collaboration, of knowing and understanding one another's experience and point of view and (ii) greater experience of what was truly needed to do the engagement and empowerment work well, *including to track how it was being done*, led to greater and eventually to widespread adoption of formal methods; including eventually to the development, implementation and analysis of the methods for empowerment evaluation which are the main content of this Report. One of the local Empowerment Initiative location officers summarised well the learning that had happened among those LOs who had little prior experience of engagement and empowerment work. In discussion at the end of the project meeting in Prague (2016), he said that he and some of his colleagues did not see the importance of this at the beginning, but over time they did; e.g. how to communicate with the public (who expect the sensors to work, even if they don't). He also recommended that in any future project like CITI-SENSE, each local empowerment initiative team should include someone with formal social scientific expertise as an integral part of the team.

b. *Within the methodological support team on engagement and empowerment itself*

The composition of the methodological support team for engagement and empowerment was itself diverse. Basically, it included two main kinds of people. A minority were specialist social scientists whose expertise included issues of engagement and empowerment in other contexts, and who were

familiar with the formal academic research literature about these issues. The bigger group in the methodological support team for engagement and empowerment were (mainly) environmental health scientists, people with a lot of experience of working with stakeholders (citizens, NGOs, policy makers) through science-policy expert committees or health promotion or health impact assessment or epidemiology, especially air pollution and health. They saw and supported actively the importance of engagement and empowerment and they had a lot of experience but they generally didn't have formal knowledge of social sciences. Consequently, within the methodological support team for engagement and empowerment, there were people with vastly different experience in (i) social science methodology; (ii) working with 'technical' scientists; (iii) actual engagement with stakeholders (citizens, policy makers…); (iv) the subject matter issues of air quality, indoor environment in schools, maintained public/open spaces.

From one viewpoint this diversity was a difficulty – those in the methodological support team for engagement and empowerment who came from a background in epidemiology, health impact assessment and health promotion themselves needed to learn both the importance of, and the detailed content of, the social scientific methods that others in the methodological support team for engagement and empowerment were well able to, and did, develop. This learning happened initially during development of the first report, i.e. the review of the social scientific literature on engagement and empowerment, especially in the context of citizen science. It was led by the social scientists, but with active participation by others in the team also.

From another viewpoint the diversity was an advantage. The social scientists in the methodological support team brought a necessary rigour to the work of engagement and empowerment. The environmental health scientists helped in getting a common language and understanding between social scientists and the local empowerment teams: the exposure and measurement scientists of local Empowerment Initiatives were more familiar with working with scientists from the environmental health-related disciplines, rather than with those whose principal expertise was in social scientific methods. Also, they could engage with the local empowerment teams, especially local Empowerment Initiatives on outdoor air pollution, on how measurement data might be interpreted, communicated and eventually used to improve air quality locally.

c. *Between those Empowerment Initiative teams and the general public.*

Here there was also two-way learning. For many in the general public, this was initially about the potential of modern technology. In due course it became also about the difficulties in getting it to work effectively, how the technology is developing very rapidly but still has many 'teething troubles'.
For the empowerment initiative teams, it was in coming to a better understanding of the real needs of citizens, citizens' organisations and policy makers in the participating cities. The most striking example concerned the schools. Here, the local empowerment teams had envisaged that results from sensor measurements would be used to understand better, and then to improve, air quality and other aspects of the indoor environment in the participating schools. In practice however schools in all four participating cities wanted to use the resource provided by CITI-SENSE for a purpose which they saw as more central to their own needs and ambitions. This was to integrate the work of CITI-SENSE into the school's programme for learning (into the school curriculum). It gave schools a means by which students could 'play' and learn about technology, measurement, data visualisation and so on, in the context of environmental measurements. Fortunately the local empowerment teams co-operated fully with this change of purpose; and indeed the adapting for their own needs, by the schools, of the resource offered by CITI-SENSE is perhaps the project's clearest example of actual empowerment.

For many of the local empowerment teams on air quality in 8 participating cities, CITI-SENSE also involved getting to know and understand much better the local policy context in which they were doing

their scientific work – the possibilities for change and the barriers to it. This led to some reflection about what might be considered an ideology underlying the use of citizen science and citizens' observatories which perhaps needs to be made more transparent and examined more critically. That is the viewpoint that by engaging people in taking measurements, and these measurements being useful, we would influence policy-making or decision-making for the better; i.e. that:

i. the additional knowledge (gained from sensor measurements that were considered usable and useful) would lead to better decisions and
ii. the additional engagement of citizens, NGOs etc., in gathering and/or understanding these measurements, would lead to better methods of decision making.

While these assumptions look plausible, it is not at all obvious on general grounds that these hopes are based on reality. In the project, we did not fully get the chance to find out for sure because we did not have useful and usable measurements with which to influence policy. This means that one of the key aims of the project was unable to be fully tested. Nonetheless, the outcomes enabled us to draw some (preliminary) conclusions, and the story of these dimensions of learning – all of which were happening in parallel but with different intensities at different times – is another important way of looking at the project.

3. User-evaluation of the empowerment potential of the tools

In this chapter, various CITI-SENSE-products that were developed and used by the local participants will be analyzed from an empowerment perspective. Evaluation checklists were developed in preparation of the empowerment evaluation. The target group for this evaluation consisted of local people collaborating with or contacted by those Empowerment Initiatives (EIs), such as individual citizens, members of local groups (NGOs), students, teachers, local authorities and other stakeholders involved. These persons were interviewed by the local project team members, either in individual interviews or in group interviews. The information collected during these interviews will help us to interpret and explain the empowerment potential of the CITI-SENSE-tools from a social scientific perspective. In this chapter, the individual tools will be analyzed in terms of benefits and possible negative consequences or pitfalls. This chapter will build on the comments from the end-users themselves (during the participatory evaluation of the tools), but will also refer to lessons-learned regarding the empowerment-potential of this kind of tools in other (similar) projects. In the introduction, it will be explained why it is important to shift away from a more technocratic discussion about the products and traditional "usability-surveys", towards a broader societal debate about the usefulness of the products and their possible impacts on society (which is also more closely related to the tasks of the methodological support group on engagement & empowerment).

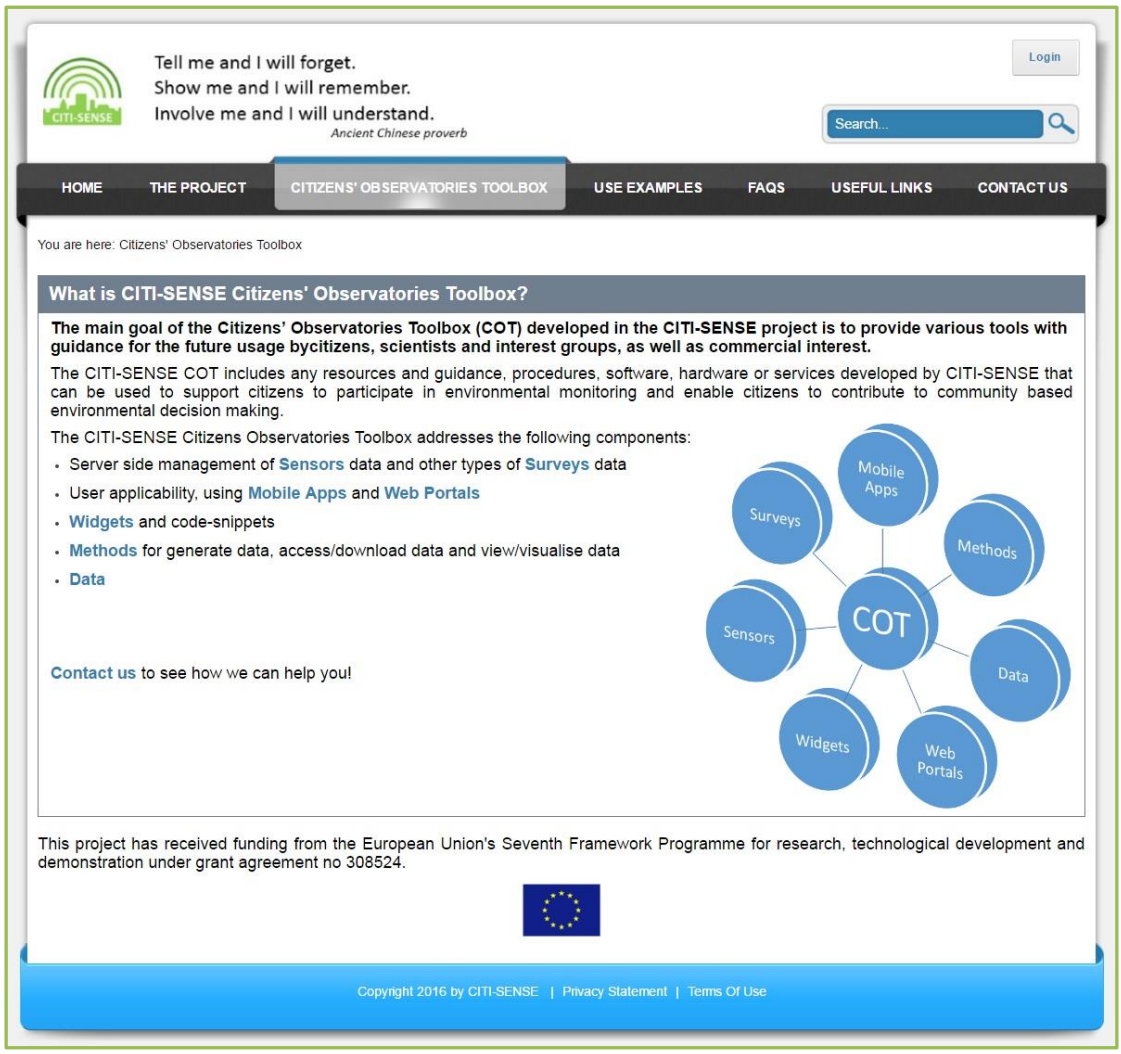
3.1 Introduction

The CITI-SENSE-project aimed to develop "citizens' observatories" (COs) in order to empower citizens to contribute to and participate in environmental governance, to enable them to support and influence community and societal priorities and decision-making (Lüders et al., 2013):

> *"Citizen Observatories can be conceived as communities of users who share technological solutions, information products and services, and community participatory governance methods using appropriate communication solutions. The activities provided by the Citizen Observatory will complement established data and information systems, and improve processes in environmental decision-making through an optimal combination of objective information (quantitative) collected through a series of sensors and Smartphone type and subjective information (qualitative) collected through questionnaires, face-to-face settings and online participation tools."*

In order to do so, CITI-SENSE would build further on technological platforms for distributed monitoring, on Information & Communication Technologies (ICT) and on societal involvement. This makes that CITI-SENSE-products (both the COs or the particular tools that underpin them) are clear examples of EDSS-products. The overall performance of these CITI-SENSE-products will be evaluated in this chapter.

These Citizens' Observatories can be seen as Environmental Decision Support Systems (EDSS). The overall acceptability of an EDSS – or a specific tool used within the CITI-SENSE-project in particular – is in its most basic form determined by the question if the system (or tool) is good enough to satisfy all the needs and requirements of the users. This has two important consequences. First of all, this means that COs (or particular tools) should not be perfect in order to be acceptable.



The Citizens' Observatories toolbox

Secondly, this indicates how important it is to mak an in depth analysis of needs and requirements, as this will be a crucial factor for success. Based on Nielsen (1993), the overall system acceptability can be seen as a combination of:

- **Social acceptability** (or responsiveness-to-societal-needs):
  Referring to how an EDSS (or a tool) complies with existing societal needs (including ethics, credibility, legitimacy, representativeness, socio-cultural issues, legislation, etc.), but also influenced by political acceptability (as probably no major policy decisions will be made when outcomes will be totally politically unacceptable).

- **Practical acceptability** (or responsiveness-to-practical-needs):
  Referring to the overall usefulness of the EDSS (or a tool), its cost or cost-efficiency (economical acceptability) and its continuity ("longevity"), but also influenced by user-expectations regarding this usefulness and various facilitating factors (such as support for users).

Social and practical acceptability of Environmental Decision Support Systems (EDSS)

When the wider context of the CITI-SENSE-project is taken into account, it is also important to emphasize the EU-goals regarding Responsible Research & Innovation (RRI). As addressed by the European Commission, *"there are many examples in which the outcomes of research have been*

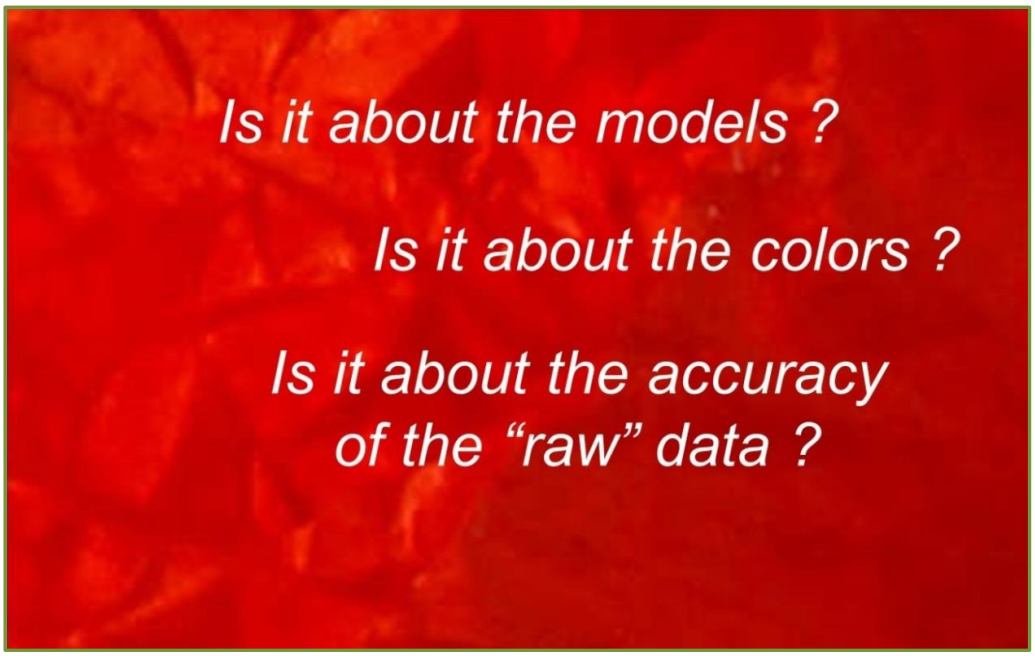
contested in society, because societal impacts and ethical aspects have not adequately been taken into consideration in the development of innovation. In many cases, the related research funding was wasted. On the other hand, there are many cases in which the successful and early consideration of societal needs has brought up innovation which were particular successful, also in economic terms" (European Commission, 2013a). The overall EU-goals regarding RRI are:

> *"The grand societal challenges that lie before us will have a far better chance of being tackled if all societal actors are fully engaged in the co-construction of innovative solutions, products and services.* ***Responsible Research and Innovation (RRI)*** *means that societal actors* work together during the whole research and innovation process in order to better align both the process and its outcomes, with the values, needs and expectations of European society. RRI is an ambitious challenge for the creation of a research and innovation policy driven by the needs of society and engaging all societal actors via inclusive participatory approaches" (European Commission, 2012).*
>
> ** Societal actors are researchers, citizens, policy makers, business, third sector organizations, etc.*

Responsible Research & Innovation (RRI) according to the European Commission

RRI practices strive for ethically acceptable, sustainable and socially desirable outcomes. Solutions are found in opening up science through continuous, meaningful deliberation with societal actors. In the end, the incorporation of societal voices in R&I will leads to relevant applications of science (Klaassen et al, 2014). As a consequence of RRI, evaluations of new (technological) products should also shift away from a more technocratic discussion about the technical details of products towards a broader societal debate about the usefulness of the products and their possible impacts on society. Although questions about user-friendliness of new technologies are definitely relevant and should be evaluated with users, there are other – more important – questions that actually should be answered together with society first, such as (Farrell, VanDeveer and Jäger, 2001; Jasanoff and Wynne, 1998; Jasanoff, 2004; Lidskog and Sundqvist, 2011; Rein and Schön, 1996):

- What is the purpose of this development?
- Why is it important?
- What is/are the driving force(s) behind this development?
- How are problems "framed" (and what does it mean in terms of proposed solutions)?
- Who will benefit? And who will experience possible negative consequences?
- Who has relevant knowledge (that should underpin this development)?
- Etc.



CITI-SENSE is not only about the technology, but about the whole picture…
(including participation, co-design, empowerment, ethics, etc.)
(photo from www.pixabay.com)

Framing as an important aspect in the user-evaluation

Framing is the process in which an issue is simplified and packaged in such a way that it becomes suitable for political management, or governable. People might define – or "frame" – a particular problem in different ways, based on their own knowledge and underlying views on the world. It is important to acknowledge these differences in perception or framing of air pollution problems in order to understand different audiences' priorities. The theory of framing theory can be used to explain how environmental conflict is a function of perceptual differences towards the dispute, the possible solutions, and the identification of those who are responsible. For example, environmental inequality might be interpreted as "just how things normally are" (e.g. as the outcome of how the market economy works), or as "the result of systematic discrimination and injustice". Framing is also an important aspect in the co-production of knowledge, for instance because it will also affect the selection of indicators that are seen as "relevant for the evaluation of possible solutions". This selection might also determine the various sources of information that will be used for evaluation and the actors that will be involved when solving the problem. In other words, the way that problems are framed often also affects how projects are evaluated. But when there are different framings and these are not explicitly addressed, the actors involved might find it difficult to understand each other and misunderstanding or disagreements might arise. Indicators or solutions from one frame may not be recognized as being relevant in another frame and participants can disagree over what information or which actors are relevant to the problem (Farrell, VanDeveer and Jäger, 2001; Jasanoff and Wynne, 1998; Jasanoff, 2004; Lewicki, Gray, and Elliot, 2003; Lidskog and Sundqvist, 2011; Rein and Schön, 1996; Walker, 2012).

Also within the CITI-SENSE-project, AQ-problems have been framed in two ways (although the technocratic viewpoint has often dominated the process):

- **Examples of AQ-related questions framed in technocratic ways:**
  How can we get as much AQ-data as possible in a cost-efficient way (e.g. in order to describe the AQ-problem better than before)?
  How can we increase the accuracy of the AQ-data (e.g. to increase scientific credibility)?
  How can we make our measurements more reliable under various weather conditions?
  Is AQ-perception-data relevant (and what about accuracy and comparability)?
  How do we make our product more user-friendly?
- **Examples of AQ-related questions framed in society-oriented ways:**
  Do we actually need more data (or do we know enough already to take action)?
  What are the different perspectives (citizens, politicians, scientists) about the required accuracy for different purposes (e.g. fit-for-purpose)?
  Are AQ-perception-data relevant (and what about representativeness in relation to empowerment)?
  What would be the positive consequences of mapping air pollution (e.g. awareness)?
  What might be negative outcomes (for instance in terms of reinforcing urban segregation)?

When a CITI-SENSE-tool would propose possible solutions (or potential actions to be taken) as a form of output for the end-users, the (overall) acceptance of these solutions should be evaluated in a similar way (in order to avoid undesired outcomes).

In order to evaluate the full empowerment potential of the tools (or the process more in general), there are four main questions that will be covered:

1. **How does (or can) this tool help you** (e.g. what can you do better with this tool, for which purposes it can be used, how does it improve your life, etc.)? This first question focusses on strategic value, available functionalities and overall usefulness of the CITI-SENSE-tools. Besides that, also the process of implementing these kinds of Citizen Observatory in general (as it has been done in the case studies) will be addressed.
2. **How might this tool be improved** (so that it can help you even more in the future)? This question focusses on particular aspects of usefulness (such as usability and relevance) and on new functionalities that might be integrated in the tools to make them.
3. **What are the concrete outcomes and potential impacts** of the CITI-SENSE-project and the tools? The focus will be on concrete actions that have been taken already and on actions that can be taken in the near future or in the longer run.
4. In a separate section, also **costs (or cost-efficiency) and continuity** will be discussed. This is partially a practical question (e.g. "what about these products or services beyond the CITI-SENSE-project?"), but nonetheless this is important in terms of empowerment too.

In conclusion, in projects with a strong focus on empowerment, a relevant evaluation should not be limited to a standard "usability-survey" but should focus on both social and practical acceptability of the products and/or services. Besides that, the evaluation should not only take into account the positive outcomes, but also the potential negative ones (or possible risks that might lead to negative outcomes in the future). The way in which empowerment is defined in various ways will become very relevant, as different definitions might also lead to varying interpretations of (positive and negative) outcomes. The CITI-SENSE-tools – developed with the best intentions – do not automatically contribute to the original CITI-SENSE-goals regarding empowerment. On the contrary, in practice the use of some of these tools might sometimes lead to (unexpected) negative consequences, indicating that there might be mismatches between theory (e.g. definitions, goals, good intentions, etc.) and practice (the real outcomes). Rather automatically, these kinds of questions will also lead us into various societal debates about citizen science, about air quality and about empowerment regarding AQ-problems. Taking into account the original empowerment-goals of this project, the social acceptability of the CITI-SENSE-concepts and tools should play a major role in the evaluation, although aspects of practical acceptability will be important too (in terms of final uptake of these tools by the intended users later on). This means that a very useful and user-friendly tool which not necessarily contributes to the empowerment goals or maybe even creates a risk of causing disempowerment, should also be evaluated as such (e.g. as not satisfying all the needs and requirements regarding empowerment that have been set at the beginning of the project).

3.2 The CITI-SENSE-tools that will be evaluated

The CITI-SENSE-toolkit consists of various products, of which a short summary is given below. For more details, we will refer to the CITI-SENSE product brochure:

- The **Personal Air Monitoring Toolkit (shortly referred to as LEO's):**
  This toolkit includes the LEO, the Little Environmental Observatory (a portable sensor device that monitors three gases: nitrogen dioxide, nitrogen monoxide and ozone) and the ExpoApp for Android systems which allows the user to establish the connection between the LEO device and the smartphone. This tool allows you to assess air quality in your immediate surroundings.

The Ateknea Sensor Tool is used by the technical support to update the LEO, and not directly by the user. The user can view data at the Data Visualization Webpage.

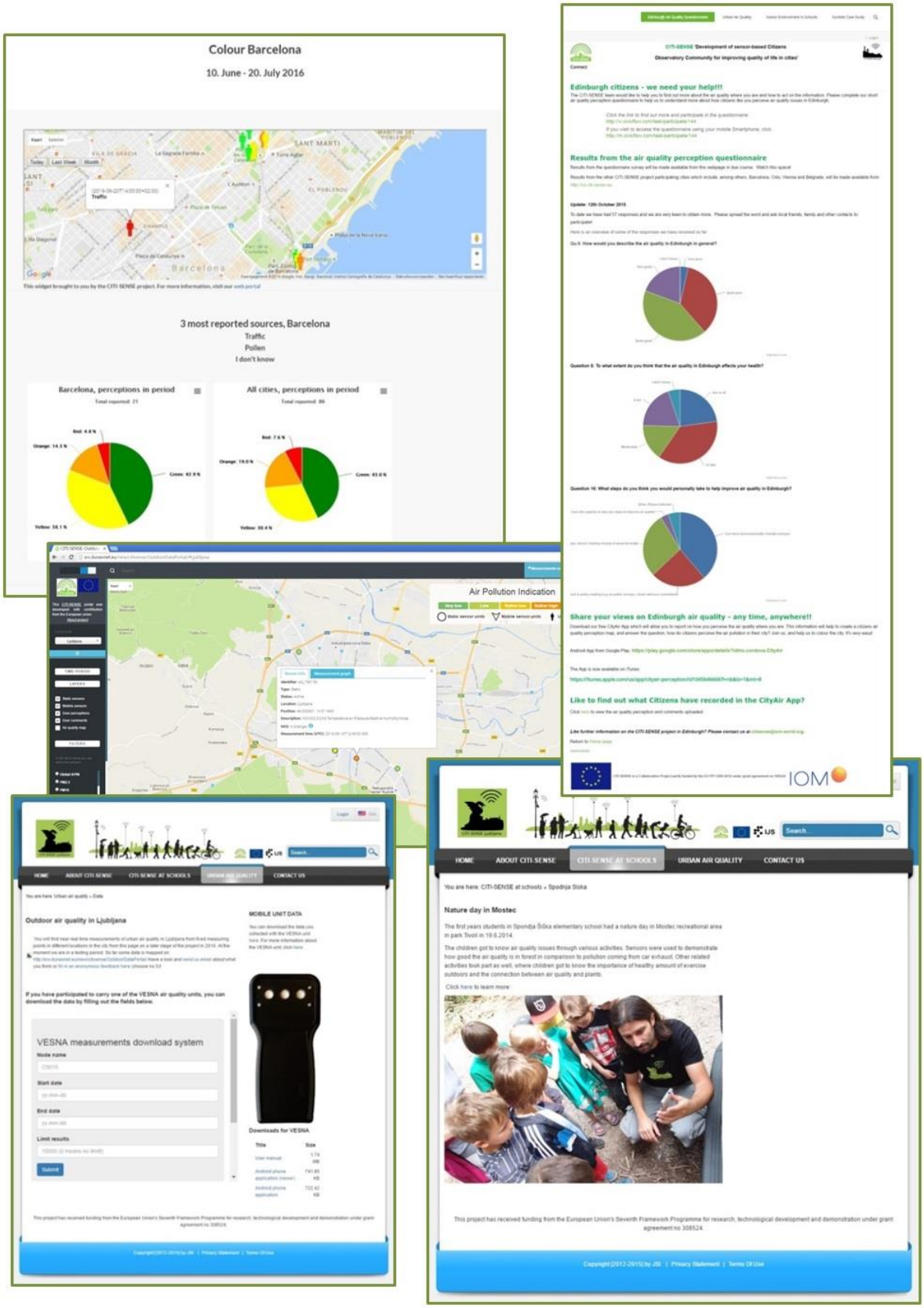
- The **CityAir Smartphone App (or CityAir-app)**:
  CityAir is a smartphone application for the public to express their perception of the outdoor air quality at their location. It allows users to collect and display individual perceptions of air quality, irrespective of where they are in the world. It also allows users to indicate the assumed source of the air pollution and write a comment. When the preferred network is available (chosen by the user), the App will upload the information provided by the user into the CITI-SENSE platform. The user can choose to download other users' perceptions reported through CityAir for the same day, the last week or the last month, directly into the CityAir App on their smartphone. In addition, the CITI-SENSE data visualization web pages allow viewing the collected perceptions reported by all contributing users.
- The **On-Line Air Quality Perception Questionnaire (Long Perception Questionnaire)**:
  The CITI-SENSE Online air quality perception questionnaire is a tool for collecting and analyzing how users perceive air quality issues. The tool is being used in the nine participating cities/locations. The questionnaire can be answered by anybody anywhere, and for mobile phone users a QR code for accessing the survey is also provided. The questionnaire includes three sections: participants' personal information, specific questions on the participants' air quality perception, and feedback from the participant. The questionnaire has also an optional part to collect user preferences on what information on air quality shall be fed back to the user. The data collected is available for visualization and analysis through the citizens' observatories web portal.
- The **Environmental Monitoring Toolkit for Public Places**:
  The toolkit for public places is a collection of tools for subjective and objective monitoring of environmental quality and satisfaction, and for giving feedback at all kinds of public places. It uses a Kestrel® 4000 Pocket Weather Meter (a commercial sensor that measures wind speed, temperature, relative humidity and air pressure). The toolkit can be used in dedicated campaigns. Prior to the user involvement, the team responsible for the campaign will initialize the toolkit and provide a short training for the users. Each user will carry out a monitoring session of about 15 minutes using the SENSE-IT-NOW-app. During measurements, the CityNoise app can detect noise events and alert the user who then can provide feedback about his/her own perception of the noise event. Based on this data, the app calculates an acoustic index and provide it to the SENSE-IT-NOW app. While the measurements are ongoing, the user will complete a survey about her/his perception of the place. At the end of the measurements, the user can take pictures of the surroundings. Collected data can be downloaded and is also displayed at the local project webpage. As a final step, the users can gather for a workshop to discuss their suggestions for improving public areas.
- The **CITI-SENSE Citizens' Observatories Web-portal**:
  This portal provides an access point to all our apps, widgets, web pages and sensor based tools and questionnaires. The user can get information about how to acquire, install and use them. We also provide access to the data already collected. The web portal contains information about the sensing devices, and about how to use our data for own applications. The portal provides also information about the CITI-SENSE project and related social media.
- The **Data Visualization Webpage** and the **Data Download Webpage**:
  These webpages (also referred to as the Dunavnet-webportal) operate on input from the CITI-SENSE central data platform, allows to visualize this information. This webpage provides an overview of all our sensor-based tools. When the location is chosen, the web page will upload as a default the last measured values on the following inputs: static sensors, mobile sensors, user perceptions and user comments. If a measurement is taken using our tools, the user should be able to find it there in some form or shape (sometimes, for privacy reasons, as part

of an aggregated picture). The Data Download Webpage allows to download sensor device data from the CITI-SENSE platform in CSV format or directly into an Excel sheet. It is intended for use within the CITI-SENSE project, but can be used by any interested party.

Besides the CITI-SENSE-tools mentioned above, there also has been an external contribution in the form of a phone application to display air pollution in cities, which was developed by students. This application demonstrated that it is possible to use data collected within the CITI-SENSE framework to create your own services. It is a centralized open source phone application for Android and iOS which visualizes air quality by using effective color schemes. Semi-transparent overlays of pollution are generated according to Air quality index (AQI) scale – at least for areas with sufficient number of measuring points per area – which are then displayed as layers over Google maps. On areas with several measuring stations, AQI heat maps of pollution will be generated. The application will be accessible from any modern device, whether from a native app or via web interface.

Examples of the CITI-SENSE-outputs that were produced by these tools (as they were published on the websites of the local Empowerment Initiatives) are shown on the next page. The output of the CITI-SENSE-tools mainly consists of AQ-maps based on data from static and mobile sensors (e.g. Dunavnet-portal), real-time AQ-data (LEO's and of-the-shelf tools), AQ-perceptions-maps (CityAir-app combined with Dunavnet-portal), AQ perception survey results (the Long Perception Questionnaire on AQ) and the web-portals (with more general information about the CITI-SENSE-project and air quality, online publications and discussion forums). During the individual or group interviews, some of these outputs have been evaluated by the users.

We have been focusing mainly on the evaluation of the Personal Air Monitoring Toolkit (referred to as the LEO's), the CityAir-app and the Long Perception Questionnaire. The Data Visualization and Data Download Webpage (referred to as the Dunavnet-portal) was only mentioned during some of the interviews. The Environmental Monitoring Toolkit for Public Places has been evaluated only in Vitoria-Gasteiz. Finally, also all the (local) CITI-SENSE-activities can be seen as output. The measuring campaigns with volunteers, meetings with citizens and various school activities (such as "nature days", conferences, etc.) and the information that was gathered during individual interviews, focus groups and co-design-activities. Some of the outcomes of all these activities will be evaluated too in a more general way (e.g. overall user-satisfaction) in a separate chapter.



Examples of the CITI-SENSE-outputs (as shown on the websites of the local Empowerment Initiatives)

3.3 Methodology used for this user-evaluation

3.3.1 General approach and analysis

Although we originally hoped to be able to do some sort of "participatory evaluation" (in terms of an approach to evaluation in which stakeholders actively engage in the development of the evaluation and all the phases of its implementation), there was neihter enough time nor resources, to do so. Besides, there was a strong question for guidance from the location officers and also comparability had to be taken into account. Therefore, an evaluation checklist was developed in preparation of empowerment evaluation. The checklist was explained and discussed with the location officers and they were able to adapt some of the questions in order to fine-tune them for the specific local context. The target group for this evaluation consisted of local people collaborating with or contacted by those Empowerment Initiatives (EIs), such as individual citizens, members of local groups (NGOs), students, teachers, local authorities, other stakeholders involved, etc. These persons were interviewed by the local project team members, either in individual interviews or in group interviews. These interviews gave us the opportunity to get a good view on how local participants in the CITI-SENSE-project perceived various aspects of the particular tools that they have used and of the project in general. The information collected in these interviews will help to interpret and explain the project's work over the years from a more social scientific perspective.

In total we received 55 interview-transcripts (of which 35 were individual interviews and 20 group interviews), covering all the Empowerment Initiatives – both outdoor EIs and indoor EIs (schools). The interviews were done over the period December 2015 to June 2016. All of the (individual or group) interviews were transcribed by the location officers (and or his/her staff) and these transcripts were collected by the project's methodological support group on engagement & empowerment (in work package 5). This analysis will mainly focus on qualitative content analysis and will only give information about the – sometimes wide – spectrum of viewpoints (e.g. diversity of the answers), the degree of consensus and/or the existence of conflicting points of view. We considered this to be the most appropriate approach for analyzing the transcripts, given the small sample of interviewees, the fact that participants did not have the opportunity to go into dialogue about the outcomes (not with each other, nor with the researchers who have been doing the analysis), and other limitations mentioned earlier. In order to protect the privacy of the participants, all interview results will be dealt with anonymously (also when using quotes to illustrate particular aspects of the societal debates).

At the start of the analysis, a more general overview of information was made first, synthesizing information according to the questions in the checklist. In order to structure this rich data in an appropriate way, a more detailed framework was developed (see below). All relevant quotes from participants or interviewers (and in some cases also longer pieces of a conversation between both) were categorized according to this framework, by linking them to one or more of the evaluation aspects when going through the transcripts again. All information available about the evaluation aspects was then synthesized into the concrete discussions about every particular aspect, while also analyzing key themes that came to the front, discussing participant's viewpoints and referring to at least some of the quotes available (e.g. an indicative sample of the most relevant ones, but often a selection out of many more comments that were available). Although it was necessary during this assessment to make this kind of selection out of many quote-worthy remarks, we made sure that at least various examples from all case-studies were integrated into the discussions (where they had the highest added value), thereby avoiding that some of the Empowerment Initiatives (EIs) would be unintentionally excluded. The range of information coming out of the interviews has also been put into context by comparison with related issues discussed in (a non-exhaustive overview of) other projects or scientific literature whenever that was considered to be relevant.

Proposed list of questions for participatory evaluation by participants

- To what extent is this AQ activity/product useful to you?
- What did you expect it to help you do better? (focusing on expectations)
- What can it help you do better? (focusing on actual outcomes/impact)
- What can it not help you do better? (focusing on actual outcomes/impact)
- What could it help you to do better if improved/adapted?
  (How should it be improved?)

- Which kind of actions did you already deploy based on this or do you plan to deploy in the short run (coming half year)?
- Which kind of actions do you plan to deploy based on this in the longer run (coming years)?
- What are opportunities for you to take AQ improvement action based on this?
- What are barriers for you to take AQ improvement action based on this?
- Which conditions should be met for you to take AQ improvement action based on this?

- What are opportunities for others to take AQ improvement action based on this?
- What are barriers for others to take AQ improvement action based on this?
- Which conditions should be met for others to take AQ improvement action based on this?

- How do you appreciate collaboration within the Empowerment Initiative (EI)?
  What is positive, what is negative?
- How do you appreciate the opportunities for you to have influence within the EI?
  What is positive, what is negative?
- Did you learn something useful within the EI?
- From whom did you learn something useful within the EI?

- How do you see the responsibility of scientists within the Empowerment Initiative?
- How do you see the responsibility of citizens within the EI?
- How do you see the responsibility of authorities within the EI?

- What are opportunities for you to take AQ improvement action based on collaboration within the Empowerment Initiative (EI)?
- What are barriers for you to take AQ improvement action based on this?
- Which conditions should be met for you to take AQ improvement action based on this?

- What are opportunities for others to take AQ improvement action based on collaboration within the Empowerment Initiative (EI)?
- What are barriers for others to take AQ improvement action based on this?
- Which conditions should be met for others to take AQ improvement action based on this?

Due to of a lack of time – the work for this evaluation had to be done close to the end of the project – we have not been able to get back to the interviewees to ask their feedback on the outcomes of this analysis. This may still be a possibility after the project's ending, for the purpose of follow-up publications building on the results. The responsibility for the following interpretation therefore lies solely with the two researchers involved in the analysis.

3.3.2 Limitations of this analysis

First of all, there is always a risk of having participants with different interpretations of the evaluation questions. Although it often has been solved by the interviewer (asking additional questions for clarification), it is still possible that not all interviewees have been answering in identical ways.

- **Participant (volunteer):** *"So when you ask 'How could the LEO be improved', that is... because I was just thinking about what it's doing now – it's measuring NO_X and ozone. I didn't even think of... Well, let's see how we interpret the questions… [laughter]."*

Small sample of indicative comments regarding AQ-perceptions during the evaluation

It also has to be acknowledged that some of the local Empowerment Initiatives (EIs) also achieved a more elaborate debate than others, especially when it comes to the social implications of these new technologies. This means that some of the information on specific topics (in particular regarding social acceptance) was somewhat fragmented amongs various case studies. Possible explanations are:

- the methods used (e.g. individual interviews versus group discussions in which people are able to respond to the viewpoint of others);
- the local context (e.g. stronger need for empowerment);
- other factors that can affect the opportunity to have a richer societal debate in AQ-problems (such as stakeholders' willingness to collaborate in the CITI-SENSE-project).

Empowerment Initiatives (EIs) who decided to organize a focus group evaluation have often been able to create the opportunity for interesting interactions between participants (resulting in valuable discussions). The involvement of more social scientists for the practical case study work might have been beneficial, because a large part of the work on the ground now had to be done by non-social scientists. This also means that in some of the Empowerment Initiatives, there was not enough real practice (which makes it more difficult to draw conclusions about (potential) empowerment).

However, from the viewpoint of empowerment it is important to have a good view on these societal topics and to the empowerment potential (also in more difficult circumstances), even if the information comes from only some of the case studies (and therefore cannot always be compared with other locations). We have dealt with this limitation by comparing some of these discussions – although in a non-exhaustive way – with findings from the literature (for example based on other similar projects). Besides that, for some of the topics that will be analysed also the results of the most relevant and recent Eurobarometers will be used to compare our findings with the overall opinions of EU-citizens on these matters (to put indicative reponses of the participants into a wider perspective), although it was only possible to do this selectively as there is very much more information available in these documents.

Eurobarometers that were used to compare our findings, are:

- Flash Eurobarometer No. 360: "Attitudes of Europeans towards air quality" (2013);
- Flash Eurobarometer No. 382b: "Europeans' satisfaction with urban transport" (2014);
- Special Eurobarometer No 397: "Corruption" (2014);
- Special Eurobarometer No. 401: "Responsible Research and Innovation, Science & Technology" (2013);
- Special Eurobarometer No. 406: "Attitudes of Europeans towards urban mobility" (2013);
- Special Eurobarometer No. 416: "Attitudes of European citizens towards the environment" (2014);
- Flash Eurobarometer No. 419: "Quality of life in European cities" (2016).

Another limitation of this analysis is that end-users have been testing tools during different stages of development. From the information that we have, it was not always clear which version of a tool they have been evaluating exactly (at least not if multiple versions of a tool were provided during the project). This means that only an overall evaluation of that product will be possible, and that some of the problems that were addressed by the participants have already been solved (partially) in a newer version. Sometimes, this has been mentioned explicitly by the interviewer during the evaluation.

A final limitation of this evaluation assessment is related to assessing efficiency. To make a full analysis of the outcomes of a project like CITI-SENSE, ideally the intentions (goals) and the efforts (resources effectively used) should be compared with actual achievements, in order to be able to conclude something about efficiency too. But due to time constraints, it was not possible to include a full analysis of all the local efforts regarding stakeholder involvement (e.g. number of meetings, number of target groups (or individual participants) contacted, means of communication used to connect with the target groups and the intensity of the communication with involved stakeholders, etc.). In other project documents (for example in CITI-SENSE-deliverables 2.4 and 3.4) these activities were described more in general terms. In this chapter, the focus will be put on the overall CITI-SENSE-goals and the local goals in every Empowerment Initiative (EI) in particular (see chapter 3.3.3) which will be used as a checklist when looking for indications that some of these original goals have been met. This will be combined with an overview of potential outcomes of citizen science projects in general (as they are described in the literature) (see also chapter 3.3.3). Unfortunately, this means that – at least in this stage – it is not possible to draw more concrete conclusions about the effectiveness of all these achievements and to fully explain why exactly some goals have not been met. Many reasons can be thought of. There might have been a more general lack of interest from the public (regarding AQ-issues), but also inappropriate means of communication can be an explanation for limited engagement. Also due to the delays that have been occurring during the project, location officers (or the local project coordinators) had to be pragmatic and probably not all EIs have been able to put as much effort in reaching all the goals that they originally had in mind as they hoped to do in the beginning of the project. This will also affect the final outcomes. Based on the information available, it is not (yet) possible to evaluate the full potential of the CITI-SENSE-concepts and tools, so the conclusions will sometimes be preliminary. Further research will be needed to get a much more detailed and accurate view on all the possibilities, limitations and risks of what the CITI-SENSE-project has been trying to achieve.

3.3.3 Framework for the evaluation of the CITI-SENSE-tools

The interviewees often described the social acceptability and practical acceptability based on their own wording (e.g. *"the accompanying software leaves a bad taste in one's mouth"*) and/or a wide spectrum of standard expressions (e.g. *"this tool is very helpful"*), but in the end these answers often refer to a more narrow set of process or tool characteristics. These characteristics can be linked to various criteria and sub-criteria for evaluation (Nielsen, 1993).

For the analysis of the social acceptability, both process and tool characteristics are relevant. Criteria to evaluate the (local) CITI-SENSE-process in general or to evaluate a particular CITI-SENSE-tool will cover ethical aspects, credibility, representativeness and legitimacy, mandates, allocation of responsibilities (particularly from authorities towards NGOs or individual citizens), socio-cultural aspects, legal issues and political acceptability. For the latter, it is important to take into account that goals regarding empowerment can be contradicting to political acceptability.

The analysis of the practical acceptability of the CITI-SENSE-tools will deal with the main criteria of overall usefulness, costs and continuity. But these criteria can be divided into more sub-criteria, and

these sub-criteria can consist of various components. For example, the criterion "overall usefulness" refers to whether the system can be used to achieve the desired goals, but can be analyzed more into detail based on 4 sub-criteria:

- Strategic value (e.g. need for additional products and potential uses of tools or information);
- Utility/functionality (e.g. can the system do what is needed) and completeness;
- Usability (e.g. how well the user can make use of its functionality);
- Relevance (e.g. is the output of a tool helpful to pinpoint something relevant).

The sub-criterion "relevance" can be described in terms of output being accurate enough and reliable, results that are (or can be) validated, output that is meaningful, etc. And the sub-criterion "usability" can be evaluated in terms of ease-of-use and required expertise or skills in order to be able to use the EDSS or a particular tool. The component "ease-of-use" in itself is influenced by characteristics such as tool-complexity, sensitiveness for errors, ease-of-data-management (input, output, processing and transferability of data), ease-of-system-maintenance (including updates), ease-to-remember, compatibility (with existing systems), extendibility (with new modules), system requirements, etc. (see full overview in Table 1). All these criteria, sub-criteria and components can be structured in a hierarchical list, although there might be some overlap due to sub-criteria or components that – directly or indirectly – affect multiple criteria.

When analyzing the interviews in terms of practical acceptability, the methodological support group on engagement & empowerment mainly wanted to contribute to the social co-design process (instead of contributing to the very technical aspects within that co-design process). However, there can be important relationships between both. What looks at first sight like a rather technical discussion about the required accuracy of the sensors, might in fact be used strategically by some of the involved stakeholders to hide their strong desire to remain the status quo. Some stakeholders might intentionally make unrealistically high demands towards the required accuracy, so that they don't have to take action as long as people will be waiting for that "perfect" sensor that might never be developed after all. Instead, sensors should be "accurate enough" (e.g. fit-for-purpose). This example implies that a discussion about technical issues can sometimes be used strategically to slow down the whole process of empowerment (by consciously obstructing the decision-making process that might lead to the concrete actions). Similarly, also discussions about definitions might be used merely as a delaying tactic, making them endless by purpose (e.g. *"what is the added value of a tool"* and *"what is cost-efficiency?"*). Although different "framings" of the problem – by various stakeholders – are very relevant, unwilling actors might also use these discussions tactically to decrease mutual understanding (in order to create misunderstandings or disagreements). Because solutions from one frame may not be recognized as being relevant in another frame, decision-making processes can be obstructed. Also the current societal debate about the trustworthiness of citizen science (e.g. *"can citizens produce accurate and reliable data?"*) is part of the CITI-SENSE-project and the technical aspects of this discussion might be used in a strategic way by opponents of AQ-action. From the viewpoint of empowerment, these are the topics that are most interesting. The chapter about practical acceptability will mainly focus on these kinds of social aspects.

Last but not least, when talking about the evaluation of Environmental Decision Support Systems (such as the COs) and/or the evaluation of tools in general, there are also some well-known indicators for success. But also other (contextual) factors might come into the picture during an evaluation. During the analysis, participants can refer to important facilitating (or obstructing) factors:

- Interest from the intended target groups (or lack of interest) (incl. interest from authorities);
- Good overall communication and good collaboration within the project;
- User-involvement in system-development (CO-DESIGN / CO-DEVELOPMENT);
- User-expectations regarding the tools (and expectation management);

- User-expectations regarding (citizen) science (and expectation management);
- User-expectations regarding air quality (and expectation management);
- User-attitude towards the COs (or towards a particular tool);
- Involvement of a “champion” (individuals who can make a difference);
- Internal organizational support and organizational structure (within the user’s organization):
  attitude of top management (towards implementation of an EDSS and towards citizen science in general), openness to new work protocols, allocation of new responsibilities (from one authority to another, or within the same institution), etc.;
- External organizational support (from the tool developer and/or provider);
- Effects based on earlier experiences (incl. “ballast from the past”):
  For example: earlier experiences of participants (which might have been positive or negative and which have led for instance to increased/decreased credibility of the research institute or company that is developing the new EDSS) might still influence current evaluations.
- Starting simple and small (e.g. with technologies that have already proven to be reliable);
- Flexibility of the project team to adapt to unforeseen opportunities and challenges (plan B);
- Availability of resources (money and/or time).

Table 1: Evaluation framework for the CITI-SENSE-project and the tools

Social acceptability (and political acceptability)
responsiveness-to-societal-needs

ethics (e.g. definitions of empowerment, privacy-issues, etc.)
credibility and transparency of tool-developers and/or tool-users (e.g. independence, etc.)
representativeness
legitimacy (e.g. referring to actions being appropriate uses of power, in the public interest, etc.)
mandate of product-developer (e.g. developer working in collaboration with authorities)
mandate of user-organization (e.g. authority as end-user, NGO in cooperation with authorities, etc.) **allocation of new responsibilities** particularly from authorities towards NGO's or individual citizens
socio-cultural aspects (e.g. needs of specific vulnerable groups, cultural preferences, etc.)
legislation (or legal acceptability)
political and economic acceptability(1) (as a specific aspect of social acceptability)

Practical acceptability
responsiveness-to-practical-needs

usefulness of the COs or a particular tool

strategic value and/or the **need for (other types of) AQ-data**
(e.g. need for additional products, need for more or better AQ-data or specific types of data (for instance about perceptions), potential uses of these tools, AQ-information, etc.)

available functionalities/utility and **completeness**
the capability to support/improve(2): AQ-assessments (in general), implementation of (continuous) monitoring activities, AQ-forecasting (next few hours), communication activities (to various audiences), social learning activities (with various stakeholders), AQ-reporting (e.g. yearly environmental reports) and decision-making (with multiple stakeholders) (completeness is about bringing together multiple functionalities in one and the same tool)

usability (for the intended target groups, including the elderly)

ease-of-use
which is determined by tools being subjectively pleasing (e.g. nice design, size/weight of tools, etc. (including disturbing or possibly frightening led-lights)), tool-complexity, ease-to-learn (e.g. logically build-up menu's), ease-to-remember, sensitiveness for errors, ease-of-data-management (input, output, processing and transferability of data), ease-of-system-maintenance (including updates), system stability, system requirements, compatibility (with existing systems) and extendibility (new modules)
required expertise in order to be able to use the EDSS or a particular tool
(e.g. AQ-expertise, GIS-knowledge, etc.)
required skills in order to be able to use the EDSS or a particular tool
(e.g. computer and internet-skills, use of Smartphones, etc.)

relevance (for the intended target groups)

accurateness, uncertainty and reliability of the tools and/or the output
(e.g. being accurate enough (fit-for-purpose!))
comparability and validation of the results (calibration, etc.)
transparency about the calculations (e.g. no black-box-tools) and model-assumptions, limitations of tools (state-of-the-art), etc…
meaningfulness of the output (including language of the system)
does the output fit the users' worldview and connect to their perception, does the tool produce understandable and meaningful results and good visualizations, etc.

cost (or cost efficiency) of the EDSS or a particular tool

continuity ("longevity")

availability of the tools/data in the future (incl. websites that are kept up-to-date)
Facilitating and/or hindering factors
interest from the intended target groups (or lack of interest) (incl. interest from authorities) **good overall communication and collaboration** with the participants **user-involvement in system-development (CO-DESIGN / CO-DEVELOPMENT)** **user-expectations regarding air quality** (and expectation management) **user-expectations regarding the tools** (and expectation management) **user-expectations regarding science and citizen science in particular** (and expectation management) **user-expectations regarding (local) authorities** (and expectation management) **user-attitude towards the COs** (or towards a particular tool or the project in general) **involvement of a "champion"** (persons who can make a difference, such as a very engaged teacher) **internal organizational support and organizational structure** (within the user's organization): *attitude of top management (towards implementation of an EDSS, towards citizen science in general), openness to new work protocols, allocation of new responsibilities (from one authority to another, or within the same institution), commitment to use EDSS, etc.* **external organizational support** (from the tool developer and/or provider) *(e.g. availability of user manuals, training, support with the maintenance of the system, etc.)* **external pressure** (from NGO's or from the public in general) **earlier experiences** (incl. "ballast from the past") **starting simple and small** (e.g. with technologies that have already proven to be reliable) **flexibility of the project team** to adapt to unforeseen opportunities and challenges (e.g. plan B) **availability of resources** (money and/or time)

1) Taking into account that goals regarding empowerment can be contradicting to political acceptability.
2) Including providing better information, improved effectiveness, more efficiency, capability to perform new activities, facilitation of existing work/processes.

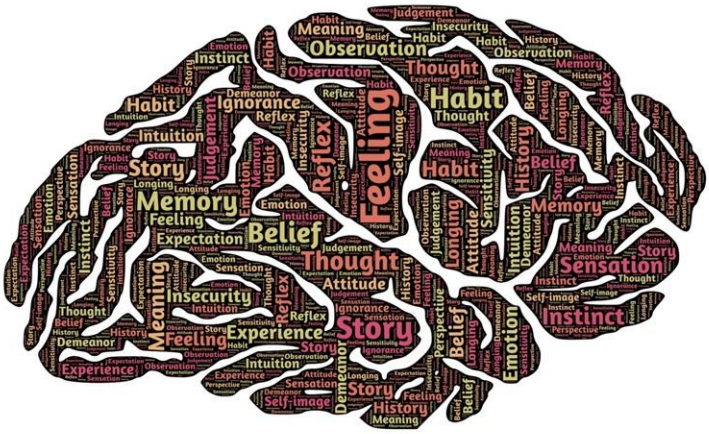
Note: *Although all these criteria mentioned above have been structured in a hierarchical list, there are some criteria which can create an overlap. For example, being transparent about a tool (e.g. calculations and model-assumptions, limitations, etc.) can contribute both to social acceptability (e.g. the credibility of the process in which an EDSS is used will increase) and to practical acceptability of a tool (e.g. people often hate "black-box"-tools as this would mean that they don't understand what actually has influenced the output and which assumptions have been used to calculate these results). Another example is that of cost-efficiency, which can be seen as a criterion for practical acceptability but which will also have an influence on social acceptability. And finally, ease-of-use is often also related to required skills and/or expertise. Besides that, criteria such as transparency of calculations, accuracy (validation), reliability, uncertainty, completeness, sensitiveness for errors, comparability, etc. will also contribute to overall credibility of the Environlental Decision Support Systems (such as the COs or particular CITI-SENSE-tools). This makes that aspects of practical acceptability can sometimes also interfere with aspects of social acceptability).*

3.3.4 Mismatches between perception and reality

Pretending that all these criteria mentioned in the evaluation framework above will be evaluated in a fully objective manner would not be really careful. For many of these evaluation criteria, you actually might think of adding "perceived…" in front of them:

- perceived social and practical acceptability;
- perceived usefulness;
- perceived usability;
- perceived tool-complexity;
- the way user-involvement has been perceived;
- the way how internal and/or external organizational support has been perceived;
- etc…

This is not unimportant, but sometimes still underestimated. Tool evaluations are about end-users' opinions that strongly rely on concrete experiences and observations, but also on much more subjective feelings, expectations, attitudes, habits, stories that have been told, meanings, beliefs, flaws in memory, ignorance, etc. This means that evaluations are often not only about hard facts, except maybe for specific tool characteristics that might be evaluated in more objective ways (for instance based on technical tests or observation of user behavior). That is why it is important to emphasize that perception can play a very important role during product evaluations (and can also influence final uptake of the tools).



Evaluations are often not only about hard facts, but also about perceptions
(www.pixabay.com)

The importance of perception was also explicitly addressed by some of the participants:

- **Participant (sales person for air pollution filters for industries):** *"I think what's mainly interesting to see is people's comprehension of what's happening as opposed to what's actually going on in reality, or to the evidence that show what are the things that affect [air quality] mostly. In my opinion, this is what's most interesting."*
- **Participant (member of school):** "*It got me thinking more about air pollution and what we can do to promote air pollution. So in that sense, I might be more inclined to get involved in things to promote action on air pollution and I can see how this could facilitate that in future, once various things have been ironed out, so that it both is accurate and is perceived to be accurate because both of those are important I think*

in promoting the message. So for me it might be that it's accurate, I don't know, but it doesn't give the perception of being accurate."

- **Participant (member of the authority – transportation sector):** "*Even though we update our website, it's not accessible enough, and I would even say that sometimes there is a problem of reliability with the public, that the public thinks that the office hides information, although the entire information is revealed. But if there's a feeling among the public that information is concealed, so you know, it's very hard convincing that it isn't true.*"

Participants' comment about the role of people's perceptions

Taking into account our way of data gathering (which occurred mainly through interviews and focus groups), this is even more relevant. There are different reasons for that. Four indicative examples will be discussed. First of all, perceptions might sometimes overrule reality. For example, a CITI-SENSE-tool might seem to be perfectly fit to contribute to a particular purpose – from a scientific point of view (e.g. expert opinion) – or experts might argue that the output produced by the tool is meaningful (for instance showing PM_{10}-values in ppm (parts-per-million))… but if users are not aware of all the functions or if they don't understand what "ppm" means, they will evaluate the output as such (e.g. participant's opinion). It often occurs that both opinions from experts and non-experts are partially true – both to some degree (e.g. experts saying that functionalities are indeed available, but end-users who are totally not aware of these functions because they are very difficult to find in the tool). In that case the functionalities do exist, but definitely not in the minds of all users. Again, this can lead to situations in which perception will overrule reality.

- **Interviewer:** *"Do you like, or do you dislike, some parts of the CityAir-app?"*
  School teacher: *"Do you fancy it? How do you like it?"*
  Participant (pupil of elementary school): *"The possibility perhaps to share our opinion and to comment."*
  School teacher: *"Do you have some space for comments?"*
  Interviewer: *"There is an option for you to insert a comment. This option already exists, perhaps you have not seen it."*
  School teacher: *"Then she likes that, because she would like to have that option."*
- **Participant:** *"I was just curious about the colors. What did they mean, what were the thresholds for these colors? But that's because I'm particularly interested... (laughs)."*
  Interviewer: *"It was an information button there, but it's probably not clear enough."*
  Participant: *"Oh! I never realized..."*

Indicative examples of mismatches with a signaling function

Secondly, the importance of perception should be emphasized because if expectations of users regarding a particular tool were too high at the start of the project, they might easily become disappointed afterwards. This might eventually lead to a more critical evaluation. Also during the evaluation of the CITI-SENSE-project and the tools, we have found various indications of this kind of "disappointment-due-to-unrealistic-expectations", some of them expressed by participants and other mentioned during the interviews with the location officers (or local project coordinators).

- **Volunteer about expectations:** *"And that is why I'm a bit disappointed with the project. Maybe my expectations were not realistic…"*
- **Participant (member of school):** "*I perhaps naively assumed that it was providing or would provide air pollution detail in real time on the app. I imagine that perhaps that's not technologically possible or they need to be tied together."*

Small sample of indicative comments regarding user expectations

Similar comments about unrealistic expectations were also addressed during the interviews with the location officers (or the local project coordinators) (see chapter 5), who for instance were saying things like *"I think our expectations were probably higher than they should have been"*, while also emphasizing how they tried to avoid this: *"We were trying not to raise expectations. We didn't want to get lots of people all enthusiastic and excited about our project which was being delayed and delayed and delayed… because that would just cause tensions and disinterest actually, from those that we would be wanting [to be] partner with."* Also in the preparatory phases of the project, this was addressed by some of the local case study coordinators, for example (Kåstad Høiskar et al., 2013):

> *"…the outdoor empowerment initiative in [city X] will be developed at an experimental level with the aim of analyzing if the technology and approach are adequate, and to learn to manage expectations from citizens and public commitments arising from the process. […] It is not worthwhile making very ambitious plans for potential participants if afterwards we fail or do not have the necessary tools to perform the tasks to recruit and involve participants. It is therefore very important to be realistic and adapt the list of potential participants to our goals, and to our capacity as promoters of the trial implementation of the empower initiative."*

A third reason for addressing perceptions as an important topic, is that people's perceptions regarding air quality can also have an influence on the evaluation of the output of the tools, especially for the output from the LEOs (or other tools based on AQ-sensors), but also for the CityAir-app (based on perceptions). If output is not in line with expected AQ-results, then some participants might project this mismatch (falsely or not) onto the CITI-SENSE-tools, which will be perceived to be inaccurate.

Similar issues can be said about people's beliefs about citizen science in general. Various examples regarding these kinds of expectations about AQ – that at least in some occasions might not fully be in line with reality – were found within CITI-SENSE:

- **Participant (other researcher, but no specific AQ-expertise):** *"…when a colleague showed me the app, I saw two perceptions of people on the map… for the whole [city X] only two people… And I could recognize one in [neighborhood Y], putting a green marker [observation] in that neighborhood. This may give you wrong ideas, how could it be 'green' in [neigborhood Y]?"*
  Interviewer: *"This is because we are measuring perceptions. We can study how the perceptions matches the reality, but maybe it depends on the time of the day when the observation was done."*
  Participant (other researcher: *"It was, I think, 11am… so it couldn't be worse."*
- **Participant (pupil elementary school):** *"I was on a trip when we went to [mountain X nearby the city], and there we then saw a very clean air, I suppose because it is close to the mountains."*

Small sample of indicative comments regarding AQ-perceptions during the evaluation

Sometimes, perceptions can also be influenced by media coverage, as it was acknowledged by one of the persons interviewed:

- **Participant (sales person for air pollution filters for industries):** "*Look, I'm in the field of transportation, so I see what is published about transportation. Once in a while you see an article: 'This fleet is the most polluting in the country'. Hmm… And this happens once in a half year, let's say. But hmm… the industry in [city X] is something that was in the center of public's attention for a long time, so it's conceived as the most problematic factor."*

Small sample of indicative comments regarding AQ-perceptions during the evaluation

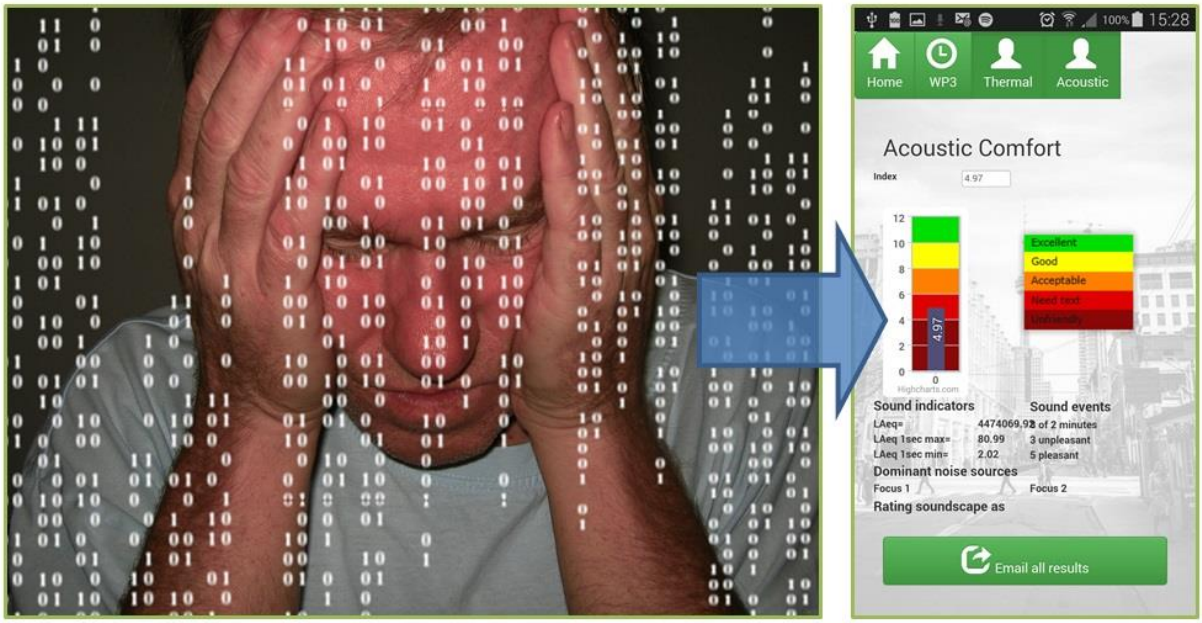
However, this does not mean at all that perceptions about AQ would be irrelevant just because they are subjective. On the contrary, these perceptions are very valuable to work with (as this is what people really experience in their daily lives) and it would be interesting to compare these data (for instance gathered by the CityAir-app and the Long Perception Questionnaire) with AQ-data from the static and/or mobile sensors. It is important to acknowledge that there might be gaps between perceptions (opinions) and reality, and to search where these gaps eventually come from. And in some occasions people's perceptions will also be very close to reality, and there will be no gaps at all (which was also expressed in some of the answers of participants: see examples below). In these situations, it should be argued if it would be useful to wait for better AQ-sensors (in order to get additional data) instead of taking action as soon as possible.

- **Participant (pupil of an elementary school):** *"I just used the CityAir-app when I went outside of [city Y]. I was on the highway and we had to stop, and literally it was hard to breathe."*
- **Participant (citizen):** *"The air polluted by car is not that bad as here from the industry. You can smell the metallic tang. Very bad."*
- **Participant (volunteer):** *"I have a neighbor who is burning wood in an old wood stove, so every second year we have to clean one of the walls of our house which is towards his house. […] I don't need the LEO. I can tell, because the wall is black (laughs)."*

Small sample of indications of situations in which perceptions will be close to reality

Finally, also perceptions regarding organizational aspects can potentially influence the willingness to become engaged in the project. For instance, the perception that top management (or other colleagues in the organization) are not really open for change (e.g. changing the curriculum or the work protocols or trying out new experimental activities) or that they distrust the nature of the project (e.g. for instance because citizen science might not be reliable) might be enough to withhold a teacher from becoming actively engaged in a citizen science project at school (and making use of the CITI-SENSE-tools), although in reality his/her colleagues or top management might be more supportive than expected. Similar examples can be thought if for individual employees from local authorities.

Nonetheless, all these examples of mismatches between reality and perceptions are always very interesting. Even if things cannot be quantified (for scientific purposes) because they are not simply black or white, mismatches can have an important signaling function (for example regarding suboptimal use of functionalities). In that case, finding out why this gap in opinions exists will be the key to explaining why the actual uptake of a tool is lower than expected and will make it possible to improve the product. In other situations, perceptions of end-users will be more important than the opinion of experts. For instance if some of the users say that they don't understand the output, then this output will have to be translated into a better understandable message (e.g. color codes), even if experts argue that "ppm" is meaningful. Some of these mismatches will show up more frequently in the later discussion in this chapter and will be discussed there more thoroughly.



While experts mind find numbers meaningfull, other users might favor indicative color codes…
(photo: www.pixabay.com)

Finally, mismatches might also indicate (hidden) power-related issues that are important for the project goals regarding empowerment. For example, if a teacher or an employee of a local authority hesitates to become involved in the project while expressing his/her concern in terms of a perceived lack of support (within the organization), then this might indicate underlying power-relations and the existence of debates about topics that local authorities rather like to avoid (e.g. their power to reject collaboration in order to remain the status quo).

The importance of checking these kind of mismatches was also recognized by a spokesman for one of the involved authorities (particularly in the situation where they were perceived by the public to be not really trustworthy). Thereby, the relevance of public participation was mentioned when trying to build trust by bridging the gaps between perception and reality. Two interesting comments – of which one also refers to the "wisdom of crowds" – are given as an example.

- **Participant (spokesman for the local authority):** *"If the fact that the average data barely show exceptions in the neighborhoods is correct, due to the public's feelings there is a gap that needs to be checked. I have no doubt regarding one thing – the public's feelings is what always counts. Since if the public doesn't believe, there's no trust, so… You can say it is night and people will say 'No, you just closed the curtain'". […] at the bottom line, the question you want an answer to is how to change the situation [in which] people have a feeling that is not… Look, as a public participation consultant, I can tell you that the public's feeling is one of the most important things. And in a considerable part of the cases, their feeling is right. And in other cases it's wrong. We, who are responsible for public participation, should bridge the gaps between the feelings and the facts, ok? For the better or for the worst. We need to build trust…"*
- **Participant (spokesman for the local authority):** *"Public participation should be as it sounds: sharing. It should be a win-win situation… That means that the wisdom of the crowds should penetrate the system, and the knowledge of the system should reach the public as well in order to improve the public's quality of life, and to generate a better feeling. It's possible that they're living in a bubble of unexplained anxiety. I'm not saying it's true… […] I do believe in the wisdom of the crowds, I truly believe in it. I*

> *can tell you from other projects that the residents' feelings are more important than the planner. Because they have their traffic habits, their cultural habits and so on… But in the same manner that many times the truth is with the public, it may also be that the information they have, especially today in the age of the internet, is wrong and causes a total distrust. It's human nature. And no matter what you do, without trust, there's no influence. You get it? Maybe there is an improvement in the health aspect, but if people don't believe you, and there's a feeling of failure and discontent with the authorities and… this impotence, [and] that I may be sick and that my kid may have a small head or whatever… it won't work. The price of apartments will not increase. And it's a long supply-chain, and it has an impact. Therefore, I think that public participation has to reach a win-win situation. The two bodies should align with the real information, and improve the situation."*

Authorities' comment regarding public's perceptions towards their credibility and trust

3.4 User-evaluation of the social acceptability of COs and the CITI-SENSE-tools

As addressed early in the project (see Deliverable 5.1 (Lüders et al., 2013)), *"research and studies of citizen participatory initiatives often point to the failures of making citizen participation work: citizens are not empowered, conflicts and organizational problems dominate, disadvantaged groups are excluded completely, and participatory methods are not used correctly (Innes & Booher, 2004)."* To mitigate these problems, Innes and Booher (2004) refer to what they call collaborative participation that should "*incorporate not only citizens, but also organized interests, profit-making and non-profit organizations, planners and public administrators in a common framework where all are interacting and influencing another*". This type of participation requires collaboration, dialogue and interaction, and subsequently builds networks, social capital and trust. This means that "building networks", "building social capital" and "building trust" are also possible goals for the empowerment initiatives.

This chapter will evaluate various aspects of this social acceptability of the COs in general and/or for specific CITI-SENSE- tools in particular. Rather automatically, some of the evaluations will also refer to various societal debates about citizen science, about air quality and about empowerment regarding AQ-problems. These will be related – often in many ways – to the 8 basic questions that were already raised in CITI-SENSE-deliverable D5.1 (e.g. questions regarding the challenge of how to institutionally arrange environmental health governance) (Lüders et al., 2013):

1. What to govern: nature and society; issues, problem framing; policy options, priorities?
2. Who is relevant: stakes, power, benefits, burdens?
3. Who should be involved: which groups, actors, stakeholders?
4. When should actors be involved: e.g. at which phase of the governance process, such as issue/problem framing, research/process design, research, social/policy interpretation, definition of policy options, prioritization, practical action, evaluation?
5. Where should actors be involved: e.g. which policy level, spatial scale or sector of society?
6. Why should actors be involved: e.g. do we involve local actors because they have a democratic right to be involved, or because we need their support for the legitimacy of the governance process, or because we need their local knowledge, or because we want to raise their awareness?
7. How should actors be involved: e.g. voluntarily, top down or bottom up, by which rules, how is power distributed?
8. Based on which information: which and whose data or knowledge?

In this chapter, the following aspects of the participatory user-evaluation will be discussed:

- **ethics** (e.g. definitions of empowerment, privacy-issues, etc.)

- **credibility and transparency** of tool-developers and/or tool-users (e.g. independence, etc.)
- **legitimacy** (e.g. referring to actions being appropriate uses of power and in the public interest)
- **representativeness**
- **mandate of product-developer** (e.g. developer working in collaboration with authorities)
- **mandate of user-organization** (e.g. authority as end-user, NGO in cooperation with authorities, etc.)
- **allocation of new responsibilities** (particularly from authorities towards NGO's or individual citizens)
- **socio-cultural aspects** (e.g. needs of specific vulnerable groups, cultural preferences, etc.)
- **legislation** (or legal acceptability)
- **political and economic acceptability** (as specific aspects of social acceptability).

3.4.1 Ethical considerations expressed by participants

Although the tool-developers and scientists might have the best intentions, some tools can (unexpectedly) become disempowering. Suppose that you gather accurate data from mobile sensing technology, you visualize this information by producing an understandable map, etc… and you disseminate it to the wider public. But what then? While new sensing capabilities can make insidious urban qualities, such as buried toxic waste sites or ground water toxins, more visible to citizens – this new vision may become *"a Siren's song seducing us to make poor choices"* (Cuff et al, 2008). Although Cuff et al focused on an example about crime rates in relation to people moving to the suburbs, also similar examples can be found for poor choices based on AQ-related information. Some approaches to empowerment focus for instance strongly on enabling individuals to gain access to assets, information, choices and opportunities so that they are able to improve their own situations. This is often coupled with a liberal emphasis on individual rights and responsibilities. One concern with this approach is that it can lead to enabling some individuals to better adapt to a fundamentally unfair situation, without addressing the conditions that produce this unfairness (for example poverty) in the first place (Pettit, 2012). These comments strongly echo a wider debate in the literature about empowerment in general and about empowerment in relation to AQ in particular. Pettit (2012) for example convincingly argued that *"empowerment has become a central objective for many organizations, but like power it can have many different meanings relating to individual and collective participation, capability, choice, autonomy and freedom."* Pettit also emphasized important risks:

> *"Because empowerment is open to selective interpretation – and as empowerment has been mainstreamed – it can become diluted and lose its transformative meaning. While empowerment broadly defined can open new avenues, there is a risk that it will be interpreted and supported in ways that quietly conform with the interests of powerful actors or with prevailing norms. Those approaches to empowerment that don't threaten the status quo might be 'cherry-picked', or tools and methods might be pursued in more mechanical and technical ways that become divorced from a social change agenda" (Pettit, 2012).*

Specifically in the context of air quality monitoring, Ottinger emphasized the possible risks that can be the result of strategic interpretative choices in the way how "empowerment" is constructed. He argues that – depending on the contexts in which data from environmental surveillance is made meaningful – empowerment for communities can refer to (Ottinger, 2010):

1. citizens' power to define environmental issues;
2. citizens' power to enforce environmental laws, or;
3. citizens' power to choose their environmental circumstances.

All of these three interpretations arguably enhance the community members' ability to act, however, the level at which they will be empowered to act will vary dramatically from one interpretation to another (see also intermezzo: *"The Bucket Brigades"*). Contrasting interpretations – which are often strategic interpretative choices – are the reason that "empowerment" can be constructed in various ways (e.g. in terms of the power to define issues, the power to enforce laws and the power to choose), and this leads to different levels at which community groups are enabled to act. The ways in which empowerment is often constructed in the context of (neoliberal) models of choice can actually constrain empowered individuals their ability to push for structural change and can even heighten inequality.

Effective mobilization of surveillance technologies by relatively powerless or marginalized groups should take this into account, because with good reason Ottinger argues:

> *"These [three] forms of empowerment are not equally potent. Increased power to define environmental issues contributes to community members' ability to challenge established structures of environmental decision-making and environmental injustice. The added power to enforce laws increases residents' status within those structures. But the power to choose individualizes environmental action with double-edged consequences: while potentially increasing community members' knowledge of local risks, this mode of interpretation also opens them to blame for not making better choices" (Ottinger, 2010).*

There are various examples from the literature that raise many more questions regarding the "empowerment-to-choose"-interpretation. First of all, which choices (e.g. real alternatives) are actually available? Secondly, what are poor choices and how can we prevent people from making poor choices? And finally, what are the possible consequences regarding empowerment if there are no sound alternatives available, or maybe not for all citizens (and especially for those who need it the most)?

Intermezzo: "The Bucket Brigades" (USA)

In his study about air quality and empowerment, Ottinger refers to the example of the "bucket brigades" that were set up in the USA by many residents of "fenceline communities" (e.g. neighborhoods that are immediately adjacent to industrial facilities and that are directly affected by their location in terms of noise pollution, unpleasant odors, chemical emissions, but for instance also traffic, parking and other operations of the company). The huge risk of empowerment in terms of "power to choose" was given to him by a case study example in which a graph with air quality data was discussed by the Health, Safety and Environment manager of the company (Ottinger, 2010):

> *"The manager explained that the data gave residents the information that they needed to decide for themselves where they wanted to live. There were places where the air was cleaner, he acknowledged, but those places might not have the kinds of amenities that one would enjoy in an industrialized area […]. Surveillance data, in this interpretation, was seen as a contributor to the risk-benefit calculations of community members. An empowered community was one made up of individuals with the ability to make informed choices."*

Source: "Constructing empowerment through interpretations of environmental Surveillance data." (Ottinger, 2010)

When analyzing the ethical aspects of the CITI-SENSE-project, these questions require a more thorough discussion, especially because this problem of individual decision-making has also been touched upon in some of the interviews. Take for instance this particular sentence in the description of the LEO:

> *"The Personal Air Monitoring Toolkit (LEO) provides an opportunity to monitor personalized levels of air pollution and their changes in time and place. […] The measurements give an indication of pollution levels and their changes, as the user moves through different locations and types of environments. They help to identify where (and when) the pollution is higher than other places, as such situations sometimes can be avoided."*

Some participants have indeed mentioned this as a useful functionality of the CITI-SENSE-tool(s).

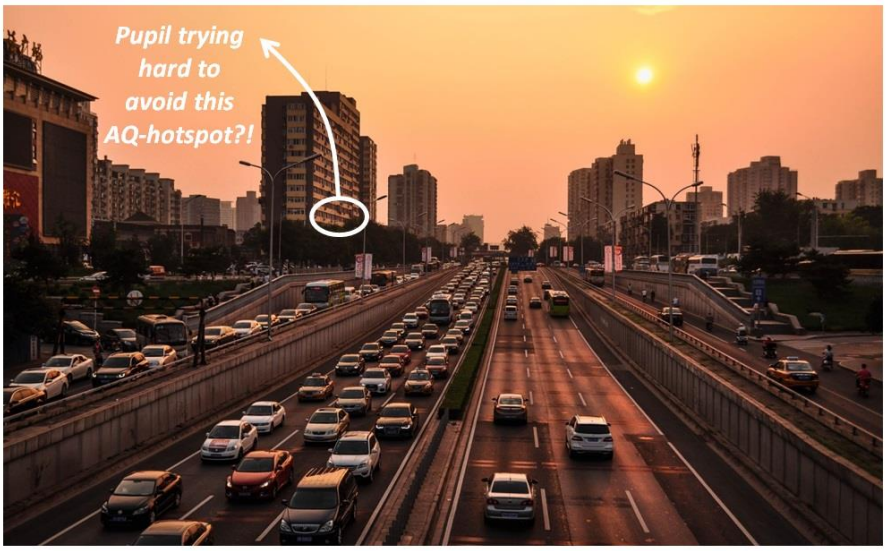
- **Interviewer:** *"What could the LEO help you do better?"*
  Participant (member of school): *"It would potentially influence my route to work for example, in terms of my own behavior, because I'd have my guesstimates as to what are less polluting routes. The level of air pollution would be an influence for me, I've asthma myself and there are cardiac conditions in the family."*

Participant's recognizing the functionality of "avoiding AQ-hotspots"

But in the situation expressed by the pupil below, it soon becomes clear that there are major limitations regarding the empowerment capacity of this tool (e.g. the kid in this example will have difficulties when trying to get home after school). If you are living or working right in the middle of such a hotspot, you will never get home (or at work), or maybe only during off-peak hours, and also when air pollution is present everywhere in the city (for instance during periods of temperature inversion and smog).

- **Interviewer 1:** *"You are aware that the poor air quality, air pollution affects your health?"*
  Participants (pupils of elementary school): *"Yes."*
  Interviewer 1: *"You're all aware of that. So, when the air quality is good, that directly impacts your health and it's a very important thing. So we should take care about our air, as this automatically means we are taking care about our health."*
  School teacher: *"So of course, because we breathe air directly. Right? It is going through our airways. And they will learn about that next year."*
  Participant (pupil of elementary school): *"How is it for me, since I live next to a highway? The problem is that I live next to the street actually. That's why I always take some flowers to smell…"* ☺
  School teacher: *"That he lives next to the street is not at all insignificant, because the noise is actually one of the pollution factors."*

Participant's comments regarding the limitations of "avoiding AQ-hotspots" (part 1)



Tools that show AQ-hotspots in order to avoid them are of limited use for people that are living nearby busy streets *(photo: www.pixabay.com)*

Also other participants have raised the issue of having no alternative:

- **Participant (volunteer):** *"For me there are not too many choices. You are going from A to B, and there's a limit to what you can do to avoid exposure. After all it disperses, so if you take another route, it might not be a big difference."*
- **Participant (NGO health):** *"One of the issues there is that some of our members with the most severe lung diseases among children, on days where it was cold and the air pollution was high, they couldn't be outside. Or the doctor said: 'Don't go outside.' So they called their kindergartens and said: 'My kid can't be outside today. Is it OK if he/she stays inside?' And some would get the reply: 'No we don't have the capacity to keep them inside, so you have to keep them at home.' So they have to leave their work and stay at home with their kids. So it doesn't just affect the one kid at the kindergarten, it also affects the parents and their workplace. And the problem is, that the air outside is harmful for all the kids, not just the ones who have asthma. […] It's one thing to be so affected that you actually have respiratory problems, so you can't be outside because you can't breathe. But everyone else also breathe the same air, so it's harmful for them as well."*

Participant's comments regarding the limitations of "avoiding AQ-hotspots" (part 2)

During periods of temperature inversion the whole city center can be seen as one big air quality hotspot that cannot be avoided by anyone *(photo: Wim Verheyden)*

When citizens are made more aware of the AQ-problems while they do not have alternatives to solve the problem, this can often lead to frustrating feelings of "learned helplessness". During the CITI-SENSE-project, this was seen for instance in one of the participants' comments in the Long Perception Questionnaire: *"How can you improve the quality of air? I had a similar application that just got me depressed. What can I do if the quality is low?"* In the example of the pupil of elementary school above, it would be quite painful to present the CityAir-appl as a solution for this pupil or other people in similar situations (especially because the negative health effects were emphasized so strongly during the conversation). A similar thing was addressed in the CommonSense-project: there are risks involved when making community members highly aware of problems without making it equally clear how to address them (Aoki et al, 2009). We might end up in "the tragedy of the Cyclops" (e.g. the impossibility of effecting change notwithstanding foreknowledge), as described by Cuff et al (2008) as:

> *"A situation in which distributed environmental sensors could detail with alarming precision the nature and extent of our environmental poisoning, but those without financial or political means may be left with debilitating information about the nature of their demise without any practical ability to change their circumstances".*

Besides these situations in which there might be no sound alternative route to avoid air pollution, there are other negative consequences to think about. When walkers/cyclists choose to avoid AQ hotspots (by walking/cycling around them), they can avoid unnecessary negative health effects. This might be perceived as some form of "empowerment". But what might seem to be a reasonable choice at first sight, is actually a poor choice in terms of real empowerment as it mainly reassures the message: *"Just go ahead car drivers. Don't bother, people who travel in a more sustainable way will adapt to your polluting way of travelling"*. According to Pettit (2012) this kind of choice does not lead to real empowerment, because *"it will only enable people to better adapt to a fundamentally unfair situation, without addressing the conditions that produce this unfairness in the first place"*. This choice will only re-enforce the status-quo. People who are giving the good example will be punished by making them walk or cycle longer distances in an attempt to avoid AQ-hotspots as much as possible, ironically after that they have had to map these hotspots themselves with their Smartphones and mobile sensors.

When there are no alternative routes available, people might also decide to stay inside (e.g. when air quality outside is worse than indoor air quality). But this is problematic in the same way, as once again this will rather be a doubtful way of enabling (vulnerable) people only to adapt better to fundamentally unfair situations and sometimes there will be no other option then leaving the house (e.g. to bring the children to school, to go to work, when you need to go shopping for food, etc.):

- **Participant 1 (NGO health):** *"If we think from our point of view and our targets, it's a useful tool for anyone with respiratory diseases, people with asthma and everything. If they can check the air quality every morning, like where they commute or where they walk to work for example, and choose a different route if the app shows a better air quality in another route. Then that's a perfect tool for anyone who have those problems. So I think that's the main advantage for our targets."*
  Participant 2 (NGO health): *"To prepare them before they go out to the kindergarten."*
  Participant 1: *"Or simply avoid going out, basically."*
  Participant 2: *"Yes, if they need to. And I think it also would be helpful and easier to give maybe their boss or managers a notification about why they have to stay at home that day. Then you can show it on the app that it is not safe for me to go out due to my condition."*

Participant's comment about authorities pushing away their responsibilities

But deciding to stay inside might even be more problematic, because air pollution does not stop at our doorsteps. Actually, indoor air often seems to be more polluted than outdoor air. This makes it even more doubtful if (vulnerable) people will be really empowered. For instance, Wichmann et al. (2010) monitored the relationship between indoor and outdoor air pollution levels in 6 schools and 10 pre-schools in Stockholm. They found that the indoor and outdoor NO_2 levels were strongly associated, indicating that the indoor environments occupied by children offer little protection against combustion-related pollutants. In the BREATHE-project, indoor and outdoor air quality was assessed in 39 schools in Barcelona. The authors found that the outdoor NO_2 concentration was 1.2 times higher at schools than at urban background sites, suggesting the proximity of some schools to road traffic. The indoor levels were similar to those detected outdoors, indicating easy penetration of atmospheric pollutants (Rivas et al., 2014). In 2007 the European Scientific Committee on Health and Environmental Risks (SCHER) was asked for their opinion to identify a Risk Assessment Strategy to support policy on indoor air quality. The Committee was also particularly asked to take into account potentially vulnerable groups of population such as children, pregnant women, elderly persons (over 65 years of age), and persons suffering from asthma or other respiratory diseases and cardiovascular diseases. The opinion was aimed to cover indoor environments where the general public may be exposed to pollutants, such as private homes and public buildings e.g., schools, day care centers, offices and places of leisure. Transport vehicles (vehicle compartments) are specific indoor environments. The same risk assessment principles can be applied for them but the means of risk management may differ. Industrial exposures, including professional cleaning, in indoor environments were excluded because they do not represent the exposure of the general public. In addition, the opinion of the SCHER did not cover active smoking but environmental tobacco smoke (ETS) was included. According to the SCHER, the composition and concentrations of the different components in indoor air vary widely and are influenced by human activities. Most indoor air pollutants consist of chemicals released, for example, the use of cleaning products, air fresheners, pesticides and emissions from furniture and construction materials, heating and cooking. In addition, outdoor sources may contribute to indoor air pollution. Aspects such as thermal insulation and ventilation rates may also play a role. Microbiological contaminants which may induce allergies and asthma also require consideration as indoor air pollutants. Examples of potential serious effects include respiratory disorders, including asthma and cancer. Since it is not feasible to regulate all possible scenarios, prevention from possible health effects

and protection of sensitive populations is best achieved by reducing exposure. As a consequence the SCHER recommended that all relevant sources that are known to contribute should be evaluated. Such sources include tobacco smoke, any open fires including candles, building materials, furniture, pets and pests, use of household products, as well as conditions that lead to the growth of moulds. Constructers, maintenance personnel and inhabitants should also be aware that appropriate humidity avoids annoyances and sufficient air exchange reduces accumulation of pollutants. That is why the SCHER explicitly concluded in their *"Opinion on risk assessment on indoor air quality"* (European Commission - SCHER, 2007):

> *"Indoor air may contain over 900 chemicals, particles, and biological materials with potential health effects. Since their concentrations are usually higher than outdoors and people spend more time indoors than outdoors, the SCHER recommends that any studies to correlate outdoor air concentration with health effects need to consider the impact of indoor exposure."*

Also in more recent publications, the European Environment Agency (EEA) has emphasized the importance of indoor air quality (thereby repeating that indoor air quality might be worse than outdoor air quality) (European Environment Agency, 2013):

> *"Many of us might spend up to 90 % of our day indoors — at home, work or school. The quality of the air we breathe indoors also has a direct impact on our health. It may come as a surprise to many of us that the air in an urban street with average traffic might actually be cleaner than the air in your living room. Recent studies indicate that some harmful air pollutants can exist in higher concentrations in indoor spaces than outdoors. In the past, indoor air pollution received significantly less attention than outdoor air pollution, especially outdoor air pollution from industrial and transport emissions. However, in recent years the threats posed by exposure to indoor air pollution have become more apparent. […] Poor air quality indoors can be especially harmful to vulnerable groups such as children, the elderly, and those with cardiovascular and chronic respiratory diseases such as asthma. Some of the main indoor air pollutants include radon (a radioactive gas formed in the soil), tobacco smoke, gases or particles from burning fuels, chemicals and allergens. Carbon monoxide, nitrogen dioxides, particles, and volatile organic compounds can be found both outdoors and indoors. […] Small actions such as ventilating enclosed spaces can help improve the quality of the air around us. But some of our well-intended actions might actually have adverse effects. Erik Lebret [from the National Institute for Public Health and the Environment (RIVM) in the Netherlands] suggests: 'We should ventilate, but we should not over ventilate as this is a substantial loss of energy. It leads to more heating and use of fossil fuels, and consequently means more air pollution. We should think of it as making more sensible use of our resources in general.'"*

When these effects were effectively measured and explained, it seemed to surprise the participants. This shows the potential for awareness-raising.

- **Interviewer:** "*It depends on the conditions in the area where the stationary monitor was located and where the people were moving. Such results we often obtain in schools and kindergartens, because children run and move in classrooms, the dust swirls.*
  Participant (local authority): *"That values are sometimes higher inside than outside, it surprised me."*

Participant's comment about authorities pushing away their responsibilities

People might decide to stay inside (e.g. when air quality outside is worse than indoor air quality) *(www.pixabay.com)*

Air quality indoors can sometimes be much more polluted than the air outdoors *(www.pixabay.com)*

Based on the arguments above, it can be argued that tools who recommend people to stay inside might (sometimes) be a doubtful way of enabling (vulnerable) people only to adapt better to fundamentally unfair situations, and sometimes this choice might actually expose them to air quality that is even worse. Similarly, it can also be questioned if the choice to wear a mask when you go outside would empower people instead of being a disempowering adaptation. But nonetheless it regularly happens in bigger cities both in Europe and also elsewhere around the world, and this choice is actually giving the same message. Although it can contribute to your health, it will only make people adapt to a fundamentally unfair situation. Wearing a mask was mentioned during one of the interviews:

- **Interviewer:** *"Some of the respondents for example were people like cyclists. Some reported that they were asthmatic. But there were cyclists and they were saying that*

some times of the year and in some places they need to use masks. And they were not feeling very comfortable and…"

- **Interviewer:** *"What are opportunities for you to take AQ improvement action based on the LEO?"*
  Participants (peer group of students and scientists): *"I can improve my 'personal air quality' by wearing special masks."*

Interviewer referring to wearing a mask

People wearing masks to protect themselves from air pollutions (photos: www.pixabay.be)

The situation can quite easily become even more disempowering when looking for other situations where there are no alternatives (for some people). Participants in the CITI-SENSE-project sometimes referred to (potential) functionality of the tools without being really aware of the potentially negative outcomes (such as the consequence that – from now on – you have to "make better choices" because you are better informed):

- **Interviewer:** *"What can the LEO help you do better?"*
  Participant (volunteer): *"[…] That you can choose where to go. […] And where to live, in a way. So if you're going to buy a house, you can maybe see if this is a bad area..."*
  Interviewer: *"It helps you to make more decisions?"*
  Participant: *"Yes."*
- **Participant (member of school):** *"Thinking out loud, if I were looking to choose a home again, I'd want to know that the area around it had relatively good air quality and having gadgets like this would enable you to answer that."*
- **Participant (from a group of volunteers carrying the LEO's):** *"I think it could help anyone looking for a house, having children, as it tells you about micro location of air."*
- **Interviewer:** *"In your view, what conditions must be met for you to adopt measures for improving air quality?"*
  Participant (citizen): *"The same story, over and over again. If I saw red figurines prevailing in the place where I lived and had a chronically ill child, I could easily move away. […] If the application provided specific figures about pollutants, I could make a picture about my neighborhood. I'd quite certainly consider whether to stay or leave such a neighborhood. […] People could get specific information about their exposure to pollutants in their locality and consider whether to stay in such locality or leave."*
  Interviewer: *"What do you consider as obstacles to take steps for improving air*

quality with the help of this application?"
Participant: *"To have the guts to leave, a fear of losing one's job."*

- **Participant (citizen):** *"I am often in [town Y], 20 km far away from here and you cannot compare. People move to further localities when they have sick children and if they have money. It does very much help for the sick people, they are healthy there now (after 6 months)."*
- **Participant (from a group of volunteers carrying the LEO's):** *"One could also use this information for estimating the property values."*

Participant's comments – indirectly – indicating a risk for other forms of disempowerment

As indicated in one of the comments above, there might be obstacles when choosing as an individual. But the example of *"not having the gutts to leave or a fear of losing one's job"* (as it was expressed by one of these participants) is not the most important one. It is obvious that this "freedom-of-choice" goes way beyond the issue of having the guts to choose. For instance, people who don't have the financial means to move away, will stay behind in communities that might become even more vulnerable. Using the tools to estimate property values was also explicitly mentioned by one of the participants, and this makes private owners who are still paying off their loans vulnerable too (because they might see the values of their property reduced because of the new AQ-maps and this will make it more difficult for them to move away to healthier neighborhoods).

Also Ottinger (2010) warned us with a similar and convincing example of the disempowering character of a "power to choose"-interpretation, in which negative data (e.g. showing evidence of poor air quality on a detailed map) actually would undermine citizens' power to choose:

> *"Community members deciding to move away based on (presumably empowering) data about local air quality would likely have difficulties selling their homes. Low property values and even red-lining (e.g. lenders' refusal to underwrite mortgages in certain neighborhoods) often characterize life in fenceline communities. Monitoring data showing air toxins in a neighborhood at unhealthy levels would likely only exacerbate these trends, and residents – figured as choosers in a free market – would find their practical opportunities to select a different place to live even more circumscribed." (Ottinger, 2010).*

There were no explicit comments in this regard in during the user-evaluation, but one is definitely closely related. It was a comment from a local authority about another non-CITI-SENSE-study that caused negative media attention:

- **Participant (local authority):** *"It's a huge negative publicity. Characteristics of this area sounds that there is the worst place for life in the world .. with a bit of exaggeration! I do not understand, when I look at the values in [town X] during summer, which are good, how those conclusions were reached when at us it is different."*

Participant's comment regarding personal safety when being an activist

According to Abel et al (2015a), this means that there can be a negative relationship between gentrification and environmental justice when affluent residents outcompete less affluent ones for neighborhoods with fewer environmental hazards. Inequitable development and environmental injustice remain overlooked dimensions of sustainability that interdisciplinary research should address. For the city of Seattle, Abel et al (2015a) found for instance unequal patterns in the distribution of relative exposure risk. Citywide summaries (like for instance the portrayal of average environmental or economic inequalities) overlooked the extreme cases and a closer analysis of variation across clusters and trends among five gentrification categories has shed a new light onto Seattle's stratified social geography and riskscape. Pollution exposure risk and lower socio-economic clusters were

converging in the same place and that Seattle's pollution riskscape and urban development burdens have been skewed towards some of the city's most socially vulnerable residents. The wealthiest and most affluent residents in terms of educational attainment, occupational status, median household income, and property values were less exposed. This means that some citizens get more environmental protection than others. The authors concluded: *"A more just sustainability instead of a gentrified one for the Emerald City will require more political and policy attention mitigating inequitable development and environmental injustice."* Many subsequent studies have found that the spatial distributions of pollution hazards and socially vulnerable populations (e.g. poor and minority) cluster together leading to environmental inequalities as a major feature of America's urban geographies in Boston, Cleveland, Detroit, Los Angeles, Portland, St. Louis and Toronto (Abel et al, 2015a).

As a consequence, this means that in a worst case scenario the CITI-SENSE-tools can even re-enforce situations of "gentrified sustainability", "environmental gentrification" and "smart segregation" (instead of smart growth) in the long run, due to unrestricted market processes that lead to changing housing prices based on the AQ-data made available. These effects have been reported already for Seattle by various journalists. In another article (Abel et al, 2015b), the authors argue that *"until Seattle's leaders recognize the connections between gentrification, zoning, affordable housing, and skewed air pollution exposures, the city's economic stratification and environmental injustice will continue to tarnish the Emerald City's brand of sustainability"*. The authors concluded that *"while Seattle has been heralded for its leadership in sustainability, we join the growing number of voices that critically interrogate this reputation"*, and they refer to concrete examples of news headlines such as *"Priced Out? Growing numbers appear to be fleeing King County"* and *"In Georgetown, the Housing Is Affordable and the Air Unbreathable"* that are an indication of these problems.

In a worst case-scenario, the CITI-SENSE-tools can re-enforce situations of "smart segregation"
(photo's: www.pixabay.com)

The potential negative influence due to segregation is only one of the possible consequences, but there might be other negative consequences too when people actually would be able to move houses. Cuff et al (2008) argue that more information does not necessarily produces more rational decision-making, because *"cognitive biases might lead us to pay more attention to particular types of data than they rightly deserve"*. Risk perception is often strongly related to these cognitive biases. If the AQ-data clearly indicate that the cities are in general major AQ-hotspots (in comparison with the suburbs), *"this information – and the rough and ready risk calculation that individuals make in deciding where to live – might persuade people to move to the distant suburbs, in spite of the far greater mortality risk created through the increased highway-driving"*. Cuff et al (2008) concluded that *"relying on highly salient, one-dimensional 'crime statistics' could produce a self-fulfilling prophecy that makes those areas with high crime rates [AQ-hotspots] grow even more dangerous*" (Cuff et al, 2008). In the specific case of AQ-data, it can be argued in a similar way that moving houses because of bad air quality might actually also increase the AQ-problems. People who have moved to the suburbs now might have to travel much more, also into the cities were they still will go to work, to shop, to visit friends, to go to the movie, to play sports, etc. If they would travel by car, this might also increase their exposure to air pollution (while sitting in their car) and also the overall pollution in and around the city might be worsened due to the increase in traffic.

These possible risks have also been acknowledged by the European Union:

> *"As part of the developments which impact upon people's mobility and transport in urban areas, increased social polarization and the spatial segregation it causes are particularly significant, making it difficult for certain low-income groups to find affordable housing in cities and access certain services such as transport. Closely linked to spatial segregation is the phenomenon of urban sprawl. This can be driven for instance by the increased gentrification of cities, leading people to find affordable housing further from the city center or, on the contrary, by the outmigration of wealthy social groups leaving the less privileged groups in run-down city centers. Stimulated by people's desire to settle in better housing with more land surface per capita, urban sprawl has negative impacts on transport and mobility. It leads in particular to an increased use of private cars due to public services being more costly and more difficult to provide in low density settlements. This leads in turn to transport congestion in and around cities, alongside road infrastructure upgrades made in order to reduce travel time and improve accessibility, thereby further fuelling urban sprawl and further congestion, creating a vicious circle" (Debyser, 2014).*

These kinds of vicious circles can be enforced by "economic traps" in which individuals have incentives to act in ways that make society worse off overall (e.g. increasing segregation and associated social problems on the one hand, and increasing urban sprawl, automobile travel and transportation costs on the other) (Litman, 2016). These effects can also be worsened by inconsiderate incentives developed as part of the (local) housing policies.

And there is yet another risk to be emphasized. It was addressed by the participants and was related to problem-solving. Especially when focusing strongly on "empowerment as freedom to choose", there might be situations in which polluters and/or local authorities will try push away their (complicated) tasks and responsibilities to the level of individual citizens who will then have to help themselves. In that case individuals will have to make their own balanced judgments based on this new AQ-information, making individual choices in order to avoid suffering from unhealthy situations. In terms of empowerment, this inactivity of authorities is problematic in itself. But there might be additional negative consequences. If individuals would have to become activists even more then they are now (because responsibilities for solving AQ-problems are shifted towards them), the potential risks of

activism might also increase (as addressed by the participant in the example below). This means that there are limitations to citizen engagement, especially when stakes are high.

- **Participant (citizen):** *"My friends sometimes say that they are worried about me when I am very engaged. I had repeatedly punctured car tires. On the other hand I am meeting also people that I do not know and they are saying nicely hallo to me, they know that there is someone who fight for them."*

Participant's comment regarding personal safety when being an activist

This fear can become a reason for citizens to become inactive. This would be very sad from a democratic point of view and it would stress once again the real need for empowerment and balanced AQ-governance. It shows how important it is that authorities should take action (and that it is also important to protect engaged citizens).

Besides all these examples of "empowerment as the power to choose" in which poor choices can be made, another remark from the interviewees also stumbles – indirectly – upon the ethical limitations of "individual choice", but now in terms of a person's choice to refuse being held responsible for his/her contribution to the problem of air pollution.

- **Participant (other researcher):** *"Pollution is always the choice between your own convenience and the general good. It is a matter of a personal choice: to drive your car or to use the public transport to cut down your emissions, but it will take more time."*
- **Interviewer:** *"Even in [a part of city X] I saw a new bike trail.*
  Participant (local authority): *"It is not a question for me, I like hiking, but the bike is not my favourite! I would not ride a bike, but I would use the car, even if I would had a bike trail."*

Participants' comment about the coice between convenience and the general good

Although not much attention was given on these two comments above during the interview, it touches upon the very interesting debates on Odum's/Kahn's "tyranny of small decisions" and Hardin's "tragedy of the commons":

- **The "tyranny of small decisions":**
  "Unfortunately, important decisions are often reached in an entirely different manner. A series of small, apparently independent decisions are made, often by individuals or small groups of individuals. The end result is that a big decision occurs (post hoc) as an accretion of these small decisions; the central question is never addressed directly at the higher decision-making levels. Usually, this process does not produce an optimal, desired, or preferred solution for society. This process of post hoc decision-making has been termed 'the tyranny of small decisions' by the economist Alfred E. Kahn (1966). […] Similarly, the gradual decline in air quality of the Los Angeles basin during the 1940s and 1950s was produced by thousands of small decisions to add one more factory or one more family automobile (Odum, 1982).
- **The "tragedy of the commons":**
  "In a reverse way, the tragedy of the commons reappears in problems of pollution. Here it is not a question of taking something out of the commons, but of putting something in – sewage, or chemical, radioactive, and heat wastes into water; noxious and dangerous fumes into the air, and distracting and unpleasant advertising signs into the line of sight. […] The rational man finds that his share of the cost of the wastes he discharges into the commons is less than the cost of purifying his wastes before releasing them. Since this is true for everyone, we are locked into a system of 'fouling our own nest', so long as we behave only as independent, rational, free-enterprisers" (Hardin, 1968).

The comment above is also connected to Mills "harm principle". Mills acknowledged that the actions of individuals should only be limited to prevent harm to other individuals. He articulated this principle in "On Liberty", in which he argued that *"the only purpose for which power can be rightfully exercised over any member of a civilized community, against his will, is to prevent harm to others. "* (Mills, 1869; Oliveira, 2012). Feinberg has controversially argued that the harm principle did not apply in the case of pollution offences, because in the case of cumulative harm it would be impossible to determine the degree of contribution of each polluter to the harm. In the case of air pollution, it would be impossible to individualize the degree of contribution of each motor vehicle in the discharge of carbon dioxide from its engine, he argued (Feinberg, 1984; Pereira, 2015). It can be seen as an example of the (political) framing of this problem (as it is for instance thoroughly discussed by Hancock):

> *"[…] the process of defining the remit and applicability of the harm principle can be seen as an overtly political act that privileges one set of values and interests over others. Its defenders advance the harm principle as an impartial, universal, natural, and indeed irrefutable expression of moral law. This premise is built upon the idea that the ordering of society is constructed on grounds that prevent individuals from harming each other. However, the process of including or excluding specific acts from the remit of the harm principle is an overtly political process in the sense that competing economic and environmental values must be privileged or subjugated and certain interests prioritized over others (Hancock, 2007)".*

This indicates that the harm principle is socially constructed and selectively applied, and the logical conclusion is that society can be rightly organized to allow those with money to pursue a consumer lifestyle whose costs should be socialized and imposed upon those individuals who are least able to avoid those social costs (Hancock, 2007). Although it is not possible in this document to go into the details of these very relevant debates, these discussions provide suitable arguments to conclude that "personal choice" does not seem to be satisfying as a basis to define empowerment.

In order to understand the full potential of COs to empower citizens, a better understanding of the relationship between the AQ-data and intervention is also required. Therefore, it is also important to recognize the (potential) influences of regulatory regimes that might occur in even much more subtle ways. Ottinger et al (2010) describes various examples of influences that might hinder intervention:

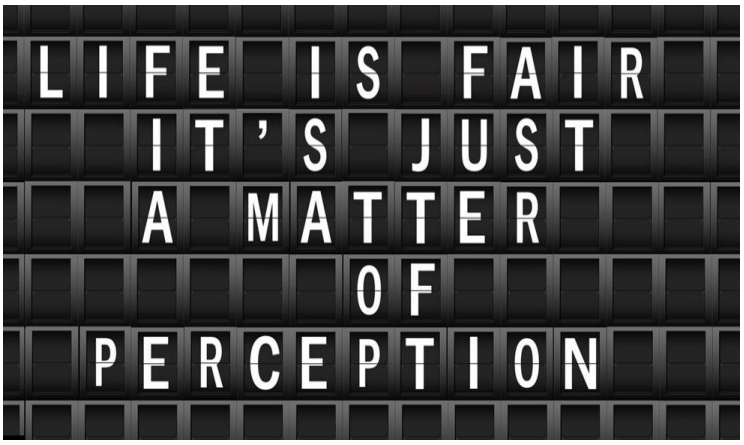
- *"Regulatory regimes, while often left implicit in studies of surveillance practices, are also central to the process through which data becomes actionable information: surveillance to prevent crime or determine compliance uses laws and regulations as the basis for evaluating the data collected and deciding how to intervene"* (Ottinger, 2010).
- *"Standards for statistical significance make it very difficult to prove elevated rates of disease in small populations like those of fenceline communities"* (Allen, 2000) and "*Causal links between chemical exposures and health effects are also notoriously hard to demonstrate"* (Bryant, 1995; Head, 1995; Tesh, 2000).
- *"Studies that have the potential to show pollution's effects on community health are unlikely to be conducted in the first place, as a result of the way that scientific research is funded and rewarded"* (Frickel et al, 2010; Frickel 2008; Hess, 2007).
- *"Regulatory standards for air quality help to define the contexts for monitoring in fenceline communities, albeit incompletely…"* (because not all possible pollutants are regulated by governments), and *"not all pollutants can be measured*" (by the existing measuring devices) (Ottinger, 2010).
- *"The scientific uncertainties around health impacts of chemical exposures reverberate through all the governmental attempts to set limits on toxic chemicals in the ambient air* (Tesh, 2000)*: although all of the standards for hazardous air pollutants are based on health*

studies, the limits set by different agencies for a single chemical can vary by orders of magnitude" (Ottinger, 2010).

- Some of the issues mentioned above *"allow monitoring to be interpreted in multiple, often conflicting ways"* (Ottinger, 2010).
- *"The incompleteness of regulatory standards for hazardous air pollutants has arguably been a factor in industrial facilities' willingness to submit to environmental surveillance, especially when the data collected could be used by a regulatory agency as the basis for a penalty"* (Ottinger, 2010).

This results in *"a persistent conflict between, on the one hand, community groups, environmentalists and sympathetic scientists who believe that appropriately designed studies would show that pollution harms the health of fenceline communities, and on the other hand the representatives of chemical companies who will defend for instance the authority of a body of knowledge that shows no causal connection between industrial pollution and community health"*. This means that, within the specific context of the fenceline communities measuring air quality nearby industrial sites, Ottinger emphasizes just another possible risk for COs in the situation in which air quality monitoring increases this conflict by documenting exposures to pollution without being able to contribute to the understanding of the health effects of those exposures. Relevant questions always to be asked are (Ottinger, 2010):

- What are the infrastructures that give meaning to data collected by the COs?
- How do they exert influence or enforce action?
- In what ways do they rely on, disrupt, reinforce or reconfigure existing power relations?



Different "framings" of a problem can be used tactically to remain the status quo (www.pixabay.com)

Also within the CITI-SENSE-project, an interesting example was found. The example below refers both to the incompleteness of regulatory standards for hazardous air pollutants and to various ways in which regulatory regimes are also central to the process through which data becomes actionable information (ways which are often left implicit in studies of surveillance practices). Besides that, it can also be seen as an example of "framing" (e.g. what is air pollution") and it covers yet another aspect of the "power-to-choose" (now in terms of authorities who have the power to opt out monitoring particular hazardous compounds if this is not obligatory according to the EU-regulation regarding AQ-standards). Finally, it is also an example of the "power-to-define-issues" (again from the viewpoint of authorities that have the power to do so). These somewhat hidden power-issues might eventually hinder citizens from being truly empowered.

- **Interviewer:** *"Ok, and what is your position regarding the air quality in [city Z]? How would you define air quality in [city Z]?"*
  Participant (member of the authority – transportation sector): *"Hmm… well this is very complicated. Many ask me about it. It's truly complicated. It's not simply saying polluted or clean, it doesn't work that way. First of all, air quality is a local issue. It's possible that there's one neighborhood which is more polluted and another neighborhood which is clean, as some of the public understands. Hmm… And apparently, in some of the neighborhoods in [city Y] the status is worse than in some neighborhoods in [city Z]. It's very location-dependent. We know that the current monitoring stations in [city Z], except for one, which monitors transportation-derived pollution hmm… do not monitor air-pollution, I mean, the air quality meets the standards. It doesn't say that we're monitoring in the right places, it doesn't say that we're monitoring all of the problematic compounds, but we monitor the same things that we monitor in the rest of the country. We monitor according to the European standards. It means that we didn't invent anything in order to [~~prevent~~: evade] information. There may be additional things that we need to check, but from the things we check now we don't see it [air pollution]. […] The monitoring stations don't measure air pollution. Actually, the air quality conforms to the standards… let's call it like that."*
  Interviewer: *"Right."*
  Participant: *"Ok, hmm… Regarding the industrial plants, we know there's more to do. The only monitoring station where air quality does not meet the standards is a traffic monitoring station. It means that we certainly have to do something about the transportation."*

Authority commenting about their official AQ-monitoring-networks

Summarizing the whole discussion about "empowerment as the power to choose", this means that this approach often would seem to support only a rather limited form of empowerment, especially when contrasted with the "power to define issues" or even the "power to participate in law enforcement" sought by activists (Ottinger, 2010). If empowerment is defined in terms of "power to choose", hopefully the choices available are not limited then to alternativess such as:

- avoiding AQ hotspots by walking/cycling around them after that you have mapped them?
- wearing a mask when you go outside?
- staying inside when air quality outside is worse than indoor air quality?
- also wearing a mask when you stay inside?
- move houses if you are living in an AQ-hotspot area (and if you have the money)?
- etc…

The examples above mainly focused on outdoor air quality situations (although at some point a link was also made between outdoor and indoor air quality). Although not fully comparable with the Empowerment Initiatives (EIs) about outdoor air quality, similar issues might also occur in the school case studies (for instance when parent might start to select the school for their children in relation the AQ-levels that were measured, which might potentially lead to segregation).

Disempowering alternatives: children wearing a mask (both outdoors and indoors… whenever needed) *(photo: www.pixabay.com)*

Also within the CITI-SENSE-project, participants have emphasized other forms of empowerment. The results could be used for instance to negotiate with authorities (thereby referring to European or local air quality standards). This example is comparable with what Ottinger calls "citizens' power to define environmental issues". These other forms will be analyzed thoroughly in the chapter 3.4.3).

- **Interviewer:** *"On the basis of this application [the CityAir-app], do you see any opportunities for you to improve air quality?"*
  Participant (same citizen)*: "Specific information on concentrations of the pollutants could help people to negotiate improvements with the authorities..."*
- **Participant (other researcher):** *"I think that the general idea of many people around is that you have to improve your capabilities to improve your spatial distribution of air quality so you have a visual real time map of air quality around the city and using that as evidence to submit to the municipality or the authorities to ask for regulations. […] Here you have the European and the local standard that enforce you."*

Participant's comment regarding negotiating AQ-improvements

Also the existing thresholds for air pollution should be open for debate. This is relevant for the empowerment perspectives, too. Take for instance the interesting gradient that is reflected in the following three comments from the participants: the first about knowing the AQ-thresholds in general (and knowing how much time you can be exposed before there are irreversible effects), the second about the availability of the official AQ-data, and the third comment questioning the current thresholds and the official methods used by authorities to measure air quality. This means that just accepting the existing thresholds – for instance when integrating them in the visualizations of the CITI-SENSE-tools without any further debate – can already be seen as a choice that might reaffirm the framing of AQ-problems by some of the stakeholders involved (thereby also reaffirming the status quo and hindering empowerment).

- **Participant (from group of volunteers carrying the LEOs):** *"It would be interesting to know that what are the concentrations when one can start to see negative health effects. How much time one needs to spend in a polluted environment that such health effects occur, and if the symptoms are reversible by going to a clean*

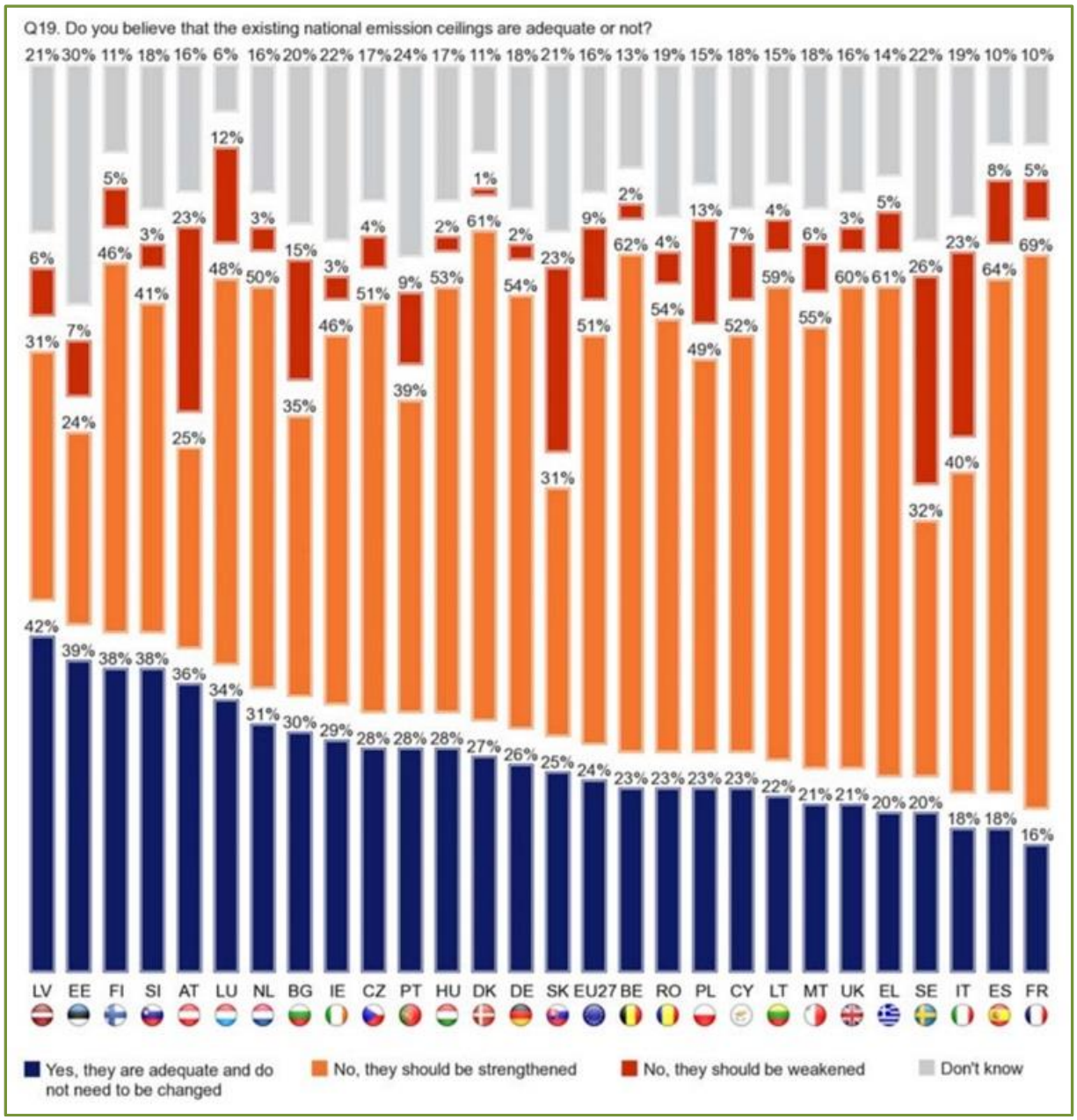
environment. An interesting fact would be to know that how much time one can be in a polluted environment without feeling the effects."

- **Participant (from a peer group of students and scientists):** "*Authorities have the responsibility to collect official data, make it available and compare with those collected through Citizen Science and possibly identify discrepancies and more transparent to deal with their own data."*
- **Participants (from a peer group of students and scientists):** *"In other cities, measures are set when certain thresholds are reached, for example, in the case of ozone. We do have a measures plan in [city X], too (for example, traffic restrictions), only the thresholds can hardly be achieved here. If we want further AQ improvements, we should also talk about the current limits and thresholds and methods of AQ measurement."*
- **Interviewer:** *"People have had the chance many times to shoot the black smoke going up from the chimneyes and from the ground of this factory. [It] must be possible to measure this."*
  Particpant (representative of authority – health sector): *"There were studies, were inspections, this is not the way forward. If we want to solve this we have to change the law. We need different methodology for measuring the emissions. But this methodology is same in all EU so then you need to change the EU law. If this will not happen, everybody here have this state known, they will measure what they have to, results are according to regulations and are ok. If there will be by chance big exceeding there will be some sanction and everything is ok. In case of trial the factories show that they have all the measurements ready in accordance with the limits and law. Another thing is that you could customoze operation so the measured emissions are ok, so you cannot prove anything. So only the change of the EU limits is needed."*

Examples of participants' comments that question the adequacy of the AQ-thresholds

When the goal of empowerment is taken seriously, this concern about the emission ceilings is very relevant. Not opening this discussion is already an act of power (that can strengthen the status-quo). This last comment about the current levels and thresholds also echoes the results of the Eurobarometer about the "Attitudes of Europeans towards air quality", in which EU-citizens were asked if they believed that the existing national emission ceilings were adequate are not (EC, 2013b):

- Three quarters of Europeans (74%) have not heard of the EU air quality standards.
- Most Europeans who have heard of the EU air quality standards think they are inadequate and should be strengthened (58%). One quarter (24%) think the standards are adequate and do not need to be changed, while 4% think the standards should be weakened.
- Three quarters (74%) have not heard of the National Emission Ceilings directive.
- Half of those who have heard of the National Emission Ceilings think they are inadequate and should be strengthened (51%), while 24% say that they are adequate and do not need to be changed. About 9% say that the ceilings should be weakened and 16% are unsure.



About half of the EU-citizens (51%) who have heard of the National Emission Ceilings think they are inadequate and should be strengthened, while 24% say that they are adequate and do not need to be changed. Just under one in ten (9%) say that the ceilings should be weakened, while 16% are unsure (European Commission, 2013b).

On a more general level, privacy and data security were also addressed as concerns (at least by some of the participants). This topic has been dealt with thoroughly in the other CITI-SENSE-deliverables (for example in D2.3, annexes with "privacy policy" and "user agreement" for the Barcelona case-study").

- **Participant (from a group of volunteers carrying the LEO's):** *"Personally I like my privacy and would not like anyone to be following me."*
- **Participant (volunteer):** *"I have a neighbor who is burning wood in an old wood stove, so every second year we have to clean one of the walls of our house which is towards his house. […] I don't need the LEO. I can tell, because the wall is black (laughs)."*
- **Interviewer:** *"What didn't you like about the LEO's?"*
  Participant (from a group of volunteers carrying the LEOs and checking the data on Dunavnet): *"Some are worried that others can see their data."*
- **Participant (member of school):** *"[…] if you could switch it off so that it wasn't clear where your home address was, then I would probably post details of that to Facebook as a means of highlighting air pollution as an issue."*
- **Participant (from a group of volunteers carrying the LEO's):** *"Data security issues needs to be taken into account in any web portal visualization."*

Small sample of participant's comments regarding privacy and data security

There are still two remaining ethical issues that were briefly addressed. One of these issues was that of the desirability of focusing on particular vulnerable groups (e.g. asthma patients) when developing or using these kinds of AQ-tools. Not only the people who have problems already will be affected by air pollution, but also the healthy ones. This means that tools which help to raise awareness should focus on the health effects for everyone and not only on the most vulnerable groups, and this is relevant for the empowerment goals too (as also healthy people will need to be empowered).

- **Participant (NGO health):** *"One of the issues there is that some of our members with the most severe lung diseases among children, on days where it was cold and the air pollution was high, they couldn't be outside. […] And the problem is, that the air outside is harmful for all the kids, not just the ones who have asthma. […] It's one thing to be so affected that you actually have respiratory problems, so you can't be outside because you can't breathe. But everyone else also breathe the same air, so it's harmful for them as well. So something like that should easily communicated 'OK, so we just have to stay inside today.' Everyone. Or go somewhere where pollution levels are not that high. So a tool like that could basically be something that a kindergarten could use and say: "OK, today the air pollution is so bad, we stay inside or go somewhere else. […] I just think it's a typical misconception that it just affects the very ill people. [But it affects] not just the ones with lung disease, but every kid."*
  Interviewer: *"Yes. You see it when there's some direct and imminent effect. Because for most of the kids the effect is not that evident. Or one day they will start with asthma problems, but they don't know why."*

Participant's comment about focusing on the needs of specific vulnerable groups

The other issue that was touched upon was the potential risk of hysteria.

- **Interviewer:** *"We are now preparing this proposal for kindergartens to also show air pollution, and the forecasting of air pollution to kindergartens. Do you also think that this kind of targeting information towards kindergartens, for example, for kids, can be useful?"*
- **Participant 1 (NGO health):** *"[…] the only downside I see, is maybe the effect it has on parents and everything when it's something that could be dangerous."*
  Participant 2: *"When they get hysterical."*

> **Participant 1:** *"Yes, hysteria. You can undermine some hysteria. Still, this isn't hysteria, this is fact. So it shouldn't be a problem, basically."*

Participant's comment about the potential problem of causing "hysteria"

Taking into account the examples that were discussed in this section, this can be read as a warning for developers of monitoring devices and/or starters of COs. As Ottinger argued, community groups might lack the scientific or statistical expertise and might become less able to interpret environmental surveillance data on their own. In that case, regulatory agencies – or even industrial facilities – will be more likely to be involved in the interpretation of data. Environmental justice activists might find their data to be interpreted in ways that restrict them rather than expand their ability to influence polluters. This indicates that understanding of the contributions – or potential contributions – of environmental surveillance to empowerment requires a good understanding of the processes by which these data are made meaningful (Ottinger, 2010).

Answering the question if all these risks for (potentially) negative outcomes should withhold us from making detailed AQ-measurements is more difficult. Taking into account the goals for Responsible Research & Innovation, the potential risks should not be underestimated, but these data can also be used positively to make AQ-problems more spatially explicit in an accurate way so that they social-economic differences in exposures can be investigated and solved. But if used very wisely, this information might also be beneficial – in the end – for solving inequalities in environmental conditions of all EU-citizens. Some participants mentioned the relevance of this type of research:

- **Participant (volunteer):** *"Getting better population exposure data... If you have a lot of people walking around with this, then in the end you will have a map showing where the really high pollution zones in [city X] are. Then we can know more about the geographical distribution and implicitly then maybe about social-economic differences in exposure. […] So that's a nice thing. That depends of course on that you have a lot of people and that they are from all over the place."*
- **Participants (group of volunteers carrying the LEOs and checking data on Dunavnet):** *"The modeled maps give an overview information about where the quality of life can be better."*

Participant's comment about studying socio-economic differences in exposure

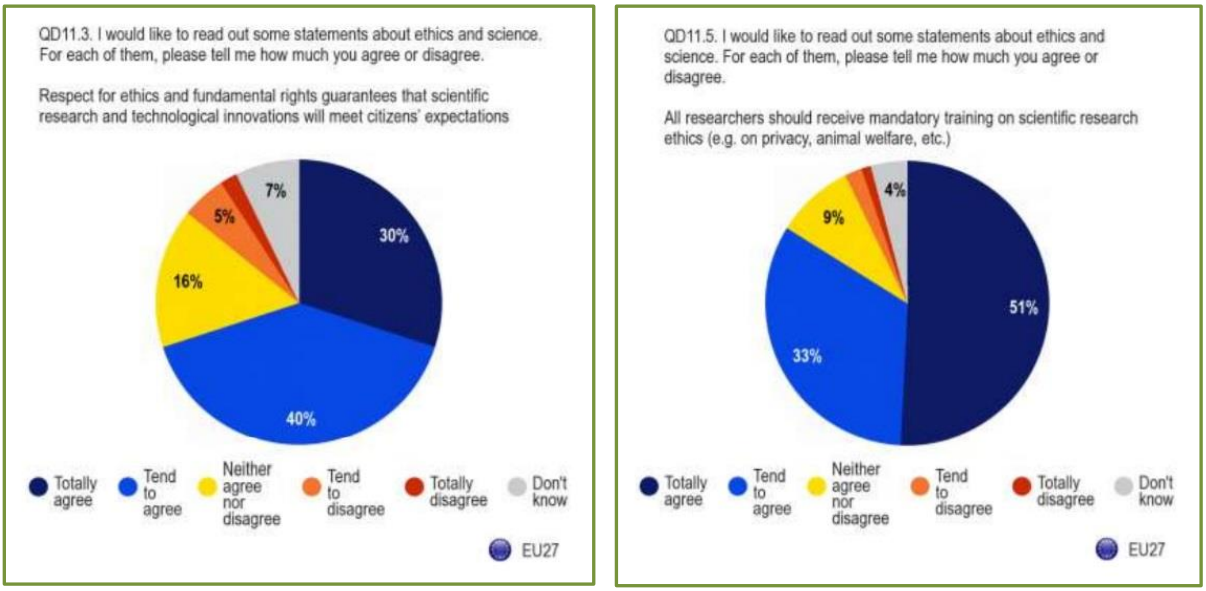
…while another one is also strongly emphasizing the scientific responsibilities in relation to the political nature of research activities:

- **Participant (from a peer group of students and scientists):** *"In my opinion, science has a political responsibility. One cannot isolate and just make his experiments as a scientist. Experiments have always impact on society and the environment. Thus the activity of scientists is certainly a political issue, which is why they must involve society. Science should scatter knowledge and information among the people as widely as possible, be more visible and transparent. For this purpose, a project like CITI-SENSE is a very good approach."*

Participant's comment about studying socio-economic differences in exposure

The European goals regarding "Responsible Research & Innovation" (RRI) emphasize these issues. But also the EU-citizens share this opinion. For the Eurobarometer about RRI, respondents were asked in 2013 whether they agreed or disagreed with the statement that *"respect for ethics and fundamental rights guarantees that scientific research and technological innovations will meet citizens' expectations"*. About 70% of the respondents agreed, while only 7% disagreed. Those EU-citizens who were interested in or felt informed about developments in science and technology were more likely to

agree: 74% of those who were interested in developments in science and technology agree (compared to 64% of those who were not interested). Respondents who thought that the overall influence of science on society was positive, were also more likely to agree (74%) compared to those who think the overall influence is negative (60%). Most EU-citizens also found that that all researchers should receive mandatory ethics training. More than eight in ten (84%) respondents agreed with this statement (of which 51% totally agreed), while just 3% disagreed and 9% were neutral towards the statement (European Commission, 2013c). In conclusion, this means that the ethical aspects should play a very important role in the further development of products such as the CITI-SENSE-tools.



EU-citizens share the opinion that ethics should be guaranteed (European Commission, 2013c)

3.4.2 Credibility and transparency of tool-developers and tool-users

A good example of a discussion about the importance of credibility and transparency in citizen science projects can be found in a very brief but interesting editorial – *"Rise of the citizen scientist"* in Nature (18 August 2015) – in which it was argued that the potential for conflicts of interest might be more troubling than data quality, confidentiality, etc. because *"one reason that some citizen scientists volunteer is to advance their political objectives".* As a solution, this Nature-editorial found full transparency about the motives and ambitions of amateurs to be essential (Anonymous, 2015). This discussion is not only interesting for citizen science projects in general, but also for the CITI-SENSE-project in particular which is explicitly aiming to empower citizens (for instance also by developing tools that might help people to advance their "political" objectives). This issue of transparency and (perceived) potential conflicts of interests might even become a pivotal discussion, as this topic of transparency is also intertwined with many other aspects such as ethics, representativeness and the issue of data manipulation, reliability, strategic value of the tools, public interest in the topic of air quality, etc.

Sometimes, the problematic nature of this discussion about "conflicts of interest" will become clear when it is looked at from the perspectives of public participation, empowerment and governance (see also upcoming sections). And also the readers of this editorial have been making very valuable contributions to the discussion (by sending in their comments). One of the readers indeed commented – with good reason – about the potential risks (e.g. *"let us hope that no citizen scientist will ever decide to modify a plant, insect or another creature using the CRISPR/Cas9 gen drive technology, followed by*

releasing it to the environment" (Gurwitz, 2015)). But most other commenters were much more positive about citizen science – also with good reason.

A small sample of the most relevant comments on the Nature-editorial related to credibility and transparence that are definitely interesting for the analysis of the COs and the CITI-SENSE-tools is summarized below. Some of them will be discussed more thoroughly in the upcoming sections and:

- *"While the concern for transparency is real, it is not unique to citizen science. All scientists and their funding agency have political views, whether they are overt about them or not. Thus, the need for transparency applies to all research (e.g., private industries may also be affected by the research they conduct or fund). One reason citizen science may end up producing some of the most robust science is because it is held to a higher standard than "traditional" science – data quality and transparency are explicitly addressed in experimental design and analysis and more critically evaluated by reviewers."*
  (Sean Ryan commenting on the Nature-editorial, message posted on 20 August 2015).
- *"[…] Because citizen scientists are volunteers, of course they will have motivations to do the work, but that is also the case with professional science. In both cases, if the work is done properly, motivations should not influence data collection and analysis (and most of the time they won't). […]"*
  (Muki Haklay commenting on the Nature-editorial, message posted on 20 August 2015).
- *"A great editorial, but let me challenge the statement: 'More troubling, perhaps, is the potential conflicts of interest. One reason that some citizen scientists volunteer is to advance their political objectives'. What is wrong with that, after all Angel Hsu, Omar Malik, Laura Johnson and Daniel Esty made clear in their paper to Nature (30 March 2014) that they had found that: 'Official data sets are not up to the task. We have found problems with government-reported sources in nearly every global data set that we have used in 15 years of constructing the Environmental Performance Index (EPI) – a biennial ranking of how well countries are implementing policies to address pressing environmental concerns […]'. They further went on to say: 'Government investments in environmental monitoring, data collection and reporting are patchy, and are influenced by limited budgets and political motivations'. They further argue that: 'the data required to track progress towards SDG targets [Sustainable Development Goals] cannot come solely from governments or intergovernmental organizations. UN negotiators must think more creatively about how to measure progress. We argue for channels by which citizen scientists, independent watchdogs, private-sector companies and third-party organizations can contribute data towards monitoring SDG progress and make governments more accountable. Without such independent monitoring, the extent of environmental challenges will not be captured, and SDG-related policies and management decisions risk being ad hoc'. Let us embrace, fund and encourage Citizen Science to provide the quality data sets we need for effective policy making and recognize that the motivation of citizens is no different to many others who collect data to advance their own arguments. What really matters is the scientific rigor behind the data collection methods and an understanding of the limitations of the data set, not the motivation of the participants."*
  (Martin Brocklehurst commenting on the Nature-editorial, message posted on 21 August 2015).
- *"How pompous and fatuous. I'm far more concerned about the ambitions and motives of professional scientists. And journals that focus on publishing supposedly 'hot' research with hyperbolical claims."*
  (Hiro Kawabata commenting on the Nature-editorial, message posted on 25 August 2015).
- *"[…] instead of seeing public engagement with citizen science as an asset – one that channels public concerns into asking targeted questions and obtaining sound scientific evidence – the editorial saw this as cause for concern and conflict of interest. Traditional science also struggles*

with issues related to transparency of motives, conflict of interest, and integrity. Citizen science is not special in this regard, but by singling it out, the Nature editorial casts undeserved doubt upon the integrity of citizen science data. The fact is, statistical testing and good design are already used to identify and minimize bias in citizen science projects."
(Greg Newman commenting on the Nature-editorial, message posted on 15 September 2015).

- *"[…] Most projects view data quality as compliance to scientific protocols (e.g. accuracy of species identification). In this sense, citizen science amounts to asking citizens to fill in blanks in a story written by scientist. This focus on predetermined, and possibly narrow, interests of scientists can bias data collection is ways analogous to the 'conflicts of interests' (among citizens) concern raised in the Nature editorial."*
(Jeffrey Parsons commenting on the Nature-editorial, message posted on 8 October 2015).

Some of the participants expected that projects such as CITI-SENSE would increase the transparency of the decision-making. This was for example indicated in this comment:

- **Participant (from a peer group of students and scientists):** *"Since an initiative like CITI-SENSE is well suited to make decision processes more transparent, it also could be an effective contribution to the general education of the people so they get able to be critical and scrutinize what is presented to them."*

Good example of the need for tranparency

Even under the difficult circumstances in which expectations could not be met, some of the local participants still emphasized their trust in the research partners involved (indicating a high level of credibility and trust). Also in other local Empowerment Initiatives, the role and overall efforts of the research partners – within the CITI-SENSE-project and/or more in general – were clearly appreciated:

- **Participant (authority):** *"It is true that the sensors have not given the expected results. However there were many civil servants from different councils interested [who were] asking about this kind of sensors. We always tell them to ask [Research Institute X] and [Research Institute Y] about these sensors, because they are the ones which work with these sensor and can give advice you about it." […]*
  "I suppose that in a few years we will have sensors that work well and with the features expected. That's why I think that it would be great to continue, to repeat the CITI-SENSE project."
  Interviewer: *"So you think that the CITI-SENSE project has to be repeated, don't you?"*
  Participant: *"Yes, I do. Science is trial and error. We have to wait for the improvement of the technology. […]. I think that [Research Institute X] is the one who has to test these new technologies."*
- **Participant (volunteer):** *"[Research Institute X] was already very helpful. Not connected to this, but I found out that your Research Institute did this study of air pollution in [neighborhood Y] that I mentioned earlier, so I wrote to the library and they actually sent me the whole study. So I have it. It actually even turned out to be available online, I just didn't have the reference number…"*

Participant's comments on the credibility of the tool developers and/or research partners

The users of the CITI-SENSE-tools – which can be local authorities – have to be credible too, as it was argued by one of the participants. This means that authorities should take into account the results and take appropriate action of needed. It is also important to conceal no information. Also authorities acknowledged the importance of credibility and transparency, but they emphasized their own viewpoint on this issue:

- **Participant (from a peer group of students and scientists):** *"Of course, the results collected in a further step must draw appropriate consequences if participants, for example, find that the pollution on a particular site is very high, keep working accordingly. It's all about credibility*
- **Participant (citizen):** *"Steps should be taken to introduce a working application showing the concentration of pollutants online, on a broadest possible scale, in many locations, to inform the public as much as possible, and to conceal nothing."*
- **Participant (member of the authority – transportation sector):** *"[…] our feeling in the office is that we need to improve the way we pass on the information, and the transparency to the public. That is to say, there are a lot of things that are being done, and the public… Even though we update our website, it's not accessible enough, and I would even say that sometimes there is a problem of reliability with the public, that the public thinks that the office hides information, although the entire information is revealed. But if there's a feeling among the public that information is concealed, so, you know, it's very hard convincing that it isn't true."*

Participant's comment on the credibility of the users of the CITI-SENSE-tools

In one of the case studies, the authorities argued that information would be perceived to be more credible (or "valuable") if it is spread by credible research institutions.

- **Participant (authority):** *"For the citizen it is more valuable if the information came from a research institution than if the same information came from the Government."*

Participant's comment on the credibility of the research partners

And in yet another case study, the representative of the local authority argued that a third party would be needed the remove the "blindfolds", and the scientists were seen as this third party:

- **Participant (spokesman for a local authority):** *"Actually, this problem arouses in every process of public participation. In general, there's a gap between the feelings, the empirical data, and the public's knowledge. Since the public's knowledge doesn't exactly correlates with the data, it causes a closed loop of more or less these three parameters. We need to come and prove… If the data show a real difference between the public's feelings and the real results, only a third factor like you, or someone similar, can bridge this gap. If not, people will say 'Only a month ago… even less than a month… it was published that there was a mistake in the lab, that the ministry of environment used the data to…' […] How we say it in [language]: 'We always look for the fifth leg of the cat'. And that's natural. People always think about conspiracies, and it's natural. I don't blame the public. […] If the empirical data solve all this, only a cooperation with a third body can remove the blindfold, or whatever. The gap may be for the better or for the worst, but the information here is not very encouraging. So we can assume that if there's a gap, it will be in favor of the system."*

Authorities' viewpoint regarding the involvement of scientists as a third party

3.4.3 Representativeness and legitimacy of the COs-activities

The topics of representativeness and legitimacy are quite strongly intertwined. In this section, a gradual increase in the importance of representativeness and legitimacy will be described, together with some of the challenges that might occur.

For some of the participants, the (perceived) lack of representativeness of the results seemed to be an relevant issue:

- **Participant (member of the authority – transportation sector):** *"On the other hand, it doesn't really represent the entire population, yeah? But it's great and it seems like it represents a part of the population who's more interested in this. The general feeling is that maybe in [the bay of city X] people are now interested, but in the entire county it's not… Overall, in [country Y] people are not interested enough."*

Interviewers' comment regarding the (perceived) lack of representativeness

The first question that can be raised is if the data from the tools always have to be representative for the whole community, when the information can still be valuable (or representative) for specific target group and/or for people's particular needs (such as asthma patients suffering from pollen).

- **Participant 1 (NGO health):** *"[…] I think that [the CityAir-app] can be a very useful tool. And it's like… [for] pollen as well. We often have our audience to say: 'Today I have started feeling reactions.' And then our researchers go in and check the data and everything, so… I think when you can cross those two, it's perfect to have the user perception as well."*
  Participant 2 (NGO health): *"And the people sometimes experience asthma and pollen symptoms before we actually start to get it in our pollen traps. It's because it's so local, so we won't get to the whole picture. But it's nice that somebody can see it in hands, you know, or feel it."*
- **Participant (NGO health):** *"If we think from our point of view and our targets, it's a useful tool for anyone with respiratory diseases, people with asthma and everything. If they can check the air quality every morning, like where they commute or where they walk to work for example, and choose a different route if the app shows a better air quality in another route. Then that's a perfect tool for anyone who has those problems. So I think that's the main advantage for our targets."*

Interviewers' comment regarding the need of minority groups to be empowered

In the first example above, legitimacy should probably not be a problem, as no one else will be really affected by any action. Other good examples can be thought of for the legitimate use of CITI-SENSE-tools to improve the life of vulnerable target groups on a rather day-by-day basis, such as for instance enabling asthmatic patients to avoid AQ-hotspots (which is different from avoiding pollen alone). But for these types of usage, it was argued earlier that questions might be raised about how empowering this would be (e.g. if people are only enabled to adapt better to fundamentally unfair situations and/or when no alternatives are available). One might argue that this kind of usage of the tools can in fact also be disempowering (e.g. not challenging the status quo) and does not really contribute in favor of the public interest.

Also when the tools are used for purposes such as gently trying to raise awareness or for reminding people about the negative consequences of AQ on health (and thereby trying to change people's behavior and attitudes towards using their car less, towards acceptance of new legislation, etc.), legitimacy and representativeness will probably be no major issue. But representativeness can be important. For instance if you want to raise awareness, you don't want to reach out only to those people who are already convinced that change is needed. Instead, the major challenge is actually that these kind of soft actions might often have limited effect on the wider public and activities probably only have some impact in the long run, so representativeness can be helpful (also because people will probably change behavior more easily when social pressure is higher). Also the use of CITI-SENSE-information for the purpose of negotiation with (local) authorities is a good example of rather "soft" power. Some of the participants indicated that the newly available information (gathered by some of the CITI-SENSE-tools) might be useful for this purposes. Although this is still a clear example of the appropriate, democratic use of power, representativeness will become even more relevant for this purpose. This negotiation might be seen as environmental advocacy (sometimes also with specific

positive or negative connotations) and debates might start to become more complicated as soon as people might be affected in their daily life by proposed new policies or actions.

- **Participant (citizen):** *"Specific information on concentrations of the pollutants could help people to negotiate improvements with the authorities..."*
- **Interviewer:** *"Do you think these kind of tools – like the questionnaires and apps to show air pollution – somehow also help to reduce the air pollution?"*
  Participant 1 (NGO health): *"I think that's up to the government. I don't know, maybe some… […] As you said before, many people who live in [city X] say that they are dependent to use the car to work. They just have to. But if it gets enough media coverage, maybe they will get the attention and see what my car is doing, [and then thinking] 'I could take the bus to prevent pollution.' Maybe in the long run. But I don't think [people of country Y] are like that."*
  Participant 2 (NGO health): *"Well, that's a complicated issue. You can change to electrical cars and everything, so there are a lot of ways to do better. But I don't think the app necessarily – or the questionnaire itself – changes air pollution, but it might change people's attitude towards legislation and laws. So maybe it helps the authorities to imply or to introduce new laws that are stricter in terms of what they can do and what kind of car you can drive."*
  Participant 1: *"Maybe not directly…"*
  Participant 2: *"So I don't think anyone necessarily will sell their car after using the app. The people that are positive to these kinds of things, are already maybe outside walking or biking."*
  Participant 1: *"They are more aware."*
  Participant 2: *"Yes. So I think it doesn't change those things, but it changes the attitude towards new laws, I think, and the way we are restricted."*
  Interviewer: *"So you think more information and creating awareness and reminding people from time to time can make a difference?"*
  Participant 1: *"Yes, it makes it easier to make legislation against air pollution."*
  Interviewer: *"Easier to incorporate laws that are not always easily accepted by the public?"*
  Participant 1: *"Definitely. I think so. […] If we can use the data, it can help us to affect politicians, because their attitude might change. Because they have to. When you have data and facts, they have to accept it."*
- **Participant (citizen):** *"The results [from the Long Perception Questionnaire] and the measurements [with the LEO's] only confirmed the bad state [of air quality] that we have here. I am happy that the results could be presented for the general public and can be used as an argument for making pressure to create new laws and regulations."*

Interviewers' comment regarding the need of minority groups to be empowered

Regarding the issue of advocacy, it is important to realize that NGO's might be discredited when advocating for better air. Often the topics of "legitimacy" and "representativeness" might be used strategically by some of the involved stakeholders who mainly want to use them for (sometimes specious) arguments in order to remain the status quo instead of supporting behavioral or policy changes and concrete action. One of the authorities involves raised questions about the statistical basis of the results you get from the CityAir-app and the subjectivity of people's perceptions (see example below).

- **Participant (authority):** *"The [CityAir-app] I think is not so useful, I would say. At least if it's only for reporting your perception on air quality. There are so many… For the first, if you had many people responding – really, really many – it might be interesting. But if you have only 300 or something, it's not really relevant. You don't have a statistical basis and you don't really know what does the person means by 'bad'. And if it's bad at that point in time there… OK, there might be some local source we don't*

> *know about. And if you only have this perception, it's very difficult to make use of it. Especially if you only focus on air quality."*

Comment from a representative of the authorities about representativeness

A more in-depth analysis of this argument above is needed, as it raises three interesting questions:

- First of all, should authorities really opt for a technocratic "experts-only-mode" in which only scientists and their sensor-data are accepted as relevant sources of information (e.g. because *"you don't really know what a person means by 'bad'…"*)? Or should authorities recognize the local and lay knowledge to be of value too?
- Secondly, it might be questioned if a statistical basis for the CityAir-app is really required. How many people should complain about air pollution before AQ-actions are justified (e.g. is *"only 300 or something"* not enough)? What if there are for instance strongly affected fenceline communities (e.g. those neighborhoods that are immediately adjacent to industrial facilities and that are directly affected) that maybe only exists of about 300 people? Can authorities then just ignore them?
- Finally, it can also be questioned if everything is okay when the perceived problem is very local (e.g. limited to "*it's bad at some point in time there*")?

Neighborhoods immediately adjacent to industrial facilities (also called "fenceline communities") can be strongly affected by local air pollution and might need more empowerment *(www.pixabay.com)*

Comments like these might be used as an argument against taking action, thereby rather unfairly referring to a lack of representativeness (for example in terms of "*really many*" versus "*only 300 or something*") in order to raise unreasonable doubts about legitimacy. We will go into the numbers later, but first it is good to mention that this concern about the use of the representativeness-argument was indeed also raised by some of the participants, for example:

> - **Participant (NGO health):** *"And of course the public or the critics might say – like they always do – that 'You need more traps, you need more sensors.' Like already when you have a warning on air pollution, they always say the sensor is placed at the wrong place."*

Interviewers' comment regarding the critique that measurements are not representative

These kinds of strategic rejections (based on the idea of raising doubts over representativeness) will also lead us to another important question that needs to be answered in order to evaluate the empowerment potential of the CITI-SENSE-tools: how does representativeness actually relate to the specific goal of empowering minority groups or (small) communities nearby AQ-hotspots? Three examples that mirror the sometimes problematic nature of this discussion about representativeness, especially in relation to the goal of empowerment:

1. **The representativeness of a small group of citizen scientists:**
   Taking another look at the editorial "Rise of the citizen scientist" in Nature (18 August 2015), also a clear link with the issue of representativeness could be found. One of the concrete examples given was that of Australian scientist asking how the animals should be managed to people who had volunteered to monitor koala population, in which the scientist found that the citizens had strong views protection that did not reflect broader public opinion (Anonymous, 2015). If there is not really much public interest in the protection of the koala, volunteers for citizens science monitoring of koala populations might quite easily become "biased per definition", and their results might be put aside too easily. So if there is a limited interest in (or awareness of) AQ-problems in society in general, then the opinions of those who are aware of AQ and who are willing (and able) to join a citizen science project might not reflect "the overall lack of opinion" of the majority in society.
2. **The representativeness minority group in society:**
   Similarly to the example above, if there is not much public interest in (or awareness of) the specific AQ-concerns of specific minority groups in society (such as asthma patients), any attempt to address the rights of these target groups might too easily be seen as "biased" and unrepresentative for the whole society. Again, their results might be put aside too easily (whether their claims are correct or not).
3. **The representativeness of referenda about :**
   The same challenges are also seen in referenda about societal decisions regarding the expansion of ring roads in order to solve the problem of traffic jams. Many people make use of these ring roads and will benefit from an increase in the number of driving lanes, but a relative minority of citizens living nearby this ring road will also have to deal with the negative consequences of the potentially increased traffic due to this expansion. In these cases, benefits and burdens can be unevenly distributed. The challenging question is then on what scale the referendum should be held, because a more general lack of interest in air quality amongst the majority of people in the whole society can become an excuse for inaction in particular neighborhoods that are clearly affected by air. The concerns of a relative minority might be put aside too easily (often strategically by calling them "NIMBY"-opinions). The earlier mentioned "fenceline communities" will have to deal with similar challenges.

These three examples indicate that representativeness is not always "relevant" – especially not in terms of empowerment – as very polluted areas might not be representative but definitely need to be solved. Information should be mainly "fit-for-purpose", and not always necessarily representative for the whole community. Although it is always important to think about how the possible burdens of specific solutions for AQ-problems need to be distributed fairly amongst different members of society (see also Delhi-example) and how various sources of air pollutions are treated differently, but nonetheless pecific target groups in society (often also minority groups such as asthma patients) might benefit from a special position in terms of empowerment within policy negotiations, at least when it comes to creating an inclusive society (thereby also questioning the relativeness of these always returning discussions about "representativeness").

- **Interviewer:** *"How would you evaluate the project activities?"*
  Participant (citizen): *"I am very happy that it was realized also in [city X], because it is also near [company Z] and finally it is also included into localities that are highly polluted. I hope that city authorities start to deal with this problem and start find the solution. I am happy we cooperated a lot with the media thanks to the CITI-SENSE project, that is big plus."*
- **Interviewer:** *"Do you think the information from the CityAir-app is useful, or too subjective to be useful?"*
  Participant 1 (NGO health): *"I actually think it's useful. It's very subjective, of course, but still… For our targets, anyone would say: 'Today I have asthma, today I feel worse.' So I think that's useful for other people with the same conditions. At least if they are able to plot in what their starting point is, if you want. If they have asthma, you can say, 'I have asthma, for me it's not good today.'"*
  Participant 2 (NGO health): *"Sort of like a warning for others with the same condition."*
  Interviewer: *"Exactly. So instead of for example... now it's just air quality, but in your case it would be more like: 'I have asthma symptoms. I feel some symptoms here in this place.' And then other people can relate to that. It may be because of air pollution, it might be because of pollen or different reasons. But somehow they can see what places can be worse for them?"*
  Participant 2: *"So you can differentiate what one person is feeling, how they perceive it, and what is actually real. But it's nice for others who have asthma to see that others react in that area."*

Interviewers' comment regarding the need to empower also minority groups

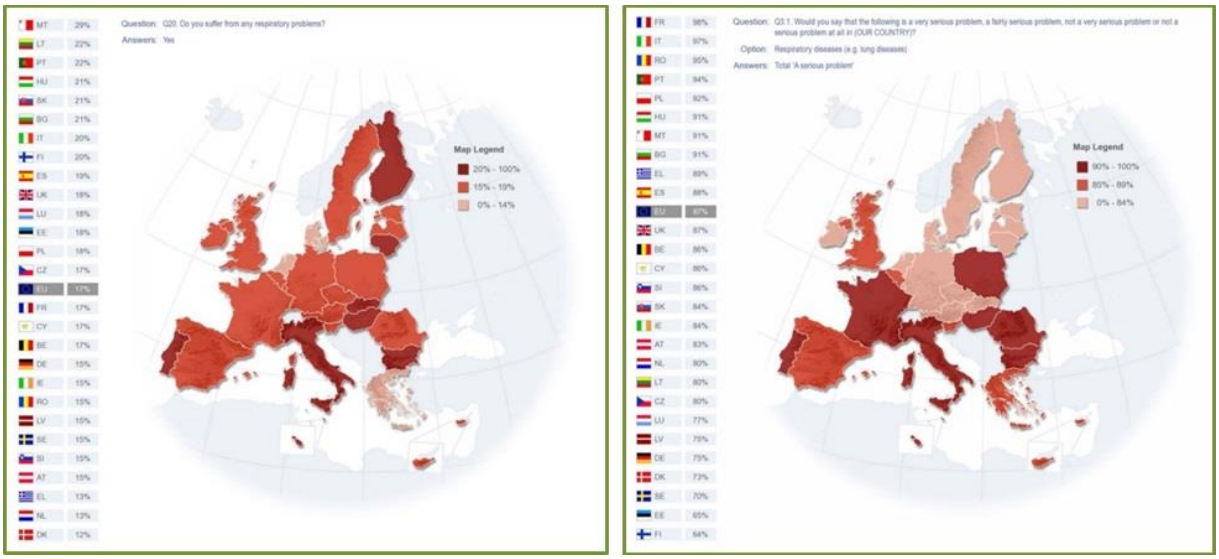
Before we go into some of the numbers, it is relevant to built further on the ealier arguments about representativeness. Therefore, it is also relevant to refer to the fundamental right of living in an clean environment as it was expressed by one of the interviewees.

- **Participant (citizen):** *"The right to live in clean environment should be met. I have this right."*
  Interviewer: *"Yes, this right you have according to the Charter of Fundamental Rights and Freedom."*
  Participant: *"And show me even one day when I can have this conditions. If I do not have this somebody have to solve the problem. Authorities and clerks are not solving these problems. It is complicating their work time."*

Participant's referring to the right to live in a clean environment

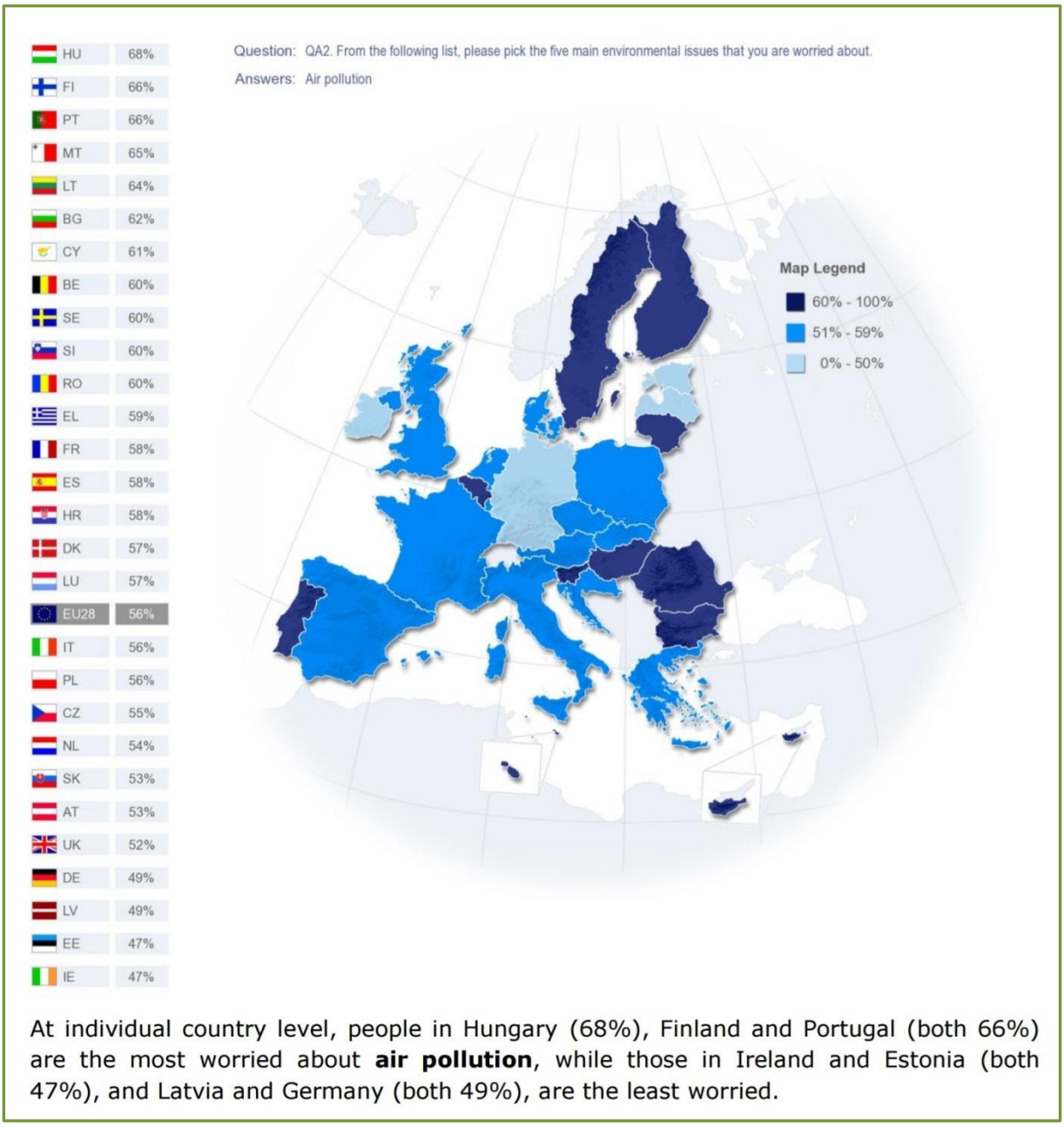
If this right is indeed fundamental – so applicable to all individuals – than representativeness should not be an issue at all (unless it is clear that a claim about unhealthy environmental conditions is really false). But the whole discussion about (the perceived lack of) representativeness and fundamental rights into can also be put into perspective based on the EU-numbers from the Eurobarometers about the topic of air pollution. These numbers are very interesting in the light of the whole discussion about representativeness. About 17% of the EU-citizens indicated that they suffered from respiratory diseases, and 87% of EU-citizens did find these an important problem. Besides that, also 87% of them thought that asthma and allergy are a serious problem, and 92% considered cardiovascular diseases to be a serious problem in their country, all desiseas which are also affected by air quality (European Commission, 2013b). And when the EU-citizens were asked about their environmental concerns as part of the the Eurobarometer-survey, air pollution was the environmental issue that was most worrying to them, with percentages ranging from 68% to 47% (European Commission, 2014a). A more recent Eurobarometer about "Quality of life in European cities" also gives an overview of the opinions about air quality in different EU-cities (EC, 2016):

- In 61 cities, a majority of respondents are satisfied with air quality, and in 20 of these cities the level of satisfaction is at least 80%. Satisfaction is highest in Rostock (94%), Groningen, Bialystok (both 92%) and Zurich (91%).
- At the other end of the scale, at least 50% are dissatisfied in 20 cities. Dissatisfaction with air quality is particularly high in Krakow (83%), Ostrava (76%) and Bucuresti (75%). There are 9 EU capitals among the 20 least satisfied cities.
- Compared with the 2012 survey, large increases in satisfaction with air quality can be seen in Praha (59%, +20), Miskolc (54%, +19), Graz (46%, +17), Ostrava (23%, +17) and Ljubljana (76%, +15). The largest decrease in satisfaction is seen in Greater Paris (27%, -12).
- Respondents in 14 cities see air pollution as one of their three main issues. In five cities, respondents rate it as the most important issue facing their city: Ostrava (76%), Burgas (62%), Krakow (60%), Valletta (54%) and Graz (54%).



Results from the Eurobarometer-survey about air pollution (conducted in 2012):
About 17% of the EU-citizens indicated to suffer from respiratory diseases (left), and 87% of EU-citizens did find these an important problem (right). Besides that, also 87% of them thought that asthma and allergy are a serious problem, and 92% considered cardiovascular diseases to be a serious problem in their country (European Commission, 2013b).

Although EU-citizens who said that protecting the environment was important to them personally are – unsurprisingly – also more likely to say that they are worried about most of the environmental problems (also about air quality in particular), they are definitely not the only ones who are concerned (European Commission, 2014a). And when looking at the problem of indoor air-quality, the Eurobarometer survey of March 2009 found that 84% of EU citizens was in favor of smoke-free offices and other indoor workplaces, 79% was in favor of smoke-free restaurants, and 61% was supporting smoke-free bars and pubs (EC, 2010).



Results from the Eurobarometer-survey about EU-citizens and the environment (conducted in 2014) (part 1): *About 68% to 47% of the citizens in the EU-countries indicated that they were worrying about air pollution (European Commission, 2014a).*

QA2 From the following list, please pick the five main environmental issues that you are worried about. (MAX. 5 ANSWERS)

	Air pollution	Water pollution (seas, rivers, lakes and underground sources)	The growing amount of waste	The impact on our health of chemicals used in everyday products	Depletion of natural resources	Agricultural pollution (use of pesticides, fertilisers, etc.)	Shortage of drinking water	Loss or extinction of species and their habitats and of natural ecosystems (forests, fertile soils)	Our consumption habits	Urban problems (traffic jams, pollution, lack of green spaces, etc.)
EU28	56%	50%	43%	43%	36%	29%	27%	26%	24%	23%
BE	**60%**	48%	42%	42%	39%	28%	31%	27%	27%	28%
BG	**62%**	51%	42%	40%	28%	37%	18%	15%	18%	28%
CZ	55%	44%	**61%**	35%	33%	25%	29%	21%	23%	26%
DK	**57%**	**57%**	41%	53%	40%	30%	45%	29%	30%	24%
DE	49%	**54%**	45%	51%	40%	35%	22%	37%	30%	19%
EE	47%	47%	**52%**	48%	31%	29%	14%	24%	31%	28%
IE	47%	**57%**	53%	44%	28%	24%	31%	19%	18%	27%
EL	59%	**64%**	36%	55%	35%	42%	35%	23%	19%	24%
ES	**58%**	57%	30%	40%	45%	33%	41%	23%	19%	20%
FR	**58%**	52%	41%	51%	47%	35%	33%	29%	28%	19%
HR	**58%**	48%	55%	39%	29%	35%	37%	12%	26%	14%
IT	**56%**	51%	40%	41%	33%	31%	19%	18%	25%	29%
CY	**61%**	58%	34%	58%	31%	36%	55%	23%	19%	28%
LV	49%	**61%**	53%	53%	25%	30%	13%	18%	14%	20%
LT	**64%**	53%	54%	63%	19%	25%	11%	11%	21%	26%
LU	**57%**	56%	41%	42%	40%	26%	35%	23%	24%	22%
HU	**68%**	49%	59%	30%	33%	29%	33%	13%	19%	19%
MT	**65%**	40%	45%	35%	15%	26%	30%	17%	14%	46%
NL	54%	**57%**	32%	48%	52%	23%	29%	38%	41%	25%
AT	**53%**	52%	49%	44%	40%	30%	26%	29%	24%	21%
PL	**56%**	37%	54%	32%	24%	19%	22%	13%	15%	22%
PT	**66%**	51%	48%	26%	36%	22%	48%	14%	15%	14%
RO	**60%**	45%	37%	33%	24%	24%	26%	14%	18%	17%
SI	**60%**	49%	49%	42%	27%	40%	39%	17%	23%	12%
SK	53%	48%	**55%**	41%	30%	23%	47%	19%	20%	20%
FI	66%	**67%**	57%	38%	46%	16%	24%	20%	31%	20%
SE	60%	**64%**	34%	61%	38%	28%	41%	50%	42%	13%
UK	**52%**	39%	48%	34%	29%	19%	18%	30%	16%	31%

Highest percentage per country | *Lowest percentage per country*

Highest percentage per item | Lowest percentage per item

Results from the Eurobarometer-survey about EU-citizens and the environment (conducted in 2014) (part 2): *Table with the % of citizens in the EU-countries that were worried about air pollution (in comparison with other environmental problems such as water pollution, waste, etc.) (European Commission, 2014a).*

QA2 From the following list, please pick the five main environmental issues that you are worried about. (MAX. 5 ANSWERS)

	Air pollution	Water pollution (seas, rivers, lakes and underground sources)	The growing amount of waste	The impact on our health of chemicals used in everyday products	Depletion of natural resources	Agricultural pollution (use of pesticides, fertilisers, etc.)	Shortage of drinking water	Loss or extinction of species and their habitats and of natural ecosystems (forests, fertile soils)	Our consumption habits	Urban problems (traffic jams, pollution, lack of green spaces, etc.)
EU28	56%	50%	43%	43%	36%	29%	27%	26%	24%	23%
Gender										
Man	56%	50%	41%	40%	39%	29%	27%	26%	23%	24%
Woman	55%	51%	46%	45%	34%	29%	27%	26%	25%	22%
Age										
15-24	59%	53%	45%	38%	39%	21%	28%	29%	25%	29%
25-39	57%	49%	43%	43%	39%	25%	29%	28%	26%	24%
40-54	54%	53%	44%	44%	39%	32%	27%	26%	25%	22%
55 +	54%	48%	43%	43%	32%	32%	26%	22%	21%	20%
Education (End of)										
15-	55%	47%	42%	39%	26%	30%	25%	19%	17%	20%
16-19	56%	50%	46%	43%	35%	29%	25%	24%	21%	22%
20+	54%	53%	42%	46%	43%	30%	30%	30%	30%	23%
Still studying	59%	52%	45%	39%	42%	23%	29%	32%	29%	28%
Protecting the environment										
Very important	57%	53%	45%	45%	39%	32%	27%	28%	25%	22%
Fairly important	56%	49%	43%	42%	35%	26%	28%	24%	23%	25%
Total 'Not important'	40%	34%	30%	27%	17%	17%	22%	12%	15%	19%

Results from the Eurobarometer-survey about EU-citizens and the environment (conducted in 2014) (part 3): *The socio-demographic analysis showed that the group of 15-24 year-olds were more likely to feel worried about air pollution (59% vs. 54% of people aged 40 and over. People who say that protecting the environment is important to them personally are, unsurprisingly, more likely to say that they are worried about most of the various environmental problems, also about air quality) (European Commission, 2014a).*

Although the numbers suggest that concrete actions to improve air quality might be needed (for exemple in the EU-cities), some of the participants have been mentioning explicitly the inactivity and even the unwillingness of some of the authorities involved to really deal with the problems, and individual employees or politicians who are willing to deal with the problem might have to be careful when sharing information with the public or they might even be bullied away (see also the section about "ethical considerations mentioned by the participants").

- **Interviewer:** *"What are barriers for you to take AQ improvement action based on this? I can see the inaction of authorities according to your information."*
  Participant (citizen): *"Yes, inactivity… reluctance to complicate their life and work."*
- **Participant (spokesman of the authority):** *"I won't publish it on my website directly, since it will cause me troubles with the municipality. […] I just have to be careful, you know."*
- **Participant (citizen):** *"Also the pediatrician, who engages a lot in air pollution and child health, put big effort into this improvement, […] but people behave[d] very badly to her."*
- **Participant (authority – health sector):** *"Everybody claim that he invest money for dedusting, but the emissions are not lower, and nobody has the political courage to solve it."*

Participants' comment regarding the inactivity of authorities

In another case study, one of the representatives of the involved authorities argued that all possible actions were already implemented (while the local CITI-SENSE-report with the results of the survey indicated that about 63% of the respondents said that air quality was "bad" or "very bad").

- **Interviewer:** "*Can this data contribute in any way to the improvement of air quality?"*
  Participant (member of the authority): *"No, since everything that can be done is already imposed. As you have just seen, the supervision of the factories and their activity is ongoing. This input will not change the [picture]."*
  Interviewer: "*So what is it useful for?"*
  Participant: "*More in the direction of understanding public opinion, how the public [perceives] it, I mean with respect to communication with the public… no, it will not change the actual daily work, I don't see this happening."*

Authorities' comment regarding the implementation of measures to improve air quality

Discrepancies like these – between citizens' call for action and the lack of reponsiveness amongst some of the authorities – indicates that there might be a (strong) need for "harder" and possibly also legal actions (for instance by NGO's or also by individual citizens), which might be justified in order to claim that fundamental right for clean air (or a clean environment in general) – at least if there is indeed a local AQ-problem. It is not possible to discuss all the juridical aspects about AQ-legislation and about taking legal actions here but some more general comments will be made in the section about legal acceptability. When harder action is required, some general recommendations should be taken into consideration in order to get the most out of the AQ-information. First of all, it is beneficial to have results that are as representative as possible (e.g. not too biased) and as necessary (e.g. "fit-for-purpose") especially when harder actions and/or ambitious goals need to be negotiated. Whether the results that could be used for these purposes would come from AQ-measurements (LEOs), from information about AQ-perceptions (CityAir app) or from the Long Perception Questionnaire, if these data would be (too) biased then these results will probably be rejected much more easily. Also participants (including NGOs) have been mentioning the importance of having representative information and/or have addressed existing or potential biases:

- **Participant (NGO health)** about the results of the Long Perception Questionnaire:
  "There are biases depending on how the people commute…"
  Interviewer: *"Yes. A lot of biases… And if people live in the center or around traffic avenues, the air quality is very bad and they can see it through their window, while others living close to the forest don't have the same experience. It is very polarized in [city X]."*

Small sample of participant's comments regarding biases in the results

This issue of the (possible lack of) representativeness of environmental data from authorities in general was also mentioned by a reader of the editorial – *"Rise of the citizen scientist"* in Nature (18 August 2015) (Anonymous, 2015), who wrote in his comment:

> *"A great editorial, but let me challenge the statement: 'More troubling, perhaps, is the potential conflicts of interest. One reason that some citizen scientists volunteer is to advance their political objectives'. What is wrong with that, after all Angel Hsu, Omar Malik, Laura Johnson and Daniel Esty made clear in their paper to Nature (30 March 2014) that they had found that: 'Official data sets are not up to the task. We have found problems with government-reported sources in nearly every global data set that we have used in 15 years of constructing the Environmental Performance Index (EPI) – a biennial ranking of how well countries are implementing policies to address pressing environmental concerns […]'. They further went on to say: 'Government investments in environmental monitoring, data*

collection and reporting are patchy, and are influenced by limited budgets and political motivations'. They further argue that: 'the data required to track progress towards SDG targets [Sustainable Development Goals] cannot come solely from governments or intergovernmental organizations. UN negotiators must think more creatively about how to measure progress. We argue for channels by which citizen scientists, independent watchdogs, private-sector companies and third-party organizations can contribute data towards monitoring SDG progress and make governments more accountable. Without such independent monitoring, the extent of environmental challenges will not be captured, and SDG-related policies and management decisions risk being ad hoc'. Let us embrace, fund and encourage Citizen Science to provide the quality data sets we need for effective policy making and recognize that the motivation of citizens is no different to many others who collect data to advance their own arguments. What really matters is the scientific rigor behind the data collection methods and an understanding of the limitations of the data set, not the motivation of the participants. We need to set up and share common methods for Citizen Science data gathering that run across national boundaries and will provide regional data sets that allow real performance comparisons to be made. Only then will be able to encourage Government to tackle the environmental problems of our era with the energy and robustness that currently is all too lacking."
(Martin Brocklehurst commenting on the Nature-editorial, message posted on 21 August 2015).

Secondly, some participants also discussed the potential risk of "data manipulation", thereby addressing that people with hidden agendas can influence the reliability of the collected data.

- **Participant (volunteer):** *"Even if this improves and everything, you may be met with an argument that these data are not reliable. If very many people start using them, and you have Facebook groups, and they have some agenda, then you can start to say: 'Oh, they are manipulating the data, they are walking along [ring road X]...'*
  So then [others might say]: 'We can't use this data. We have to rely on our monitoring data.' That was maybe too creative?"
  Interviewer: *"No, good point. […] I think it's... data manipulation..."*
- **Participant (scientist within the national authority):** *"So I'm guessing people might have been there on a busy day or it was actually poor air quality and that's what they've thought at the time or again it's just somebody else who is maybe thinking: 'I don't like poor air quality and I'm just going to keep pressing red' [laughs]."*

Example of the misinterpretation of "data manipulation"

Data manipulation – or consciously trying to lead the results into the direction of more extreme biases and then presenting them as the "normal" situation – can work in both ways: environmental activists can try to increase the amount of negative AQ-data (by consciously measuring the most polluted AQ-hotspots with the LEO's or by addressing only their negative AQ-perceptions with the CityAir-app), while other stakeholders who oppose stronger AQ-regulations might also do the opposite (by trying to influence the data so that they look better than reality). In both situations, the overall credibility of the assessment might be flawed. Real data manipulation needs to be avoided as much as possible, but the example in the comment above was based on a faulty idea about data manipulation. Measuring air quality along a particular – heavily polluted – road is definitely not a good example of data manipulation. The AQ-data that are gathered along that road might not be representative for the whole neighborhood or the whole city, but it still is representative for the people living in that street and it has not been manipulated. Only when these particular data would be (consciously) misrepresented as being representative for the whole city while in fact they are only representing a particular street, then it might be called data manipulation. But that would be rather an issue with

transparency (e.g. being dishonest about what is being presented). A good example of data manipulation would be for example holding the AQ-equipment close nearby the exhaust pipe of an idling car and then presenting this information it as a "normal" measurement (done from a more realistic distance from the source of pollution).

Most probably "data manipulation" (left) versus most probably "no data manipulation" (right), depending on the purpose of the measurements and the way the results are presented *(photo's: www.pixabay.com)*

It can also be argued quite easily that the official AQ-measurements can also be "misleading" (as they are often mainly representative for background concentrations and not for air quality as it is inhaled at street level). This was also one of the reasons to start the CITI-SENSE-project: by using novel sensor technologies, CITI-SENSE wanted to investigate the opportunity to monitor air quality at spatial resolutions not possible to reach with traditional monitoring systems.

- **Participant (volunteer):** *"I would wish that [city X] had more fixed monitoring stations. They definitely need them, because when you look at the map, there are areas which are not covered at all that happen to have a lot of traffic."*

Participants' comment about official AQ-measurements that might be "misleading"

These limitations regarding the representativeness of the official measurements (for instance for very local air quality levels or also for particular compounds) was also mentioned by one of the involved representatives of an authority:

- **Participant (volunteer):** *"I would wish that [city X] had more fixed monitoring stations. They definitely need them, because when you look at the map, there are areas which are not covered at all that happen to have a lot of traffic."*
- **Interviewer:** *"Ok, and what is your position regarding the air quality in [city Z]? How would you define air quality in [city Z]?"*
  Participant (member of the authority – transportation sector): *"Hmm… well this is very complicated. Many ask me about it. It's truly complicated. It's not simply saying polluted or clean, it doesn't work that way. First of all, air quality is a local issue. It's possible that there's one neighborhood which is more polluted and another neighborhood which is clean, as some of the public understands. Hmm… And apparently, in some of the neighborhoods in [city Y] the status is worse than in some neighborhoods in [city Z]. It's very location-dependent. We know that the current monitoring stations in [city Z], except for one, which monitors transportation-derived pollution hmm… do not monitor air-pollution, I mean, the air quality meets the standards. It doesn't say that we're monitoring in the right places, it doesn't say that we're monitoring all of the problematic compounds, but we monitor the same things*

> *that we monitor in the rest of the country. We monitor according to the European standards. It means that we didn't invent anything in order to [~~prevent~~: evade] information. There may be additional things that we need to check, but from the things we check now we don't see it [air pollution].”*

Authority commenting about the limitations of their official AQ-monitoring

One participant from an involved NGO mentioned that this way of data gathering by the public (indirectly referring to citizen science) heavily relies on mutual trust. On the other hand, it was also addressed by someone else that there might be more subtle problems with data-quality. For instance people who are not lying, but who – unconsciously – tend to exaggerate their input in the CityAir app (e.g. AQ-perceptions). This can also bias the results, which again can be detrimental for decision-making. The (perceived) subjectivity of the AQ-perceptions might also be another issue. Although the latter two examples have less to do with representativeness, and more with accuracy, reliability and comparability (see also next sections), these effects might lead to a decrease in the perceived legitimacy and could reduce the (social) acceptability of the proposed actions.

- **Participant 1 (NGO health):** *“The problem is… It's very biased, so you can't trust it 100 percent. Someone can be coughing and say it's because of the air pollution, but it's not. But then again, if many people say the same things without knowing that others say it, then it's more trustworthy. But in the app you need to see that others have said the same thing, so you have a problem there. So that's the barrier. You have to trust people, basically. But I don't think people will be lying. I don't think anyone will use the app and just for fun say it's bad while it's not.”*
  Participant 2 (NGO health): *“But people tend to exaggerate. And it's very subjective… what one person feels.”*
- **Participant (scientist within the national authority):** *“It’s easy to say you’ll be truthful, but you’re not always.”*

Example of participants commenting on trust and exaggeration of AQ-perceptions

From the viewpoint of empowerment in particular, representativeness is also really important for other reasons that go beyond the discussions above. Three major questions – directly or indirectly referring to representativeness – need to be answered:

- “Why should actors be involved”? (e.g. do we involve local actors because they have a democratic right to be involved, or because we need their support for the legitimacy of the governance process, or because we need their local knowledge, or because we want to raise their awareness?)
- “Who needs to be empowered most (and who will actually be empowered)?”
- “How to decide democratically about setting (policy) priorities and solving AQ-problems?”

These questions are very relevant for the CITI-SENSE-project. For instance, amongst other goals, the project also aimed to empower more vulnerable groups in society with these new technologies (such as for instance asthma patients, children, the elderly or other individual citizen who are strongly affected by air pollution). But the existence of the “digital divide” can be a challenge. This gap between demographics and/or regions that have access to information and communications technology (ICT), and those that don't or only have restricted access, might lead to a situation of “empowerment of the elite” (e.g. the well-educated, the technology-minded, the young people, the wealthy…). Instead, we mainly want to empower also the most vulnerable target groups that we originally had in mind. In CITI-SENSE-deliverable 5.1 (Lüders et al., 2013), it was emphasized that it was a particular challenges to create inclusive empowerment spaces: *“Political and deliberative offline and online spaces typically engage those who are already politically involved, and there are considerable participatory divides when it comes to citizens who choose to participate in online social spaces, and citizens who take on a*

more passive role as information receivers (Brandtzaeg, 2012; Hargittai & Walejko, 2008). Moreover, there is the risk that discussions take place within homogenous echo-chambers, rather than heterogeneous networks of opinions (Sunstein, 2007)". This challenge was also touched upon by one of the interviewers:

- **Interviewer:** *"In the questionnaires, for example, we were asking about some of your vital data, like gender, education level and age. So we will also collect that information […]. We haven't talked about this, but one of the things that this technology raises, is about who will carry the sensors. Is it going to be more educated people, is this technology for everybody? It's not about being poor or less poor, but about education level."*

Interviewers' comment regarding the "digital divide"

The (local) authorities also have an important democratic role to play here, for instance in supporting projects and trying to involve social groups that might be more difficult to reach. Although the various roles of scientists, citizens and authorities in AQ-policy will be discussed later in this chapter, one relevant remark from one of the interviewees can be mentioned here already (because it is connected the topic of representativeness):

- **Participant (from a peer group of students and scientists):** *"First, governments need to support such projects, by activating larger social groups, which are probably more difficult to reach."*

Participants' comment regarding one of the possible roles of authorities

When it comes to democratically setting priorities and making decisions in order to solve (local) AQ-problems, the (local) authorities also have major responsibilities (e.g. regarding stimulating a fruitful societal debate, providing good conditions for inclusive risk governance and guaranteeing democratic decision-making processes). Renn and Schweitzer (2009) indicated that inclusive governance in relation to decision-making requires the following aspects:

1. Involving representation of all relevant groups or stakeholders;
2. Empowerment of all actors to participate actively and constructively;
3. Co-design of the framing of the risk;
4. Generating a common understanding about the problem framing, solutions and likely consequences;
5. Conducting a forum for decision-making ensuring equal opportunities for all involved to voice their opinions;
6. Establishing a connection between the participatory bodies of decision making and the political implementation level.

Instead of a top down steering and management of society, they can help to organize inclusive social processes based on dialogue – both within and between different stakeholders groups – and based on a broad stakeholder participation in policy- and decision-making. Authorities can also help to avoid that citizens are confronted with (false) dilemma's posed by other stakeholders, such as the choice between jobs or a healthy environment for example, and they can try to negotiate a reasonable way out. But in the end, they will also face similar challenges regarding legitimacy (for example when deciding on new legislation). Often the discussions about representativeness and legitimacy are not always clear and easy. It should be emphasized that citizens cannot be reduced to a homogenous mass of people, but represent divergent opinions, experiences, and competing values and interests (Arnstein, 1969). This adds to the complexity of sound decision-making, and how to mitigate between conflicting interests and points of view:

- Who is going to decide on what is important?

- And who is going to decide what people's most urgent priorities are (or should be)?
- What if people depend on their car to go to work (and might be strongly affected by new legislation)?
- Etc.

Stakeholder participation does not take place in a power vacuum: the empowerment of previously marginalized groups may have unexpected and potentially negative interactions with existing power structures (Kothari, 2001). There are ways in which participation can reinforce existing privileges and group dynamics may discourage minority perspectives from being expressed, creating "dysfunctional consensus" (Cooke, 2001; Nelson and Wright, 1995; Reed, 2008). It is important to think about how to decide democratically about setting (policy) priorities and solving AQ-problems. But even then there might be no "one-size-fits-all"-strategy, because all decision-making strategies will have their advantages and disadvantages.

Citizens cannot be reduced to a homogenous mass of people, but represent divergent opinions, experiences, and competing values and interests *(www.pixabay.com)*

Table 3: Examples of strategies for democratic decision-making and their limitations
"Consensus for action": *It's not always possible to reach consensus, defined by Susskind as "a process of seeking unanimous agreement which involves a good-faith effort to meet the interests of all stakeholders". Consensus has been reached when everyone agrees they can live with whatever is proposed after every effort has been made to meet the interests of all stakeholder parties (Suskind, 1999). Although it is often assumed that the objective of stakeholder dialogue should be to build consensus (Susskind and Field, 1996; Susskind et al., 2003), such an emphasis can suppress diversity of opinion and values, and lead to a focus on general principles (rather than operational decisions) and easily solved but often less important problems (van de Kerkhof, 2006). In this context, Steinman et al. (2002) suggest that rather than seeking consensus, participatory processes should adopt the "shared adversity principle"' in which recognises that trade-offs are inherent to decision-making. This more deliberative approach focuses on communication and argumentation rather than negotiation, exploring the diversity of positions and assumptions held by the participants (Dryzek, 2000; Renn, 2004).*
"Voting for action": *The phrase "tyranny of the majority" is used in discussing an inherent weakness in the system of pure direct democracy and majority rule. Tyranny of the majority involves a scenario in which a majority of an electorate places its own interests above, and at the expense and to the detriment of, those in the minority, where by that detriment constitutes active oppression comparable to that of a tyrant or despot (Mill, 1869).*
"Voting for action with veto-possibility": *The existence of non-negotiable positions in combination with actors who have veto power, can limit the extent to which the process can empower participants to influence decisions. The resulting cynicism can lead to declining levels of engagement and put the credibility at risk (Reed, 2008). Minoritarianism is most often applied disparagingly to processes in which a minority is able to block legislative changes through supermajority threshold requirements. For example, if a 2/3 vote in favor is required to enact a new law, a minority of greater than 1/3 is said to have "minoritarian" powers. Even in the case where minority control is nominally limited to blocking the majority with veto power (whether as a result of a supermajority requirement or a consensus process), this may result in the situation where the minority retains effective control over the group's agenda and the nature of the proposals submitted to the group, as the majority will not propose ideas that they know the minority will veto (Derbyshire, 2002).*
"Strong focus on individual decision-making" (and individual action): *In this strategy, there is always a possible risk for the "tyranny of small decisions", in which a series of small, apparently independent decisions are made, often by individuals or small groups of individuals, which does not produce an optimal, desired, or preferred solution for society (Kahn, 1966; Odum, 1982).*
"Strong focus on top-down decision-making by authorities": *From the viewpoint of empowerment, participation is not appropriate if a decision has already been made or cannot really be influenced by stakeholders. This situation is analogous to Rowe and Frewer (2000) one-way flow of information from decision-makers to stakeholders, or with the lower rungs of Arnstein's (1969) ladder. It is important to ensure that participants have the power to really influence the decision (Chase et al., 2004; Fiorino, 1990; Laird, 1993; Reed, 2008; Tippett et al., 2007).*

Beyond the limitations of particular decision-making strategies that are described above, there are also more subtle mechanisms that can lead to "dysfunctional consensus", in which the credibility of participation can be questioned on the basis that many stakeholders may not have sufficient expertise to meaningfully engage in what are often highly technical debates (e.g. Fischer and Young, 2007). Therefore it is important to ensure that participants have the technical capability to engage effectively with the decision (Richards et al., 2004). Besides these democratic challenges there might also be a more general lack of public interest in society, which can also make it harder to negotiate solutions.

This can be seen as some sort of "dictatorship of the majority" too, as it will make it easier for some stakeholders to argue for remaining the status quo. It has been claimed that participatory processes can become "talking shops" that create ambiguities and delay decisive action (Bojorquez-Tapia et al., 2004; Vedwan et al., 2008).

Also NGOs can play an important role. It is useful to mention the aspect of representation of citizens by these NGOs. When people prefer to be represented in a (political) debate and negotiation by the NGO's that they do support and if these NGOs are indeed democratically advocating the ideas supported by (the majority of) its members, then they can have a legitimate role in the negotiation and they should not be put aside too easily that they are "just another biased organization with a hidden agenda which is not representative for the whole community".

- **Interviewer:** *"I remember some of the questions [asked] if citizens should be involved in the management and decision making regarding air pollution, and only like two percent of the respondents said no. In different ways, but they would like to be involved, and most of them actively. They said that citizens should be actively involved, through forums, participatory networks and so on. Then, when you ask them a little bit about how would you like to be involved, it's like 'OK...' but then they back up. But it's good to know that they would like to have forums. The possibility should be there if they want to attend."*
  Participant (NGO health): *"But that's what organizations like ours do. We represent a certain part of the population. So in a way, many of our members do that through us."*

Participant's comment regarding representation by NGO's

This section will end with showing some clear examples that can be seen as (potential) indications of the illegitimate use of some of the CITI-SENSE-tools. As already mentioned in a previous section about "ethical considerations expressed by participants", AQ-data should be used cautiously in order to avoid negative outcomes (such as disempowerment). Inappropriate use of this new data-source can be seen as illegitimate or misuse of power in a way that does not contribute to the public interest:

- **Participant (from a group of volunteers carrying LEOs):** *"One could also use this information for estimating the property values."*

Clear example of the inappropriate use of the CITI-SENSE-tools

Another example that was also mentioned in the same section about ethics, was about the misbehavior by some stakeholders (e.g. frightening activists). This example is not only a form illegitimate use of power (by other stakeholders who do not share the same opinion as the activists), but it is in fact an illegal action:

- **Participant (citizen):** *"My friends sometimes say that they are worried about me when I am very engaged. I had repeatedly punctured car tires."*

Clear example of illegal actions by some stakeholders

3.4.4 Having a clear mandate

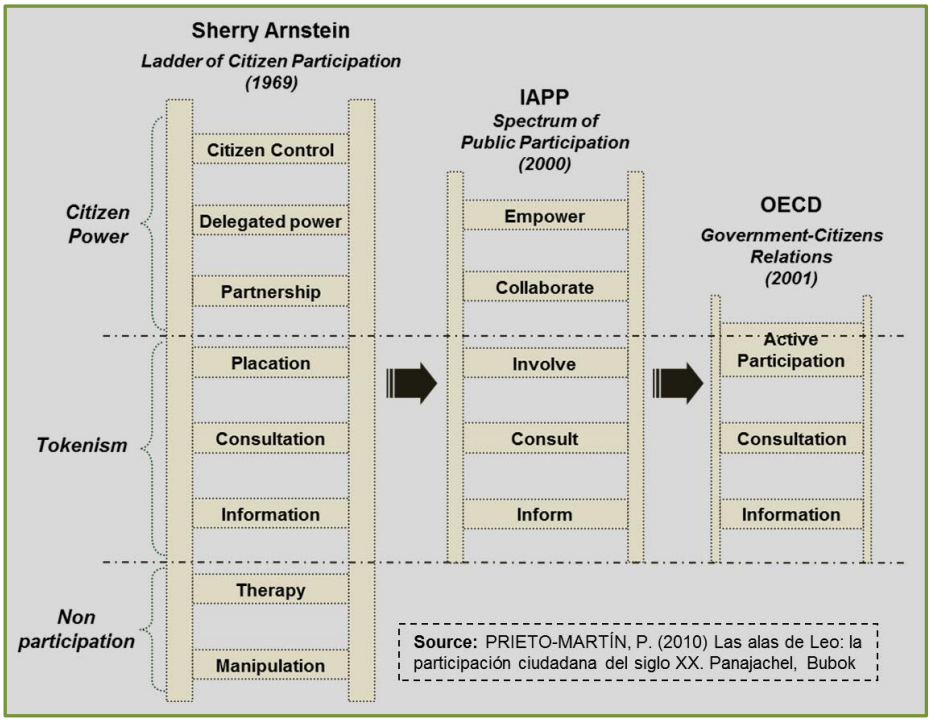
Without genuine empowerment, participation can quickly become a "token exercise" (see also the ladder of participation) or even a means of maintaining power relations. And without meaningful participation, empowerment can remain an empty, unfulfilled promise (Cornwall et al, 2005, Reed, 2008). When the goals of a COs would oppose the interests of the (local) authorities, and for some initiatives this can be problematic. Citizens or scientists might need the authorization to act (for example to install sensors on public infrastructure, to get access to air quality data from the (local)

authorities, etc.). But for others partners this might be more difficult, and they might need to ask for a clear mandate first. This issue can manifest itself in various ways and for different actors:

- Being a tool-developer or a scientist that is working in collaboration with authorities during the project (e.g. to get access to existing data in order to validate the sensors);
- Being an NGO that is working in close cooperation with authorities (e.g. to raise awareness amongst the public about AQ-problems);
- Being an individual volunteer that wants to make use of the public infrastructure (such as for example meeting rooms, etc.) and/or would like to have technical support for an event;
- Authorities will often have a mandate themselves as the end-user of CITI-SENSE-tools (at least to act within their legal responsibilities at local level), but might need a mandate for issues that go beyond these local responsabilities;
- Etc.

Often these authorities will explicitly refuse to cooperate (for example in terms of funding, access to AQ-data from the authorities, etc.). But authorities can also use their power in more subtle ways. Also within an established "partnership" (see Arnsteins' ladder of participation) or within a "collaborative" effort (see the IAPP-spectrum), the status quo can still be reassured by those who have the power to set out the rules for collaboration (Arnstein, 1969; IAP2, 2007; Karsten, 2012; OECD, 2001):

> *"Partnership: At this rung of the ladder, power is in fact redistributed through negotiation between citizens and power holders. They agree to share planning and decision-making responsibilities through such structures as joint policy boards, planning committees and mechanisms for resolving impasses. After the ground rules have been established through some form of give-and-take, they are not subject to unilateral change"* (Arnstein, 1969).



Comparison of 3 models of citizen participation:

Prieto-Martín draws on the "Ladder of Citizen Participation" by Arnstein[(1)], the Spectrum of Public Participation by IAPP and the OECD's "Active Participation Framework". Interestingly, the graphical comparison shows that the active participation framework developed and promoted by the OECD hardly goes beyond the levels of tokenism identified by Arnstein. In other words, the OECD model completely ignores, in Martín's view, any kind

of citizen control and thus rejects any transfer of power from representative organs to citizens. Martín argues that to ignore the question of power is a key reason for the "vicious circle of participation" – that a lot of money is spent on participation without much impact or change resulting from it. Martín's comparison underlines how crucial it is to meaningful participation to accept and plan for the transfer of power and control (Prieto-Martín, 2010 – based on Arnstein, 1969; IAP2, 2007; OECD, 2001 – in Karsten, 2012).

(1) The "Ladder of Arnstein" explained (Arnstein, 1969): The bottom rungs are (1) Manipulation and (2) Therapy. These two rungs describe levels of "non-participation" that have been contrived by some to substitute for genuine participation. Their real objective is not to enable people to participate in planning or conducting programs, but to enable powerholders to "educate" or "cure" the participants.
Rungs 3 and 4 progress to levels of "tokenism" that allow the have-nots to hear and to have a voice: (3) Informing and (4) Consultation. When they are proffered by powerholders as the total extent of participation, citizens may indeed hear and be heard. But under these conditions they lack the power to insure that their views will be heeded by the powerful. When participation is restricted to these levels, there is no follow-through, no "muscle", hence no assurance of changing the status quo. Rung 5, Placation, is simply a higher level tokenism because the ground rules allow have-nots to advise, but retain for the powerholders the continued right to decide.
Further up the ladder are levels of citizen power with increasing degrees of decision-making clout. Citizens can enter into a (6) Partnership that enables them to negotiate and engage in trade-offs with traditional power holders. At the topmost rungs, (7) Delegated Power and (8) Citizen Control, have-not citizens obtain the majority of decision-making seats, or full managerial power.
Obviously, the eight-rung ladder is a simplification, but it helps to illustrate the point that so many have missed - that there are significant gradations of citizen participation. Knowing these gradations makes it possible to cut through the hyperbole to understand the increasingly strident demands for participation from the have-nots as well as the gamut of confusing responses from the powerholders.

In other words, tokenism can still be (partially) reintroduced in what seems to be higher levels of participation. Arnstein's descriptions of the different rungs in the ladder of participation also indicate this, when he states that in the lower rungs of the ladder (informing, consultation and placation), "*there is no follow-through – no 'muscle' – hence no assurance of changing the status quo"*. What may be called a partnership or a collaboration by some actors, might in fact still be a rather hidden form of "placation" (rung 5) in which *"the ground rules mainly allow have-nots to advise, but retain for the power holders the continued right to decide"* (Arnstein, 1969). When the ground rules (and structures) for the partnership are to be established through some form of give-and-take between involved partners, power will often only be redistributed to a degree that is still acceptable for the power holders (e.g. the given "muscle" might be rather weak).

Also within the context of CITI-SENSE, this might have important repercussions. For example, as long as scientists (or COs) depend on having access to the data of (local) authorities in order to be able to validate their own measurements made with the (mobile) sensors (e.g. tools that currently still need to be tested), then they might stay in a position that allow these authorities to restrict the distribution of power during these negotiations. Similar situations might occur when permission is needed to place (additional) static sensors on the public space. The unwillingness to cooperate might be a problem. During the user-evaluation, it was mentioned for instance that:

- **Interviewer:** *"Based on the usage of the LEO, what do you consider as obstacles for you to improve air quality?"*
  Participant (citizen): *"What can a citizen do against 'force majeure' sort of obstacles of state authorities...?"*

Example of how the "muscles" of authorities might be strong…

Arnstein emphasized that participation without real redistribution of power is an empty and frustrating process for the powerless, because it allows the power holders to claim that all sides were considered while they make it possible for only some of those sides to benefit. This maintains the status quo (Arnstein, 1969). Again this might lead to feelings of disempowerment. Empowerment and

participation are deeply complementary and can be considered both means and ends, processes and outcomes. Most would also agree that meaningful empowerment and participation require significant changes in power relations, both at the level of agency and structure. But the nature of power is to reassert itself. The power relations that drive inequality and exclusion do not yield easily, and efforts to challenge them can be quickly "hollowed out", co-opted or rendered tokenistic. Structures run deep, are harder to see and address than agency, and structures to not yield easily to interventions (Pettit, 2012). Decision-makers often also refuse to meet with community groups (Ryder et al, 2006). And Ottinger (2010) mentions that *"where community groups have organized themselves against neighboring facilities, their pollution- and health-related grievances are typically compounded by frustration with industry representatives' treatment of residents"*. Also within CITI-SENSE, people were not always taken seriously by the representatives of a polluting company:

- **Interviewer:** *"You will see those pictures today, of black smoke coming out of chimneys, but also from the ground at the bottom layer of the atmosphere. In these companies, such condition is frequent. They wrote me that this was an exceptional situation... but it is interesting that every time I come here, it is an exceptional situation!"*

Example of how the "muscles" of authorities might be strong…

3.4.5 Allocation of new responsibilities

The overall aims of the CITI-SENSE-project – both those regarding to citizen science and to the increase in empowerment – can lead to an allocation of (new) responsibilities. Also in citizen science projects for instance, tasks can be allocated from scientists to citizens. And empowerment can lead to an allocation of responsibilities from (local) authorities to citizens.

Regarding citizen science, the importance of trust was mentioned in various ways during the user evaluation. First of all scientists (and authorities involved) should trust citizens more (for example when sharing data).

- **Participant (other researcher):** *"There is a contradiction between the aim of the project and the way of sharing the data. It was shared very restrictively. You should try to trust [people] more."*
- **Participant 1 (NGO health):** *"You have to trust people, basically. But I don't think people will be lying. I don't think anyone will use the app and just for fun say it's bad while it's not."*

Participants' comment regarding trust in citizens (involved in citizen science)

Also the (desirability) of the allocation of some of the governmental tasks in the direction of citizens was addressed during the interviews. Again mutual trust was a topic of concern (see example below).

- **Interviewer:** *"Yes, but do you think there's a difference between... because the LEO allows also for other things but only monitoring in more places: it allows regular citizens to monitor, not only the authorities. Do you think that also makes a difference? If you could trust that the device is working, will it make you feel more comfortable, being able to do your own measurements, or do you prefer third parties?"*
  Participant 1 (volunteer): *"I like to have an option to actually verify the data provided by my public authorities, because although I'm [nationality X] I don't actually trust my public authorities that much [laughter]."*
  Participant 2 (volunteer): *"I think I'm a bit different there. I'd like to have more municipalities to have monitoring stations."*

> **Participant 1:** *"I agree, absolutely. But it's... What I'm saying is only that I think it's a positive addition to have citizens being able to double-check the data."*

Participants' comment regarding trust in authorities

There is also another risk related to problem-solving that was addressed by the participants. Especially when there is a strong focus on "empowerment as freedom to choose", there might be situations in which polluters and/or local authorities will try push away their (complicated) tasks and responsibilities to the level of individual citizens who will have to help themselves. In that case individuals will have to make their own balanced judgments based on this new AQ-information, making individual choices in order to avoid suffering from unhealthy situations. Take for instance this interesting conversation that took place one of the focus groups with a group of participants from an NGO (in which both the benefits but also important disadvantages are mentioned):

- **Interviewer:** *"So then they can plan a little bit with what is more helpful for them. […] Are you meaning for example that they just take the map, or like for example that you can get advices like: 'Oh, it would be nice to go from A to B. Instead of the usual, you can just walk these other streets that are less polluted'."*
  Participant 1 (NGO health): *"Yes. For example, you can cross the park instead of going around that corner. The problem is if you include something like that, that's a solution that day for someone with a disease, but it's not a solution to help [improve] air quality. So I'm afraid the authorities might just say: 'OK, then you have the tool to avoid the pollution', you know. So it's helpful for those who need to do something like that [people with respiratory diseases avoiding], but it shouldn't be a solution for the authorities. So that's a very important difference. It would be perfect for someone with a respiratory problem, […] to avoid one particular road or one particular area of the city if they can."*

Participant's comment about authorities pushing away their responsibilities

An important new element in this comment is that some of the CITI-SENSE-tools might also give authorities the possibility to stay inactive (and thereby reinforcing the status quo for some of the major stakeholders that strongly contribute to air pollution). This potential inactivity from authorities – as it is already perceived now – has been addressed in various ways by other participants too.

- **Participant (citizen):** *"The right to live in clean environment should be met. I have this right."*
  Interviewer: *"Yes, this right you have according to the Charter of Fundamental Rights and Freedom."*
  Participant: *"And show me even one day when I can have this conditions. If I do not have this somebody have to solve the problem. Authorities and clerks are not solving these problems. It is complicating their work time."*
- **Participant (citizen):** *"Also the pediatrician, who engages a lot in air pollution and child health, put big effort into this improvement, […] but people behave[d] very badly to her."*
- **Interviewer: "***About the limitations of the LEO - what can it not help you do better?"*
  Participant: *[…] "It can't help me to get people to elect politicians who actually take air pollution and environmental protection seriously."*
- **Interviewer:** *"Have you learned anything new during the project?"*
  Participant (citizen): *"I have been fighting like this for 10 years. So it was rather a confirmation of my information."*

Small sample of participant's comments about authorities inactivity

Allocations should not be seen as an excuse for (local) governments to withdraw themselves entirely from taking action (e.g. leaving it all up to the citizen who is now supposed to be empowered). Is it was argued before, this might bring important risks when stakes are high.

- **Participant (citizen):** *"My friends sometimes say that they are worried about me when I am very engaged. I had repeatedly punctured car tires."*

Participant's comment regarding personal safety when being an activist

3.4.6 Socio-cultural aspects which can influence social acceptability

In of the Empowerment Initiatives (EIs), socio-cultural differences might have had an influence on social acceptability of the COs and/or specific CITI-SENSE-tools in particular. For instance the specifi needs of specific vulnerable groups – and the urgency – can increase the acceptability of the CITI-SENSE-tools. People who suffer from respiratory diseases or who have children that suffer from these kinds of diseases might be more tolerant to some of the remaining problems with the tools (e.g. privacy issues or other ethical concerns mentioned earlier in this chapter). When they are in need of solutions, they might accept more easily some of the possible pitfalls that come with the tools (in general of also because their current stage of development). This means that, although some of the tools might be actually disempowering (because they only help people to adapt better to a fundamentally unfair situation), they still can be relatively useful to patients (e.g. as a second best option as long as better solutions have not yet been implemented). Some of the participants – or their children – also belonged to these vulnerable groups, or they were working for an NGO that represented these groups, have mentioned functionalities that might be seen as disempowering too (although these functions can also help them to some degree).

- **Participant 1 (NGO health):** *"If we think from our point of view and our targets, it's a useful tool for anyone with respiratory diseases, people with asthma and everything. If they can check the air quality every morning, like where they commute or where they walk to work for example, and choose a different route if the app shows a better air quality in another route. Then that's a perfect tool for anyone who have those problems. So I think that's the main advantage for our targets."*
  Participant 2 (NGO health): *"To prepare them before they go out to the kindergarten."*
  Participant 1: *"Or simply avoid going out, basically."*
  Participant 2: *"Yes, if they need to. And I think it also would be helpful and easier to give maybe their boss or managers a notification about why they have to stay at home that day. Then you can show it on the app that it is not safe for me to go out due to my condition."*

Participants' comment about the economic consequences of proposed solutions

Regarding the socio-economic aspects, people who are financially weaker might have more problems with the potential negative consequences, for instance because of AQ-data that might affect housing prices. Besides that, they might also be more critical about the proposed solutions (e.g. who has to benefit from policy investments). In a more general way – regardless the financial situation of the interviewees – the topic of economic consequences and/or other economic concerns were only raised a few times (see also chapter 3.4.8: political and economic acceptability).

Also cultural preferences might have an influence, but within the user-evaluation there weren't found any explicit indications of that. Also demographic factors and personal interest in the topic or the technology can be related to specific preferences (of the various subcultures involved). There have been found some differences regarding the attitude of the participants regarding the tools for instance (e.g. related to their age), although these effects might have most probably been flattened out

somewhat – during the selection process – by the fact that mainly people who were interested in the topics and the technologies have been joining (which might have influenced their available skills, willingness-to-learn, etc.).

3.4.7 Legal acceptability

The local Empowerment Initiatives (EIs) within the CITI-SENSE-project have explicitly chosen not to challenge authorities with the AQ-measurements. There were many different reasons for this. On the one hand, there more pragmatic ones (such a lack of data quality, the need to have access to local AQ-data for validation to improve the sensors and the need to keep authorities engaged in the process in order to be able to do this research about empowerment and citizen-authority-interaction). On the other hand, there can also be thought of more fundamental ones (for instance reasons based on debates about the possible roles of science in these kinds of projects or on the recognition that it will not always be possible to find easy solutions, thereby for instance taking into account the challenges regarding inclusive risk governance). Nonetheless, from the viewpoint of empowerment it is necessary to investigate the possibilities of challenging authorities with the CITI-SENSE-tools, also because this possibility has been recognized by many of the participants. As mentioned earlier, one of the participants also referred explicitly to the fundamental right of living in an clean environment:

- **Participant (citizen):** *"The right to live in clean environment should be met. I have this right."*
  Interviewer: *"Yes, this right you have according to the Charter of Fundamental Rights and Freedom."*
  Participant: *"And show me even one day when I can have this conditions. If I do not have this somebody have to solve the problem. Authorities and clerks are not solving these problems. It is complicating their work time."*

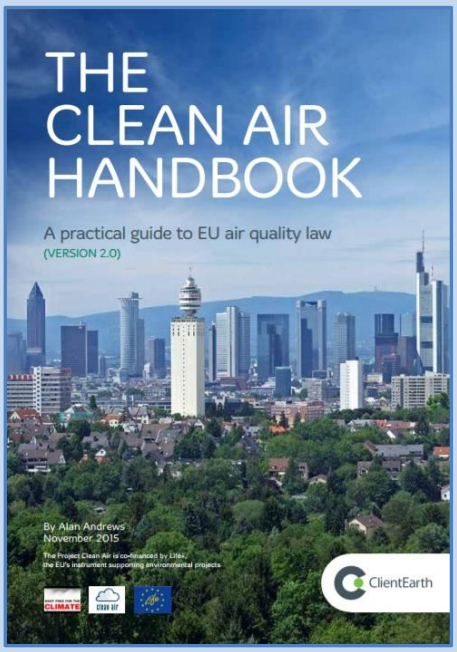
Participant's referring to the right to live in a clean environment

Other participants mentioned that the AQ-data (from the LEO's) might be useful for these purpose of challenging the authorities, at least if the sensors are improved in the future (see also the section about "functionalities of the CITI-SENSE-tools"). Other participants that were interviewed also said that they were already involved in (advocating) legal actions (such as changing traffic laws, etc.) and one of the interviewers mentioned that their country was involved at that time in a law case for European Court. Some of the new information – such as the results from the Long Perception Questionnaire – was expected to be useful when developing new documents for local environmental advocacy and negotiation with (local) policy-makers.

- **Participant (NGO health):** *"We do work against the politicians, in terms of legal problems and political problems. Changing the laws in traffic. Right now we are working on reducing traffic on days where it's high on pollution, but on permanent basis. So there are now hearings on the legislations of new laws, so in those kinds of documents we send over to the politicians, these data could be incorporated, I think. We could show how people feel the air pollution and refer to that in our report. So it's very useful."*
- **Interviewer:** *"[Our country] is now in the courts... the Asthma and Allergy Association of our country took it to the courts because of the exceedances of NO_2 levels... or nitrogen dioxide levels."*
  Participant (volunteer): *"Interesting."*
  Interviewer: *"So now the authorities are developing more plans to make sure they comply with everything, so there are more and more plans. […] But it is really difficult to get down the nitrogen dioxide. They are taking a lot of actions. So now they are a little bit unpopular."*
  Participant: *"Sorry again for the distraction, but was that tried in the [national] court or the European court?"*
  Interviewer: *"It's a European court."*

Example of the use of the CITI-SENSE-tools for legal action

But in a case of legal action, the earlier debate about representativeness and legitimacy will become much more complicated and some tough or tricky discussions might arise soon (as we will see in the examples below). Although it is not possible to discuss all the juridical aspects about AQ-legislation and about taking legal actions here and because we would like to focus on the social debate about representativeness and legitimacy, it is still definitely useful to refer to the online available *"The Clean Air Handbook - A practical guide to EU air quality law. Version 2.0"* which has been developed by Alan Andrews as a part of the "Life+"-project "Clean Air Europe" (funded by the EU).



The Clean Air Handbook (version 2.0):

This handbook *"provides individuals, groups and lawyers with a straightforward, easy to use guide to EU air quality law. Whether you are a concerned citizen trying to find out what levels of pollution are like in your neighborhood, an experienced nongovernmental organization (NGO) campaigner trying to influence an air quality plan for a heavily polluted city, or a lawyer trying to bring a case concerning air quality, this guide will give an overview of the relevant aspects of EU law, together with some practical tips on how they can be used effectively"* (Andrews, 2015). The handbook gives an overview of current possibilities for legal actions. On the other hand, limitations or pitfalls of these legal possibilities are explained, thereby uncovering the reality behind "the right to clean air" and indicating that it will not always be easy to be fully empowered if no voluntary action is undertaken to solve a problem regarding (local) air quality.

The Clean Air Handbook summarizes relevant information for legal AQ-action

Sometimes legal action might be required… the scales of Lady Justice must be balanced somehow *(www.pixabay.com)*

Particular challenges regarding legal action, representativeness, legitimacy and also the possible (negative) consequences have been discussed in the literature. One very interesting example is that of a law suit in Delhi (see intermezzo below). This example is also a perfect bridge towards the next aspect that will be discussed: the economic acceptability.

Intermezzo: "AQ law suit in India… pros and cons"

A related question over whose space and whose air the city is deemed to encompass was raised starkly in the case of Delhi in the late 1990s. With the support of many in the middle class, a pioneering lawyer managed to persuade the Supreme Court of India to issue directives that led to the closing of numerous industrial outfits in Delhi in the name of the public good for the city. But the action stirred heated controversy because the closures impacted many urban lower-class industrial workers. In their review of this case, Amita Baviskar, Subir Sinha and Kavita Philip raise a serious of questions about the framing of the issue:

> *"The pursuit of the 'public interest' deprived a large section of Delhi's working class of their means of subsistence. Environmental benefits – clean air and water – were obtained at the cost of losing working environments, resources that sustained some of the most vulnerable citizens of Delhi. How did the middle class succeed in presenting health and hazard, beauty and order as environmental concerns that superseded the welfare of Delhi's working class? Why were the environmental priorities of workers – jobs, food and shelter – overlooked? Why were workers not represented in the decision-making process that led to the factory closings? Why was action routed through the judiciary when the Indian government has an extensive administrative setup for monitoring and regulating pollution? Was the closure of the factories the most effective way of improving air quality?" (Baviskar et al, 2006).*

The argument used by the campaigners against the closures was that the middle-class groups were pursuing their own objectives under the guise of the public interest. The campaigners felt that the latter groups' position was blinkered, as indicated by the fact that the middle class was uninterested in curbing traffic – a source of air pollution that it was very happy to tolerate. The middle class seemed to want to achieve a cleaner city by targeting only forms of air pollution that did not impact on its own lifestyles and direct economic interests. The case was further complicate because it seemed that many of the legal directives were rather blunt in their consequences, leading to the closure not only of grossly polluting plants but also installations that fell within the same legal classification as polluting ones but that were in practice comparatively innocuous. In this way, numerous relatively nonpolluting working-class jobs were lost while wealthier people's lives were left unaffected.

Source: "Governing Air Quality. The dynamics of science, policy and citizen interaction" (Lidskog et al, 2011).

3.4.8 Political and economic acceptability

One important aspect of the economic acceptability is that of the "accessibility" of the CITI-SENSE-tools. The main questions here is that of the cost for individuals in order to purchase and use to the tools, which can be seen both as an aspect of economic acceptability and potentially an ethical aspect

too (inclusiveness). Some of the participants commented about what should be a maximum prize for these kind of devices, and also the idea that companies could rent them out to people was proposed (which might give more people access to these tools):

- **Participant (volunteer carrying the LEOs):** *"The device should cost between €50-100. Max anyone is ready to pay is €200."*
- **Participant (volunteer carrying the LEOs):** *"Companies or research institutes could rent out these devices to people."*

Participants commenting on the cost for the end-user

Regarding the economic acceptability, it is also important to emphasize that people who are financially weaker might have more problems with the possible negative consequences, for instance because of AQ-data that might affect housing prices (see also chapter 3.4.1). They might also be more critical about the proposed solutions (e.g. who has to benefit from policy investments). As the example of the lawsuit in India made clear (see intermezzo on the previous page), this might be a real concern. But also the use of taxpayers' money to solve AQ-problems was questioned.

- **Participant (citizen):** *"Yes, in [city X] and [city Y] the mayor is better now. They are pushing [company X]. This company claimed that they have already the new technologies and when there were the EU money, suddenly they bought new filters (10% paid by the company and 90% from EU money). Why do these private companies, who earn billions, do not invest and then taxpayers should pay the filters for them? It is money from working people!"*
- **Participant:** *"When the entrepreneurs receive subsidies from the EU, officials should push them to go far beyond the common BAT (Best Available Techniques). It is not logical that one entrepreneur must adhere to these technologies without subsidies and the second one gets the subsidy. Something here is not right."*

Participants' comment about the economic consequences investing taxpayers money

In a more general way – that is regardless the specific financial situation of the interviewees – the topic of economic consequences and/or other economic concerns were raised a few times in other ways, also in relation to possible policies to decease air pollution. One of the examples is that of the policy towards stimulating the purchase of electric cars. This indicates that investments from authorities should take into consideration the socio-economic aspects of these policies too.

- **Participant 1 (volunteer):** *"Free electric cars for everybody (laughter)."*
  Participant 2 (volunteer): *"Except the people who can actually afford them."*

Participants' comment about the economic consequences of subsidy-policies

For this reason, it is important to repeat our earlier recommendation that – when possible solutions or potential actions would be proposed to the end-users as a form of output from a particular CITI-SENSE-tool or the process in general – the (overall) acceptance of these solutions should be evaluated in a similar way (in order to avoid undesired outcomes). This evaluation of proposed solutions should also take into account social acceptability (e.g. "social justice", legislation, etc.), including political acceptability and economical acceptability (e.g. cost-efficiency, financial investment, time-investment, socio-economic aspects, etc.).

Finally, also the economic acceptability of the project was (partially mentioned). When the cost and the cost efficiency have to be evaluated, many aspects need to be considered (including the costs for the maintenance of the whole system). But one of the participants questioned the cost efficiency of

this project, especially when related to the perceived lack of continuity. He/she also doubted if there would be an economic benefit at the end of the project:

- **Participant (other researcher):** *"Now, considering the whole European project: how can it be possible that after investing so much effort and money in setting up all the sensors, once the batteries are empty the whole deployment is dismantled? I found it absurd."*
  Interviewer: *"But you have to take into account not only the batteries, but also the costs of the maintenance of the server, SIM cards, the replacement of the broken parts… So, do you have the feeling that it was useless?"*
  Participant: *"Yes, I have the feeling that it won't continue, because there is not an economic benefit at the end of the project. It is not logical for me. For example, a company wouldn't act that way. Once it's all settled, it's to stay for long."*

Participant doubting the overall efficiency of the project (in relation with the continuity)

There were also more critical user-evaluations regarding the Environmental Monitoring Toolkit for Public Places (or SENSE-IT-NOW-app) in terms of cost/benefits-ratios:

- **Interviewer:** *"To what extent is this product useful to you?"*
  Participant (scientist within the national authority): *"Broadly speaking, it is an interesting experience, but what you have done involves a lot of work and your conclusions and findings aren´t very surprising. Obviously people perceive that green areas are conformable and roads uncomfortable. We know that. When you have the opportunity to assess different spaces where a combination of elements happens, maybe CITI-SENSE is more interesting. But I´m sceptic about CITI-SENSE. […] All the contributions are good, but you have to look into the cost-benefits to develop a public participation process. […] With usual workshops we can have the same findings, or even better ones. CITI-SENSE makes a public participation process expensive."*

Indicative example of a comment about the added value of the CITI-SENSE-webportal

Overall, arguments related to economic acceptability where not raised very often during the user-evaluation of the empowerment potential of the CITI-SENSE-tools, also because it was not explicitly asked for (but mainly indirectly in terms of possible barriers). We only rely on a few statements that were mentioned by the participants. To put these statements into perspective, we can compare the comments with the Eurobarometer of 2014 about EU-citizens' attitudes towards the environment. People were asked if public authorities should favor environmentally-friendly considerations over cost considerations when they are spending or investing money in environmental problems in general (not particularly in air pollution). About 59% of the people thought that public authorities should favor environmentally-friendly considerations over cost considerations, while only 21% would put cost considerations first and 13% of the people said spontaneously that neither should be given special priority (European Commission, 2014a).

One of the participants in CITI-SENSE also mentioned that jobs and clean air can go together, but that people often don't realize it. Others participants recognized that people indeed have fear of losing their jobs, which makes that they are not supportive to take any major actions to solve AQ-problems.

- **Participant:** *"Still there is concern about employment or social issues. Wrong assessment of information and fear of new things, fear of the unknown! People do not realize the link between clean air and jobs. They do not understand that when a big polluter does not pollute, there will be more work. that we all will be better off."*
- **Participant (representative from the authority – health sector):** *"There is no political will, because the change will affect the economy. It is why only small part of the*

population support the air quality improvement, the bigger part of [city Y] do not support this topic because they are affraid of loosing their jobs.
Interviewer: *"If the comanies used the new possible technology, everything would be better."*
Participant: *This is for sure. But [company Z] claimed that it is not possible to do it quickly. If they will be pushed to big investing they will close the factory and people will lose their jobs.*
Interviewer: *"Authorities have the power to push them to use the new modern technology."*
Participant: *"But the authorities do not want to push becasue do not have the support from the citizens. People want their jobs. It is more important for them than air quality. […] The state of air pollution is same more than 10 years and do not improve. The improvement in the 90s were not about new technologies but about industrial restructuring. Many factories disappeared of changed their operation. I am pessimistic."*

Participants commenting about the corruption and people's fear of losing jobs

However, there was also a strong consensus amongst EU-citizens that big companies (77%), national governments (70%) and individual citizens (65%) were not doing enough to protect the environment (European Commission, 2014a), which makes it also an issue of political acceptability (European Commission, 2014a). There might be many explanations (see also earlier ethical discussions), but one of the problems that was mentioned by a participant was that of corruption, which again makes it not only an economic and political issue, but also an ethical one.

- **Interviewer:** *"What measures should be taken for others to improve the air quality?"*
  Participant (citizen): *"A little pressure on the State Administration to change the conditions and to create a system that would improve the situation. Industry, with [its] great power, is not interested in improving the air quality. There is corruption."*

Participants commenting about the corruption as an economic aspect

Comments like these are not really unexpected. According to the Eurobarometer about corruption, this problem – whether it takes the form of political corruption, corrupt activities committed by and with organised criminal groups, private-to-private corruption or so-called petty corruption – continues to be one of the biggest challenges facing Europe. While the nature and scope of corruption varies from one EU Member State to another, it harms the EU as a whole. Corruption can also undermine trust in democratic institutions and weaken the accountability of political leadership (European Commission, 2014c). When EU-citizens were asked in 2014 about this problem:

- Three-quarters of the respondents (76%) thought that corruption is widespread in their own country. The countries where respondents were most likely to think corruption is widespread were Greece (99%), Italy (97%), Lithuania, Spain and the Czech Republic (all 95%), Croatia (94%), Romania (93%), Slovenia (91%), Portugal and Slovakia (both 90%). The Nordic countries were the only Member States where the majority thought that corruption is rare: Denmark (75%), Finland (64%) and Sweden (54%) (European Commission, 2014c).
- About 26% thought that it is acceptable to do a favour in return for something that they want from the public administration or public services. A slightly smaller proportion (23%) think it is acceptable to give a gift, and around 16% consider it acceptable to give money (European Commission, 2014c).
- More than half of Europeans believe that bribery and the abuse of positions of power for personal gain are widespread among political parties (59%) and politicians at national, regional or local level (56%). Across other areas of public service a minority think it widespread: officials awarding public tenders (45%), those issuing building permits (43%),

private companies (38%), police/customs and banks and financial institutions (both 36%), inspectors (35%), healthcare (33%) and officials issuing building permits (33%).

- More than half of Europeans (56%) think the level of corruption in their country has increased over the past three years, with three in ten (29%) saying that it has increased "a lot" (European Commission, 2014c).
- The majority of Europeans agree that corruption exists in the national public institutions in their country (80%), in their local or regional public institutions (77%) and within the institutions of the EU (70%) (European Commission, 2014c).
- Around three-quarters of Europeans (73%) agree that bribery and the use of connections is often the easiest way of obtaining some public services in their country. This belief is most widespread in Greece (93%), Cyprus (92%), Slovakia and Croatia (both 89%), and Lithuania, the Czech Republic, Italy and Slovenia (all 88%); and least so in Denmark and Finland (both 35%) and Sweden (40%).
- Eight in ten Europeans (81%) agree that too-close links between business and politics in their country lead to corruption; seven in ten (69%) that favouritism and corruption hinder business competition; two-thirds (67%) that corruption is part of the business culture in their country; and more than half (56%) that the only way to succeed in business in their country is through political connections (European Commission, 2014c).
- Around one in eight Europeans (12%) say that they personally know someone who takes or has taken bribes. Respondents in Lithuania (35%), Slovakia (33%) and Greece (31%) are most likely say that they know someone who has taken bribes, followed by those in Latvia (25%), Croatia (24%), Cyprus and Hungary (both 21%), and Bulgaria and the Czech Republic (both 20%). The UK has the lowest proportion of respondents who say they know someone who has taken bribes (7%), followed by Ireland and Malta (both 8%), and Germany, Finland and Italy (all 9%) (European Commission, 2014c).

Although these survey-results are about perceptions, it is clear that there is indeed a risk for corruption that should not be underestimated and which might also be a barrier for taking action.

QB7 In (OUR COUNTRY), do you think that the giving and taking of bribes and the abuse of power for personal gain are widespread among any of the following?

	Political parties	Politicians at national, regional or local level	Officials awarding public tenders	Officials issuing building permits	Private companies	Police, customs	Banks and financial institutions	Inspectors (health and safety, construction, labour, food quality, sanitary control and licensing)	None (SPONTA-NEOUS)	Don't know
EU27	59%	56%	45%	43%	38%	36%	36%	35%	5%	7%
BE	57%	52%	46%	45%	41%	39%	36%	35%	8%	3%
BG	41%	42%	42%	46%	17%	67%	12%	38%	1%	12%
CZ	73%	69%	69%	47%	37%	55%	15%	45%	1%	4%
DK	34%	38%	22%	26%	44%	12%	25%	23%	32%	5%
DE	51%	49%	40%	41%	50%	16%	38%	38%	6%	9%
EE	61%	52%	45%	49%	32%	38%	12%	30%	6%	9%
IE	56%	57%	32%	33%	28%	26%	48%	21%	6%	6%
EL	68%	66%	55%	64%	28%	51%	31%	52%	1%	1%
ES	84%	72%	44%	54%	48%	41%	62%	36%	1%	3%
FR	70%	58%	48%	44%	44%	44%	34%	31%	3%	7%
IT	68%	63%	55%	54%	31%	33%	40%	44%	1%	5%
CY	52%	38%	42%	44%	28%	55%	31%	42%	4%	9%
LV	54%	41%	47%	48%	25%	58%	13%	40%	2%	9%
LT	43%	40%	46%	39%	21%	63%	13%	41%	2%	4%
LU	45%	45%	32%	40%	42%	31%	25%	30%	10%	10%
HU	51%	49%	43%	39%	32%	38%	23%	28%	3%	7%
MT	52%	42%	45%	53%	21%	37%	8%	26%	3%	18%
AT	60%	59%	46%	43%	36%	19%	29%	30%	4%	10%
NL	47%	55%	64%	69%	56%	37%	57%	46%	4%	2%
PL	39%	42%	41%	33%	19%	40%	8%	28%	2%	11%
PT	59%	59%	41%	43%	35%	43%	47%	40%	3%	16%
RO	46%	52%	40%	35%	16%	67%	15%	36%	1%	11%
SI	72%	68%	60%	59%	41%	40%	44%	51%	2%	6%
SK	51%	49%	44%	31%	26%	48%	15%	41%	0%	6%
FI	43%	51%	31%	31%	24%	3%	6%	11%	18%	5%
SE	30%	46%	49%	43%	51%	22%	23%	34%	16%	4%
UK	56%	55%	33%	30%	41%	32%	47%	21%	10%	10%
HR	65%	66%	58%	57%	44%	57%	34%	60%	2%	6%

Highest percentage per item | Lowest percentage per item

Top 8 answers given at EU27 level

The majority of Europeans believe that bribery and the abuse of positions of power for personal gain are widespread within political parties (59%) and among politicians at national, regional or local level (56%). More than four in ten think corruption is widespread among officials awarding public tenders (45%) and those issuing building permits (43%). Just under two-fifths of Europeans believe that there is widespread corruption among private companies (38%) and more than one in three think it widespread within the police or customs (36%), banks and financial institutions (36%) and inspectors (35%) (European Commission, 2014c).

QC6 In your opinion, what are the reasons why there is corruption in (OUR COUNTRY)'s society? (MAX.3 ANSWERS)

	There are too close links between business and politics	Politicians (Government and the Parliament) do not do enough to fight corruption	Public money is not spent in a transparent manner	There is no real punishment for corruption (light sentences in the courts or no prosecution)	Many appointments in the public administration are not based on merit or qualifications	Many people accept corruption as a part of daily life	The law is often not applied by the authorities in charge	Poor socio-economic conditions (low income, poverty) lead to corruption	Other (SPONT.)	None\ There is no corruption in (OUR COUNTRY)'s society (SPONT.)	Don't know
EU27	40%	36%	33%	29%	22%	19%	18%	18%	2%	2%	6%
EU15	41%	35%	35%	29%	23%	19%	18%	17%	2%	3%	5%
NMS12	34%	42%	24%	30%	20%	22%	20%	24%	1%	1%	6%
BE	**44%**	32%	30%	33%	32%	24%	*20%*	23%	1%	3%	1%
BG	35%	39%	16%	**47%**	*14%*	24%	35%	37%	0%	0%	3%
CZ	42%	**53%**	33%	42%	22%	21%	21%	*16%*	0%	0%	3%
DK	22%	14%	**27%**	17%	17%	18%	*13%*	22%	2%	25%	4%
DE	**47%**	27%	36%	25%	28%	17%	*12%*	19%	3%	3%	7%
EE	**47%**	24%	31%	23%	*15%*	19%	17%	31%	3%	2%	7%
IE	44%	**48%**	33%	32%	26%	20%	22%	*11%*	3%	1%	6%
EL	19%	**57%**	43%	43%	30%	21%	37%	*11%*	1%	0%	0%
ES	28%	40%	**43%**	33%	16%	20%	25%	*14%*	2%	0%	5%
FR	**55%**	28%	45%	32%	19%	*16%*	19%	23%	2%	2%	5%
IT	**50%**	48%	28%	23%	29%	18%	19%	*11%*	1%	1%	3%
CY	23%	54%	25%	37%	**56%**	29%	35%	*12%*	0%	0%	1%
LV	**32%**	31%	30%	28%	*18%*	25%	24%	30%	1%	1%	3%
LT	37%	**44%**	35%	31%	*14%*	26%	15%	23%	2%	1%	4%
LU	**37%**	17%	27%	19%	21%	27%	*11%*	16%	3%	7%	12%
HU	**40%**	36%	34%	33%	22%	20%	*14%*	35%	2%	1%	3%
MT	**50%**	40%	21%	24%	21%	22%	14%	*9%*	1%	0%	12%
NL	29%	17%	**37%**	29%	23%	22%	*13%*	23%	6%	6%	6%
AT	**45%**	37%	40%	36%	34%	21%	23%	*11%*	2%	3%	4%
PL	**31%**	30%	20%	25%	18%	24%	*15%*	21%	0%	2%	10%
PT	22%	**40%**	27%	27%	19%	15%	27%	*12%*	1%	1%	9%
RO	30%	**61%**	22%	25%	24%	*17%*	25%	28%	1%	0%	6%
SI	50%	47%	25%	**51%**	*14%*	21%	18%	16%	2%	2%	1%
SK	38%	**46%**	28%	29%	24%	35%	*15%*	24%	1%	0%	2%
FI	**50%**	21%	29%	28%	25%	17%	15%	*9%*	3%	11%	2%
SE	29%	25%	27%	**35%**	30%	32%	*13%*	21%	3%	4%	4%
UK	33%	**38%**	30%	28%	*14%*	19%	*14%*	15%	5%	4%	9%

Highest percentage per country / Highest percentage per item

Lowest percentage per country / Lowest percentage per item

Eight in ten Europeans (81%) agree that too-close links between business and politics in their country lead to corruption, with almost two-fifths 'totally' agreeing (37%). Seven in ten Europeans (69%) agree that favouritism and corruption hinder business competition, with a quarter (26%) saying that they 'totally' agree this to be the case. A similar proportion (67%) agree that corruption is part of the business culture in their country, and a quarter (26%) again say that they 'totally' agree. Europeans are somewhat less likely to agree that the only way to succeed in business in their country is through political connections, although the majority (56%) still hold this view, with one in five (20%) 'totally' agreeing.

QA14 Thinking about the spending and investment of public authorities in (OUR COUNTRY), which of the following two statements comes closest to your view? Public authorities should favour...

	Environmentally-friendly considerations over cost considerations	Cost considerations over environmentally-friendly considerations	Neither the one nor the other (SPONT.)	Don't know
EU28	59%	21%	13%	7%
BE	**57%**	30%	*11%*	2%
BG	**53%**	21%	*9%*	17%
CZ	**70%**	14%	*11%*	5%
DK	**58%**	26%	*13%*	3%
DE	**63%**	17%	*16%*	4%
EE	**49%**	22%	*16%*	13%
IE	**53%**	28%	*15%*	4%
EL	**74%**	*12%*	*12%*	2%
ES	**59%**	25%	*9%*	7%
FR	**60%**	18%	*15%*	7%
HR	**62%**	24%	*7%*	7%
IT	**58%**	25%	*10%*	7%
CY	**76%**	*9%*	10%	5%
LV	**69%**	16%	*10%*	5%
LT	**65%**	14%	*11%*	10%
LU	**63%**	*13%*	17%	7%
HU	**49%**	29%	*16%*	6%
MT	**71%**	16%	*6%*	7%
NL	**61%**	*15%*	21%	3%
AT	**60%**	20%	*16%*	4%
PL	**36%**	30%	*18%*	16%
PT	**47%**	31%	*9%*	13%
RO	**44%**	29%	*17%*	10%
SI	**78%**	12%	*7%*	3%
SK	**71%**	16%	*7%*	6%
FI	**62%**	19%	*16%*	3%
SE	**75%**	*7%*	16%	2%
UK	**65%**	21%	*6%*	8%

Highest percentage per country *Lowest percentage per country*

Highest percentage per item | Lowest percentage per item

Most EU-citizens (about 59%) think that public authorities should favor environmentally-friendly considerations over cost considerations (European Commission, 2014a).

3.5 User-evaluation of the practical acceptability of the tools

Although the social acceptability of the CITI-SENSE-tools is the first priority, the practical acceptability might also strongly contribute to the empowerment potential. Interviewees were asked – indirectly – about this practical acceptability of the tools (see questions below).

Proposed list of questions for the tool evaluation by participants

- To what extent is this AQ activity/product useful to you?
- What did you expect it to help you do better? (focusing on expectations)
- What can it help you do better? (focusing on actual outcomes/impact)
- What can it not help you do better? (focusing on actual outcomes/impact)
- What could it help you to do better if improved/adapted? (How should it be improved?)

In their answers participants have been mentioning a wide spectrum of topics, and they often did this in a very detailed way. The following aspects of the participatory user-evaluation have been passing the revue during the interviews and focus groups (both more in general or on a tool-by-tool basis):

- **usefulness** of the COs in general or a particular CITI-SENSE-tool
  - **strategic value** and/or the **need for (other) AQ-data**
  - **available functionalities/utility** and **completeness** (e.g. are all functionalities brought together in one tool)
  - **usability** (for the intended target groups, including the elderly)
    - ease-of-use
    - required expertise (in order to be able to use the COs or a particular tool)
    - required skills (in order to be able to use the COs or a particular tool)
  - **relevance** (for the intended target groups)
    - accurateness and uncertainty of output (e.g. being fit-for-purpose!)
    - comparability and validation of the results (calibration, etc.)
    - reliability of the tools and/or the output
    - transparency about calculations, model-assumptions, limitations of tools, etc…
    - meaningfulness of the output (including language of the system)
- **cost (or cost efficiency)** of the COs or a particular tool
- **continuity ("longevity")**

The information on all these aspects is very valuable in terms of further development of these tools in the future (especially from the perspective of co-development and co-design, but the methodological support group on engagement & empowerment (working package 5) was confronted with a huge challenge during the analysis of this particular information. As indicated in the introduction of this chapter, it was explicitly aimed for to shift away from a more technocratic discussion about the products towards a broader societal debate about the usefulness of the products and their possible impacts on society. But many of the interviewees also talked – with mucht detail – about very technical aspects of the tools (such as *"It should measure PM"* (particulate matter), *"it should more fractionation between the index (APIN) values"*, etc.), sometimes without referring clearly to why this aspect is important in terms of raising the empowerment potential of the tools. Although this kind technical information is definitely useful for the tool developers, from the viewpoint of empowerment it is much more important to understand if a particular tool did actually contribute to the overall aims of the CITI-SENSE-project or to the local goals in the Empowerment Initiatives (EIs), and what of the practical aspects might be a barrier for that. Therefore, instead of focusing on the question *"what should be improved"* from a very technical point of view, we found it more relevant to focus on the question *"why should that be improved and how does this affect the overall goals"* from a social point of view

(see also chapter 4). Nonetheless, there can be important relationships between the technical and the social aspects, as it was explained earlier (see also chapter 3.3):

> *"What looks at first sight like a rather technical discussion about the required accuracy of the sensors, might in fact be used strategically by some of the involved stakeholders to hide their strong desire to remain the status quo. Some stakeholders might intentionally make unrealistically high demands towards the required accuracy, so that they don't have to take action as long as people will be waiting for that "perfect" sensor that might never be developed after all. Instead, sensors should be "accurate enough" (e.g. fit-for-purpose). This example implies that a discussion about technical issues can sometimes be used strategically to slow down the whole process of empowerment (by consciously obstructing the decision-making process that might lead to the concrete actions). Similarly, also discussions about definitions might be used merely as a delaying tactic. Although different "framings" of the problem – by various stakeholders – are very relevant, unwilling actors might also use these discussions tactically to decrease mutual understanding (in order to create misunderstandings or disagreements). Because solutions from one frame may not be recognized as being relevant in another frame, decision-making processes can be obstructed. Also the current societal debate about the trustworthiness of citizen science (e.g. "can citizens produce accurate and reliable data?") is part of the CITI-SENSE-project and the technical aspects of this discussion might be used in a strategic way by opponents of AQ-action. These are the topics that are most interesting from the viewpoint of empowerment. The sections about practical acceptability will mainly focus on these kinds of aspects."*

The focus in this chapter will be on the empowerment-related aspects of this practical acceptability, such as for example how different participants perceived the strategic value and the need for more data, how people might differ about the meaningfulness of the output, etc. (thereby leading away the debate from only discussing consumer gadgets to discussing really useful empowerment tools). By this approach, the analysis hopes to contribute to a better integration of the social aspects of the co-design process of COs – or similar initiatives – in the future.

Due to the risk that this report would become too voluminous, it was not possible to describe all the aspects that were discussed. Therefore we will focus on 3 specific examples in particular. Some of the other most relevant aspects will be summarized only briefly. The examples that will analyzed have been selected within the following main topics:

- Strategic value and the need for data (including comments regarding overall usefulness);
- Available functionalities and completeness;
- Relevance for the intended target groups (where the focus will be limited to the interesting debate about the aspect of accurateness in particular).

3.5.1 Strategic value and the overall usefulness of the tools

On a more general level, various participants mentioned that additional AQ-data would definitely be useful, thereby expressing the need of additional AQ-measurements and/or gathering of other types of AQ-data, while other participants sometimes had doubts about this. This seems to be valid for all kinds of AQ-data collected by the CITI-SENSE-tools.

In terms of overall usefulness of the CITI-SENSE-tools, people have been stating general comments ranging from *"I rated [tool X] is being useful"*, over *"I find it useful, but…"* and *"If it really works as it is supposed to work, I think it's useful or even rather useful"* to *"I don't find it useful at all"*. In some situations, participants concluded that they didn't find a particular tool useful, even although it had been contributing to (some of) the original CITI-SENSE-goals regarding awareness-raising. Again, this indicates also that these aspects of the user-evaluation are about perceptions, not facts.

- **Interviewer:** *"So in the current state, none of you would have any use of it?"*
  Participant 1 (volunteer): *"No."*
  Participant 2 (volunteer): *"Uh-uh."*
  Interviewer: *"But it has helped you as to be more aware of..."*
  Participant 1: *"Yes."*
  Participant 2: *"Uh-huh."*

Perceptions about usefulness can differ from actual achievements (e.g. awareness-raising)

Some of the participants also explicitly mentioned the current stage of development (e.g. that for instance was not yet fully satisfying). In other cases it was not always very clear which version of the tools had been tested:

- **Participants (peer group of students and scientists)** about the LEO's:
  "The device is rather useful. However, at the time of measurements (spring 2016) the usefulness was limited in many cases mainly due to various technical reasons, such as: limited access to data, unstable connection between phone and device, unexpected problems, negative values (for ozone and NOx), wrong GPS-data…"

Example of participants referring to the current stage of development

When evaluating the strategic added value, first of all it can be relevant to ask whether new AQ-data – or other types of AQ-data – are actually needed. There were for instance participants who rather doubted if additional AQ-data was actually always necessary. They mentioned that some of the (local) AQ-problems seemed to be (quite) well-known, for example because the problem was very visible or because more detailed studies about local air quality have been carried out earlier and results were available. In these situations, no new AQ-data is really needed in order to start working as soon as possible on finding solutions. Another very particular example mentioned by another participant is about the issue of people smoking, which also affected air quality for other people around. Due to the implementation of the European Council Recommendation on smoke-free environments of 2009 (focusing on enclosed public places, workplaces and public transport), the problem of protecting EU citizens from passive smoking has been dealt with (although in some of the Member States enforcement still seems to be a problem because of complex legislation including many exemptions). But the problem of cigarette smoke in some public outdoor area might still be seen as a problem for some people:

- **Participant (volunteer):** *"[…] I found out that your Research Institute did this study of air pollution in [neighborhood Y] that I mentioned earlier, so I wrote to the library and they actually sent me the whole study."*
- **Interviewer:** *"And why did you say that [town X] had bad air?"*
  Participant (pupil elementary school): *"I do not know, but when we were there it was very polluted."*
  School teacher: *"Did you see smog, or something?"*
  Participant: *"No, it was just that a very bad smell could be felt."*
- **Participants (from a group of volunteers carrying the LEOs):** *"Even the common sense tells you not to go out during the rush hour."*
- **Participant (citizen):** *"The air polluted by car is not that bad as here from the industry. You can smell the metallic tang. Very bad."*
- **Interviewer:** *"Do you think that some other things can be done... for example choosing a cleaner route? Can it help you if you are crossing on your way to work, like ring roads, or you need to go along, and then you see that it is a lot of pollution there..."*
  Participant 1 (volunteer): *"I would say I don't need the LEO for that. If I see a lot of cars, if I see the rush hour, it makes me upset that I better avoid the area anyway, but*

secondly I would choose a less trafficked route anyway."
Participant 2 (volunteer): *"Now we are assuming that traffic is the one and only source of pollution..."*
Participant 1: *"It's not, clearly."*
Participant 2: *"I have a neighbor who is burning wood in an old wood stove, so every second year we have to clean one of the walls of our house which is towards his house. But of course traffic is an obvious source, and it's affecting everybody..."*
Interviewer: *"With the LEO you couldn't measure PM anyway..."*
Participant 2: *"I don't need the LEO. I can tell, because the wall is black (laughs)."*

- **Participant (other researcher):** *"I think in Barcelona you do not need a LEO if you walk behind a person who smokes. You do not need a LEO to know that the air quality is bad."*

Participants indicating that sometimes additional AQ-data is (probably) not really needed

In these situations, waiting for instance for better (not to say "perfect") AQ-sensors or AQ-data from surveys might only be a waste of valuable time to take concrete action then. Of course, sometimes participant's perceptions about air quality (e.g. the common sense) might not be fully accurate.

Other particpants, both participating NGO's and authorities, did indeed see a real added value of new AQ-data, for example from the viewpoint of awareness-raising as this might help to increase the publics' acceptance for AQ-measures that might be not popular. The process of data-gathering itself was also recognized by some of the participants as a (potentially) valuable action, but that added value would also depend on how the tools would be developed in order to fulfill specific purposes. While the authority in the example below mainly focused in increasing the acceptance amongst the public, the NGO was also addressing the possibility to affect the attitude of politicians in order to increase their acceptance to make legislation (e.g. *"when they have data and facts, they have to accept it"*).

- **Interviewer:** *"Do you think that the results from surveys […] can be used to improve air quality in some way? For instance… increasing awareness?"*
  Participant (authority): *"I think that's maybe the main result from a survey, and maybe also an app. It depends on how you develop these for raising awareness. […] More awareness will result most likely in willingness to do something to improve air quality, I think. So in that sense… But it's maybe not the main abate measure we have. (laughs)"*
  Interviewer: *"No."*
  Participant: *"But you can get more acceptance also for measures that are not so popular, if you raise awareness. And that's a good thing."*
- **Interviewer:** *"So you think more information and creating awareness and reminding people from time to time can make a difference?"*
  Participant 1 (NGO health): *"Yes, it makes it easier to make legislation against air pollution."*
  Interviewer: *"Easier to incorporate laws that are not always easily accepted by the public?"*
  Participant 1: *"Definitely. I think so. […] If we can use the data, it can help us to affect politicians, because their attitude might change. Because they have to. When you have data and facts, they have to accept it."*

Participants' comments about raising awareness

The last sentences of the example above are interesting as they refer to the "speaking truth to power"-debate in the literature, also discussed in "Governing the air" (Lidskog et al, 2011):

> *"Although speaking truth to power has long been a major theme in political science and policy studies, commentators are increasingly skeptical about whether modelers and scientists are capable of developing truth and whether power ever listens to them anyhow. Indeed, international relations scholars tend to be surprised by the occasions when it does. […] Even when scientists think they have developed truths for power, power appears disinterested at best and possibly even uninterested. Yet*

> *sustainable development has gradually encroached on environmental policymaking worldwide, bith in international regimes and in national legislation and practices. Power listening to truth is rare, and science policy analysts and political scientists too often dismiss truth entirely. […] The path from truth to power is circuitous at best"* (Haas et al, 2011; Lidskog et al, 2011).

Although the authors summarize a valuable list of 18 conditions that might help to increase the effectiveness of development and mobilization of usable knowledge (based on their experiences with addressing transbandoury and global environmental threats), they also argue that we shouldn't assume that all organizations are rational and will automatically recognize and adopt what prove to be the appropriate policy responses. To underpin this statement, they refer to a historical example:

> *"Scurvy was arguably the single most important limiting factor to the expansion of trade and geopolitical influence in the fifteenth and sixteenth centuries. Trade and exploration was significantly hampered because the mortality rate of sailors on long-distance expeditions was often in excess of 90 percent. Expeditions would return with far fewer ships not because of storms, but because too few crew members were left to be able to serve the entire fleet. And yet in the early 1600s the scurvy problem was solved by Captain James Lancaster, who suggested that citrus trees be brought along on ships, but the solution was forgotten for nearly 150 years, until Captain Cook rediscovered it in the 1760s. So much for rational societies responding effectively to important issues. We should not expect a fully formed sustainable development science to be developed and applied in response to the presumptive need for such a view. We shouldn't assume that all organizations are rational and will automatically recognize and adopt what prove to be the appropriate policy responses with the virtue of hindsight or reflect the material needs of their most powerful constituencies"* (Haas et al, 2011; Milton, 1999).

In this debate about "speaking truth to power", those powers can be interpreted broadly, as also shown in another famous historical example in which a entire scientific sector itself ignored the truth that was brought up by one of its own members for a long time. The example is that of Dr. Ignaz Semmelweis, a Hungarian gynaecologist described as the "savior of mothers" because he discovered that the incidence of "childbed fever" could be drastically cut by the use of hand disinfection:

> *"When he gained the position as assistant in obstetrics at the Vienna General Hospital in 1846, Semmelweis was appalled by the 'horrible devastations' caused by childbed fever. […] Thinking himself armed with the unbeatable backing of truth, Semmelweis set out to diffuse his theory and institute change in 1847. […] Semmelweis introduced mandatory hand washing with chlorinated lime… [But] Semmelweis was the bearer of an inconvenient truth. […] As he later wrote 'the facts cannot be changed, and denying the truth only increases guilt'. As is well known, the path of least resistance for many of his colleagues was to dismiss the legitimacy of his ideas. Despite a dramatic reduction in mortality, Semmelweis and his theory were met with tolerance at best and, at worst, with derision. His contract did not survive the renewal process in 1849. Truth, it might have seemed to him, does not always triumph after all. […] According to him, the facts should speak for themselves. But he overplayed his hand. Despite strong evidence of a clearly lifesaving intervention, his uncompromising message generated anger and rejection rather than behaviour change. In 2011, about 150 years after this milestone publication, his unsuccessful attempt to implement a patient safety initiative remains as instructive as his great achievements" (Stewardson et al, 2011).*

Only in 1865, the year Semmelweis died, his idea was rehabilitated by Joseph Lister. This story of Semmelweis' teaches us that – by definition – such conflicts with society are at core of any medical innovation or any scientific progress in general. It offers us a site to see that the limits of the society are constantly being reached and being hurt (Durnová, 2014). The "Semmelweis reflex" (a metaphor for a certain type of human behaviour characterized by reflex-like rejection of new knowledge because it contradicts entrenched norms, beliefs, or paradigms) is named after Semmelweis, whose ideas were ridiculed and rejected by his contemporaries.

Both protagonists in the examples above are sometimes referred to as persons who deserve the "they-really-were-right"-award… But also more recently – and related to air pollution – there are indications that it cannot be assumed that citizens' ability to influence powerful corporations that run industrial facilities will be expanded just because community groups have data (Ottinger, 2010). This was also addressed by one of the participants, who argued that monitoring air quality in itself does not automatically solve the AQ-problems.

- **Interviewer:** *"What can't the LEO help you do better?"*
  Participant (citizen): *"To perform activities that I need to perform, no matter what the air [quality] is [like]; monitoring won't help me to improve air quality."*

Participant mentioning the limitation of monitoring

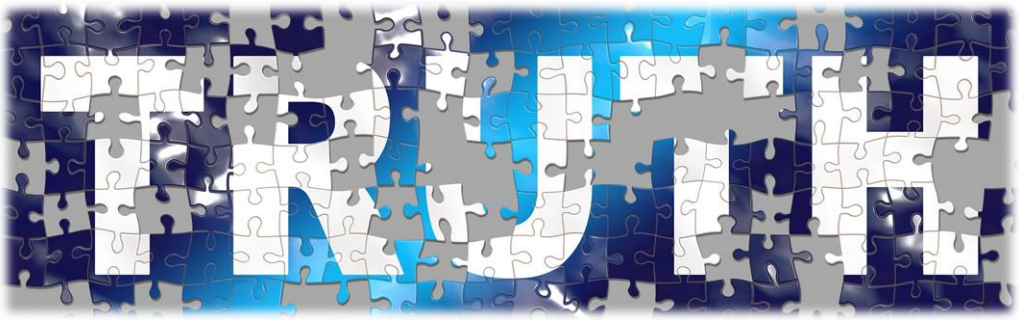
Monitoring campaigns can help to bring air quality problems into the picture, but you can not automatically "swipe away" these problems
(www.pixabay.com)

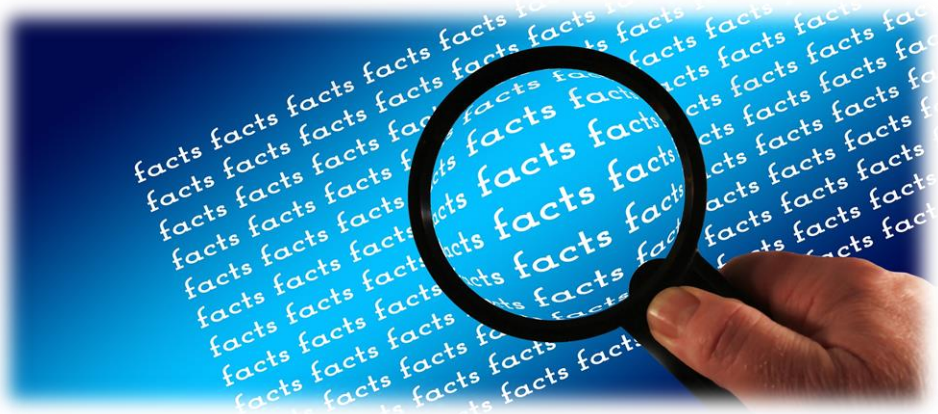
When it comes to recognizing the particular strategic value of the CITI-SENSE-tools, the opinions of participants might even differ more (also partially depending on the particular tool that was tested). Regarding the **Little Environmental Observatory (LEO's)**, one interviewee who had been combating air pollution for many years seemed to be somewhat undecided, saying both that new AQ-data from the LEO's would be good and saying at the same time also that – as a local citizen – you don't always need these data in order to know the problem. For him/her, the newly gathered information from the LEO's seemed to be a confirmation of what he/she already knew, which means that the strategic added value of this tool might be somewhat limited.

- **Interviewer:** *"You have tried also the personal sensor (LEO) and I have sent you the charts of the measurement afterwards. How would you evaluate this?"*
  Participant (citizen): *"Every measurement is good! But we, who live here, can smell the pollution. We do not need to know the actual state of the air quality. For me it is enough to open the window and breath. Sometimes I cannot open the windows when I see how the smoke from the chimneys of [company Y] are approaching here or when*

my neighbor burns the leaves. I try to not go outside in these periods. The authorities do nothing..." […]
Interviewer: *"Have you learned anything new during the project?"*
Participant (citizen): *"I have been fighting like this for 10 years. So it was rather a confirmation of my information."*

Participants' comment about being somewhat undecided about the need of new AQ-data





The facts (in terms of new AQ-data) will not necessarily affect the attitudes of politicians… as "speaking truth to power" has its limitations
(photo's: www.pixabay.com)

Another participant didn't even seem to expect any concrete added value from the LEO's at all (at least not for him/her personally):

- **Participant (from a group of volunteers carrying the LEOs):** *"Personally I would not buy such device to measure air quality. I do not see the added value for myself."*

Participants' comment about being somewhat undecided about the need of new AQ-data

Nonetheless, many other participants acknowledged that there is a need for additional AQ-data that can be collected with the LEO's and also the strategic value of this tool in particular was recognized. Various participants argued that – at least if necessary and if the LEO's would be improved – the additional data would be useful. Different reasons were given. Some participants just recognized that additional AQ-data from the LEO's would be valuable anyhow, in a very general way, in order to have more information about the problem. Additional data could also be explicitly used to oppose the critique of some of the stakeholders that currently available data would not be representative, leading to a similar conclusion: "the more, the better".

- **Interviewer:** *"Do you think it [the LEO/sensors] could be useful for citizens?"*
  Participant (other researcher): *"Yes, sure, in the way of having more data about a problem."*
- **Participant 1 (NGO health):** *"And of course the public or the critics might say – like they always do – that 'You need more traps, you need more sensors.' Like already when you have a warning on air pollution, they always say the sensor is placed at the wrong place."*
  Participant 2 (NGO health): *"It could be very local".*
  Participant 1: *"Yes, so the more sensors you have, the better the results are, and the less you are prone to critique."*

Participants indicating that additional AQ-data would be valuable

According to some of the participants, the AQ-data from the LEO's might also be used strategically to put pressure in (local) authorities (for instance after establishing citizen organizations), even although the CITI-SENSE-project has explicitly chosen not to challenge authorities with the AQ-measurements (see also earlier discussion about legitimacy and representativeness).

- **Participant (citizen):** *"Thanks to this new information [from the LEO's], citizens should be more proactive, establishing citizen organizations and pushing state authorities more."*
- **Participant (other researcher):** *"I think that the general idea of many people is that you have to improve your capabilities to improve the spatial distribution of your air quality map. So then you have a real time map of air quality around the city and you can use that as evidence to submit to the municipality or the authorities to ask for regulations."*
- **Participant (citizen):** *"The results [from the Long Perception Questionnaire] and the measurements [with the LEO's] only confirmed the bad state [of air quality] that we have here. I am happy that the results could be presented for the general public and can be used as an argument for making pressure to create new laws and regulations."*

Participants indicating that data can be used to challenge the authorities

Another participant did agree that the potential to do this is there, but that the LEO's should be improved first so that if produces verifiable data. At the same time, this person raised some doubts about a potential gap between theory and practice, without clearly mentioning what remaining challenges exactly he/she was thinking about then. The interviewer could give an example (for their own country) to show that it is really possible in practice, and how it can help to solve some of the

problems because authorities might be urged to make more concrete plans to comply with the EU-legislation. Apart from that, also the potential for "just double-checking the authorities" with the LEO's was mentioned as an strategic opportunity (because people who have the ability to do their own measurements might feel more comfortable):

- **Participant (volunteer):** *"But I would add […] that if it actually was developed to a point where it gave absolutely verifiable data, it would be very useful, because some of these limits are legally enforceable or should be, at least in principle. So... I mean, I could really kick up some trouble for my local representatives if I could prove the extent of air pollution, because there are lots of kindergartens in that area, there are schools, there are old age homes... and you know, the limit values are actually legally binding, so... In theory, at least."*
  Interviewer: *"In practice too. [Our country] is now in the courts... the Asthma and Allergy Association of our country took it to the courts because of the exceedances of NO_2 levels... or nitrogen dioxide levels."*
  Participant: *"Interesting."*
  Interviewer: *"So now the authorities are developing more plans to make sure they comply with everything, so there are more and more plans."*
- **Participant (volunteer):** *"What I'm saying is only that I think it's a positive addition to have citizens being able to double-check the data."*

Participants indicating that data can be used to challenge or double-check the authorities

The LEO's might deliver also other strategically valuable information (again at least when the sensors are improved first). The (potential) functionality of having better data about personal exposure was mentioned multiple times, both by representatives of the authorities and by other participants, thereby clearly showing that there is indeed particular interest in these kinds of AQ-data:

- **Interviewer:** *"What did you like about the LEO's?"*
  Participant (from a group of volunteers carrying the LEOs): *"It would be actually really good for individuals who are really sick, if they were constantly wearing these and get information of their exposure, which is otherwise very difficult to obtain. This is a common problem here at our institute. For example in case of air quality, you cannot actually know where the person has been walking and what kind of concentrations he has been exposed to in reality. So if one would have a sensor similar to those used in radiation, which would constantly measure the pollutants, this would be great! A small, unnoticed device would be good for this purpose."*
- **Participant (authority):** *"For CITI-SENSE, another very interesting concept was the opportunity to know the personal dose inhaled by the measurement of these [LEO's]."*
  Interviewer: *"So do you think this will help to raise the awareness?"*
  Participant: *"Yes, absolutely. It will help to know how much time you spend in a high traffic intensity area or in open areas such as the seafront. In the end, we want to protect our health."*

Participants' comments about the need to know personal exposure

Finally, someone else addressed the more specific problem of the "blind spots" in the existing AQ-measuring-networks, emphasizing that additional data would be needed to get a better view on the problem (on local scale). But thereby he/she was referring to the need for more static monitoring stations (instead of to the LEO's).

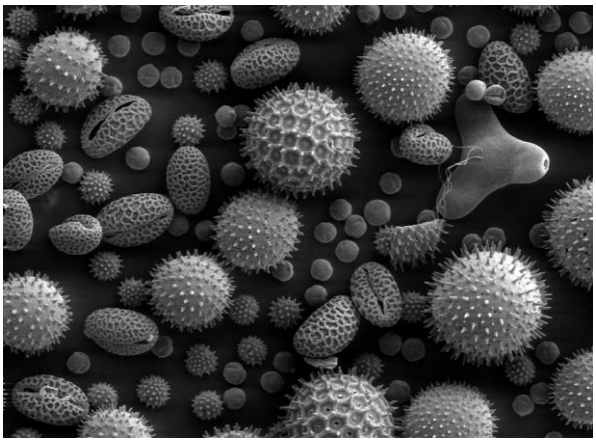
- **Participant (volunteer):** *"I would wish that [city Y] had more fixed monitoring stations. They definitely need them, because when you look at the map, there are areas which are not covered at all that happen to have a lot of traffic."*

Participant arguing that additional static monitoring stations would be needed

The strategic added value of the **CityAir-app** was evaluated differently. For instance due to the more subjective nature of the data that would be gathered, participants indicated that they might rather prefer to use the tool only for specific purposes (for example for people with respiratory diseases who can refer more explicitly to specific symptoms related to their condition when they share their AQ-perceptions).

- **Participant 1 (NGO health):** *"[…] I think that [the CityAir-app] can be a very useful tool. And it's like… [for] pollen as well. We often have our audience to say: 'Today I have started feeling reactions.' And then our researchers go in and check the data and everything, so… I think when you can cross those two, it's perfect to have the user perception as well."*
- **Participant (NGO health):** *"If we think from our point of view and our targets, it's a useful tool for anyone with respiratory diseases, people with asthma and everything. If they can check the air quality every morning, like where they commute or where they walk to work for example, and choose a different route if the app shows a better air quality in another route. Then that's a perfect tool for anyone who has those problems. So I think that's the main advantage for our targets."*

Participants' comment about the usefulness of the CityAir-app




The CityAir-app might be a very useful tool for people suffering from hay fever (to monitor pollen) *(www.pixabay.com)*

Some of the participants who clearly saw the added strategic value of comparing citizens perceptions with real AQ-measurements (in order to find ways to overcome the public's feelings). They indicated that there might be interesting research opportunities (for example to make links with representativeness and level of education) or asked of such a comparison has been done already (because they were curious about the results):

- **Participant (spokesman for a local authority):** *"Since we have interesting data regarding the public's feeling, I would check it as opposed to the real data from the sensors, which I understand can be found in the ministry of environment, in order to see if those places actually differ from others. That's really required. […]"*
  Interviewer: *"That is to say, to face the report of the public's position as opposed to a realistic report and see what's the gap?"*
  Participant: *"And to see if their feelings are correct, especially since they mentioned very specific geographic areas […]. If there'll be a gap between the data and their feelings, it can be very useful for your research, in my opinion… And also to find the ways to overcome the public's feelings. For the better and for the worst, yeah? […] The additional issue, as we've said before, is the fact that the majority of the*

respondents are highly educated, you barely have uneducated people. I have two things to say about it: there is an assumption that highly-educated people read more, or are more familiar with the data, in order to determine their opinions or make decisions. It will be very interesting to see whether the same opinions affect the public which daily fights for his existence and is not much familiar with the data, only a little from the press or similar sources. […] As a researcher I'm talking now, it's just important to know what influences their opinion. The press or the exposure to information? And if it's the exposure to information, maybe the question for your next survey should be: What information? You need to ask them in one of your questions: 'What affects your opinion?'"

- **Participant (authority):** *"I was wondering about one thing. You have compared this perception with PM_{10} or something. And with $PM_{2.5}$."*
  Interviewer: *"Yes…"*
  Participant: *"But did you also do some studies for NO_2? I was just curious."*
  Interviewer: *"Yes, I think I also…"*
  Participant: *"Because you maybe then should write one sentence on what the results were."*
  Interviewer: *"Yes, I can do that."*

Indicative examples of using the CityAir-app for specific research in combination with real data from AQ-monitoring-networks

…while there were others who just didn't see the point of the CityAir-app, or didn't really felt the need to use it anyway.

- **Interviewer:** *"What didn't you like about the CityAir-app?"*
  Participant (from a group of app-users): *"I do not see the point."*
- **Participant (from a group of app-users):** *"I did not feel the need to use it."*

Participants' comment about the usefulness of the CityAir-app

When taking a closer look at the **Long Perception Questionnaire**, contrasting views regarding the added value were seen too (although those opinions might also depend on the local context). One of the participating NGO's expressed a clear strategic added value for action:

- **Participant (NGO health):** *"We do work against the politicians, in terms of legal problems and political problems. Changing the laws in traffic. Right now we are working on reducing traffic on days where it's high on pollution, but on permanent basis. So there are now hearings on the legislations of new laws, so in those kinds of documents we send over to the politicians, these data could be incorporated, I think. We could show how people feel the air pollution and refer to that in our report. So it's very useful."*

NGO's comment on the added value of the Long Perception Questionnaire

On the other hand, one of the participating representatives of a (local) authority indicated that he/she did not find the Long Perception Questionnaire to be very useful, probably because several (similar) surveys on the same issue had been carried out already in that city. But nonetheless, this person too recognized that there are always interesting – or "funny" – results in some way and repeating such a survey once in a few years might be interesting in order to look for changes when new AQ-policies or concrete actions have been implemented:

- **Participant (authority):** *"I think such a survey is always interesting in some way, but of course it's mainly interesting if we can look at the results. The most interesting thing is this first question when you asked them about their perceptions, that half of the people think it's very bad or bad and the other half think things were good. That's*

kind of funny. But actually this survey… I think apart from actually this thing, it didn't tell us so much new I would say. […] It just underlines the point that we have been trying to make for many years, but that's of course nice."
[…]
Participant (authority): *"Now we have the survey, and it kind of is a basis. But there has been several surveys carried out on the same issue, so I think now we have this basis, so... We have enough to build upon."*
Interviewer: *"Is there any question you miss in the survey that you would like to ask the citizens?"*
Participant: *"I haven't thought about it this way. But I think it's a very general survey. […] I don't think we need more surveys at this point in time. Now we should develop something and give out information… more important. […] We know enough about what people would like, and of course we know that we might not be able to give the people what they want on all aspects, but that's another issue which has to be handled."*
[…]
Participant: *"And also there will be carried out several measures now in years to come, so everything will possibly change and then you kind of have to start again. You have a new starting point."*

Authorities' comment on the added value of the Long Perception Questionnaire

For the **CITI-SENSE web portal** in particular, the strategic added value was for instance seen in terms of the content that was provided, although this does not mean that the provided information should be complete. The participant mentioned that tools such as the website should be "fit-for-purpose" (whoch also means that completeness is not always needed).

- **Interviewer:** *"Do you think it would be useful to others, the website?"*
  Participant (scientist within the national authority): *"Again, it depends what you are using it for. On an information basis, I'm sure there are other websites out there that would give you more detailed information but as an easy to the eye look, yes it's quite good in that sense."*

Indicative example of a comment about the added value of the CITI-SENSE-webportal

The Environmental Monitoring Toolkit for Public Places (or SENSE-IT-NOW-app) is somewhat specific, as is was only tested in one of the local Empowerment Initiatives. This toolkit for public places is a collection of tools for subjective and objective monitoring of environmental quality and satisfaction, and for giving feedback at all kinds of public places.

- **Interviewer:** *"Within a range from 1 (very negative) to 10 (very positive), to what extent is this product useful to you?"*
  Participant: *"I would say 7, is useful. I think that new technologies are important and we have to use them. […] But taking into account that it is a tool… is just another tool to deal with (within a public participation process)."*
- **Participant:** *"It is useful if it is perfectly checked, as you have previously done, and if it is complementary to public spaces evaluation by citizens."*
- **Participant:** *"The measurements and perceptions using this product are closely related with physical findings. The product is useful when assessing public spaces quality, but more functionalities are needed."*
- **Participant:** "*We can use new technologies to improve public spaces, but it depends of your goals. […] Probably each actor (e.g. schools, NGOs…) may consider that this is a useful tool for different processes."*

Indicative examples of "undiscovered while available" functions

But there were also more critical evaluations for this tool (in terms of cost/benefits-ratios):

- **Interviewer:** *"To what extent is this product useful to you?"*
  Participant (scientist within the national authority): *"Broadly speaking, it is an interesting experience, but what you have done involves a lot of work and your conclusions and findings aren´t very surprising. Obviously people perceive that green areas are conformable and roads uncomfortable. We know that. When you have the opportunity to assess different spaces where a combination of elements happens, maybe CITISENSE is more interesting. But I´m sceptic about CITI-SENSE. […] All the contributions are good, but you have to look into the cost-benefits to develop a public participation process. […] With usual workshops we can have the same findings, or even better ones. CITI-SENSE makes a public participation process expensive."*

Indicative example of a comment about the added value of the CITI-SENSE-webportal

On the other hand, it was also questioned if this tool would be really needed to make visible the problems (because there might be other methods to do this), although in the end this participant still recognized that this tool might definitely be useful if you want the have more verified information.

- **Participant:** *"When there is a public problem (an area with a lot of noise for example), people already know and they are aware of that problem without this product. So, if I´m going to improve a public space it is useful to talk about thermic comfort. This product may help to make visible certain problems, but I can make visible too this problems with other processes, such as surveys or [by] asking directly to the people what their worries are. Maybe the response is not so real, or the information that you want to collect is not verified if you just ask questions (in contrast with this product), and that´s why I see that this is a useful product."*

Indicative examples of "undiscovered while available" functions

But there were also longer, more in-depth answers about the added value of this tool in a participatory process (when using it for empowerment). First of all, when this tool would be used in a participatory (empowerment) process, then there should be the capacity to make a change.

- **Interviewer:** *"Is this product useful for Vitoria-Gasteiz public spaces improvement with regard to environmental quality?"*
  Participant: *"It depends of the type of public participation process and the moment. I find [it] difficult to answer this question, because if I´m going to do an intervention, this is a tool and the empowerment comes when the citizens participate in the public spaces adaptation (taking into account citizens perceptions and needs). So, when carrying out a real public participation process, we have to assess if this product would be useful enough or appropriate. Maybe yes or maybe not. If I´m going to undertake an intervention within a neighbourhood, I have to assess if I´m able to respond to citizens' concerns. It depends. If I haven´t got the capacity to deal with public demands I can generate conflicts. If there aren´t legal conditions, administrative conditions and economic conditions to carry out certain processes (such as an acoustic panel to measure noise), I can´t empower the people. We undertake public participation processes when we certainly now that we have the real capacity to empower citizens. […] You have developed an intuitive tool that may be useful to make a diagnosis about certain variables, and that´s useful for me. But the challenge is how to characterize and how to design public participation processes taking into account social reality."*

Indicative examples of "undiscovered while available" functions

Secondly, also for this product, the subjectivity of some of the generated output was seen as a challenge:

- **Participant:** *"If you want to analyse how an agent transmits perceptions about a public space, it is positive to do it like this, and to contrast [it] with objective parameters. However, the 'comfort' is difficult to objectify."*

Indicative examples of "undiscovered while available" functions

In order to get a much better view on the usefulness of the tools, it is important to take a closer look at the specific aspects of usefulness (such as strategic value, specific functionalities that are currently available or that are asked for, usability and relevance and other more detailed characteristics of the tools). Due to the risk that this report would become too voluminous, it was not possible to describe all these aspects.

Apart from the question if citizens indeed will or will not be empowered by the collected data, it might also be important to ask how effective different forms of monitoring and/or other actions are in terms of being helpful to meet the communities' goals and if continuous monitoring (instead of more sporadic forms of air sampling and/or other activities) is always needed to achieve these goals. Episodic surveillance with AQ-buckets (which produce short-term snap-shots of air quality) during more heavily polluted periods might be complemented with continuous monitoring, but also with log books that record the date and time of "pollution incidents" and video cameras to document flares and smoke from facilities (Ottinger, 2010; Ryder et al, 2006). For instance, for more general CITI-SENSE case study goals regarding awareness-raising towards AQ, also many other – accessible and often low-tech and symbolic – community activities might be useful, even if they are only indirectly related to the local AQ measuring campaigns. Possible examples (that were used within some of the Empowerment Initiatives) are street interviews and questionnaires in order to raise awareness, or placing AQ-related posters made by pupils in front of the school, creating "no idling"-signs, etc.

Posters placed outside of High school, Ljubljana (in April 2015)

3.5.2 Functionalities and completeness of the tools

As mentioned earlier, some users were not always fully aware of the existing functions available in a particular tool (for instance when working with an earlier prototype of a tool). This means that it was sometimes difficult to fully separate comments about already implemented functionalities, those functionalities that were not yet available at that moment in time (e.g. but becoming available later on

in the project in a new version) and the potential functionalities hat people would hope for in a newer version of a tool in the future. This also makes it a challenge to fully analyze how participants appreciated the overall functionality of a particular CITI-SENSE-tool, as clearly addressed in the examples below, especially on these situations in which participants expressed their opinions very briefly. Nonetheless this particular choice of focus, the (group) interviews for this tool evaluation have also been useful to discuss some of the technical functionalities and especially to uncover signaling mismatches regarding "undiscovered while available" functionalities indicating suboptimal use of available tools and thereby also limiting the empowerment potential. Finding out why these gaps exists can help to explain why the actual uptake of a tool might be lower than expected and this knowledge will make it possible to improve the product (for example as part of a more thorough co-design process in the long run).

- **Interviewer:** *"Do you like, or do you dislike, some parts of the CityAir-app?"*
  School teacher: *"Do you fancy it? How do you like it?"*
  Participant (pupil of elementary school): *"The possibility perhaps to share our opinion and to comment."*
  School teacher: *"Do you have some space for comments?"*
  Interviewer: *"There is an option for you to insert a comment. This option already exists, perhaps you have not seen it."*
  School teacher: *"Then she likes that, because she would like to have that option."*
- **Participant:** *"I was just curious about the colors. What did they mean, what were the thresholds for these colors? But that's because I'm particularly interested... (laughs)."*
  Interviewer: *"It was an information button there, but it's probably not clear enough."*
  Participant: *"Oh! I never realized..."*

Indicative examples of "undiscovered while available" functions

Many types functionalities were discussed during the user-evaluation of the CITI-SENSE-tools. Often also very technical functions were mentioned (for example *"the LEO should measure particulate matter and it should display temperature data" or "it would be good if the device could have the GPS instead of the phone"*). And very practical issues were mentioned too (for example *"the tool was made in multiple languages"* or *"it has the possibility to write an answer yourself in a selection box, if the option you want to report is not on the list"*). Although these issues can indeed be seen as "functionalities", the methodological support group on engagement & empowerment rather wanted to focus on the more structural functionalities that can help to answer the questions in the textbox below, this again in our effort to shift away from a more technocratic discussion about functionalities towards a broader societal debate about what the CITI-SENSE-tools can really help people with in their lives. It is for example definitely handy – also from the viewpoint of empowerment – to have the ability to write an answer yourself in one of the selection boxes if your answer is not in the list, but it is not the main issue that will make or break the empowerment. The users' opinion about the overall functionalities that they recognized in the tools are way more important to analyze, because if these are not fulfilling their needs then the tool will not really help you in addressing and solving your AQ-concerns. Although there was a tremendous amount of interesting information in the interviews – technical or practical details about particular tools that can definitely be used to co-design newer versions – only the most relevant comments will be analyzed in this section.

Related questions about functionality for the tool evaluation

- What can it help you do better? (focusing on actual outcomes/impact)
- What can it not help you do better? (focusing on actual outcomes/impact)
- What could it help you to do better if improved/adapted?

A small sample of examples of functionalities – both empowering and potentially disempowering ones – that were recognized for each of the evaluated tools is given below. According the interviewees:

- The Personal Air Monitoring Toolkit (referred to as the LEO's) provides in the ability:
  - to know the approximate air quality in different parts of the city;
  - to monitor air quality in real time (or nearly real-time);
  - to help people learn more about air quality (e.g. learning process);
  - to help people managing their daily activities (e.g. better planning of their activities throughout the day in order to spend more time in healthier air);
  - to help people choose were to go in order to avoid places with bad air quality;
  - to help specific target groups in particular (e.g. anyone with respiratory diseases such as people with asthma);
  - to help people choose were to live (e.g. if you're going to buy a house, you can maybe see if this is a bad area);
  - to know more about the geographical distribution and implicitly then maybe about social-economic differences in exposure;
- The CityAir-app provides in the ability:
  - for individuals to share their observations;
  - to join actively in monitoring air quality;
  - to control complaints about AQ (e.g. the local administration would be able to keep good track of places where intervention is most needed);
  - to check the map in order to see what other people think of air quality;
  - to look for places that have bad air, so that people can avoid them (by taking alternative routes);
  - to help specific target groups in particular (e.g. anyone with respiratory diseases such as people with asthma);
- The Long Perception Questionnaire provides in the ability:
  - to raise awareness;
  - to gather a lot of useful data that can be used in the political work as well (e.g. quote answers in political statements);
- The Data Visualization and Data Download webpage (or Dunavnet-portal) provides in the ability:
  - to look for places that have bad air, so that people can avoid them (by taking alternative routes);
- The Environmental Monitoring Toolkit for Public Places (Vitoria-Gasteiz) provides in the ability:
  - to propose improvements for public spaces (in terms of environmental comfort).

In some occasions, also hints were given to use a tool in another way then originally intended, to combine the use of multiple tools or to open up the campaigns to a wider spectrum of environmental topics (e.g. urban development), for example to make the tools more complete.

- **Participant (other researcher)** about the CityAir-app: *"Actually the CityAir-app will work well if you use it to monitor the air quality indoor rather than outdoor. For example to record the air quality of your home or your office and then track it down in epidemiological studies. I think this is a good use of your app at this simple stage. […] It will work more like as an air quality diary at home."*
- **Interviewer:** *"How can the CityAir-app be improved?"*
  Participant (from a group of app-users): *"Combine the Expo-app and CityAir-app."*

- **Interviewer 1:** *"Maybe [you can use it] in campaigns, for example if you want to develop an area. As for now they can ask the people what they think about the environment and the spaces that are being constructed."*
  Participant (authority): *"But then it would be part of something bigger, in a way."*
  Interviewer 1: *"Bigger, like noise and air quality and… wind and thermal comfort. More things on the same…"*
  Participant: *"Because you know the perception is always more…"*
  Interviewer 2: *"Holistic?"*
  Participant: *"Yes, holistic, but it's also very subjective. So if you see an area where there is a lot of traffic, people will also experience environmental… negative aspects of that, I think. […] But then it's more an urban environment issue and urban development issue, so it's not really related to air quality anymore. This is regarding the app. I'm not sure if this app will be used at all in this kind."*
- **Participant (scientist within the national authority):** *"If you combined it with another app that maybe mapped out your routes that you were planning on taking, things like that, then it might be more useful."*

Recommendation to use particular tools for other purposes and/or to combine tools

Co-design and co-development:
Recommendations were given by the participants to use tools for other purposes and/or to combine various tools *(www.pixabay.com)*

On the other hand, many recommendations were also given in order to improve the functionality of the tools. From the viewpoint of co-development and co-design, these comments are very valuable. They might allow tool-developers to improve their products, while better products will also be used more and will also be able to better fulfill the needs from the users. A small sample of examples for the different tools is given below. According the interviewees…

- The Personal Air Monitoring Toolkit (or LEO's) should also provide in the ability:
  - to use a log function (so that you can make additional notes while you are moving through the city);
  - to get feedback from the tool;
  - to trigger an alarm (e.g. a noise or a popup) when pollution levels are too high;
  - to have some kind of report with an interpretation of the AQ-data;
  - to use tagging options in the app in order to mark down daily routines that would be downloadable with a time stamp (e.g. a checklist of most used ones: commuting, at home, doing exercises, at work, plus an option "other" which you could type yourself where you could provide some special occasion);
  - to connect with Air Quality Monitors (AQM-data) all over the world, so that people can compare their data with this data (in order to make it a more global product).
- The CityAir-app should also provide in the ability:
  - to get feedback from the tool (e.g. to have a feedback on what air quality is in the reality, when people think the air is bad and report it).
  - to use this tool also for reporting other things than just air pollution.

    - to help specific target groups in particular (e.g. people suffering from pollen);
    - to be better informed about the current state of the atmosphere when travelling to other countries;
- The Long Perception Questionnaire should also provide in the ability:
    - the ability to have a summary of what the other respondents have answered (as soon as you have finished the questionnaire);
- The Data Visualization and Data Download webpage (or Dunavnet-portal) should also provide in the ability:
    - to check all the data generated by the sensor, including historical data;
    - to have a clickable map where each point on a track would have some data.

From the empowerment-perspective, it is also important to know if the tools also propose concrete solutions. As it was mentioned earlier (see also chapter 3.4.1), when citizens are made more aware of the AQ-problems while they don't have alternatives to solve the problem, this can often lead to frustrating feelings of "learned helplessness". During the CITI-SENSE-project, this was seen for instance in one of the participants' comments in the Long Perception Questionnaire: *"How can you improve the quality of air? I had a similar application that just got me depressed. What can I do if the quality is low?"* There were also particular examples of participants who mentioned that they missed the functionality of getting more concrete feedback from the CITI-SENSE-tool, which is also really important from an empowerment perspective (because it can contribute strongly to the overall usefulness of the tools). Therefore, the need for "solution-oriented" tools was addresses (instead of only having tools that allow people to measure the problems) (see also examples below).

- **Participant (citizen):** *"I would have to gain specific information on how I can improve air quality. I failed to gain such pieces of information. […] I would appreciate concrete information on how I can be of any help."*
- **Participant (from a group of volunteers carrying the LEOs):** *"It is important to know how to proceed with the data. If it is for example just a preliminary score, some kind of very rough one combined with the GPS and time stamps, one can get an overview what time some locations should be avoided so that individuals could choose to go a bit earlier or later than the peak concentration appears. This would be helpful for example to asthmatics. If an individual gets feedback through this kind of device that she/he happens to go to a highly polluted place at the worse time i.e. at rush hour while grocery shopping, she/he can decide to adjust her/his schedule."*
- **Interviewer:** *"If improved, what would the questionnaire help you do better?"*
  Participant (citizen): *"If the questionnaire was simpler and opened me up to other possibilities to reduce pollution [that] I am now not aware of, I'd integrate them into my lifestyle and reduce pollution."*

Recommendations to get more feedback from the tools

It is not enough to monitor the problem… because people also want to learn about possible solutions… *(www.pixabay.com)*

3.5.3 Relevance for the intended target groups: the debate about "accurateness"

The "accurateness" of a tool in one of the factors that can contribute to its "relevance" (see also full overview in Table 1). The output that was produced with a tool will not be found relevant by the involved stakeholders if the results are totally inaccurate. In practice, the aspects accurateness, reliability, comparability and validation are often discussed together. Many of the participants have been using the terms accuracy and reliability quite interchangeably, thereby often referring to accuracy when they actually meant reliability or the other way around. Both terms were also often combined with opinions about comparability and the need for validation of the data. For example, the AQ-perceptions that are registered in the CityAir-app were subjective, so they were not comparable and that did also raise questions amongst the participants regarding the overall accuracy of the final output of this tool. However, in this sub-chapter the focus will be on the interesting debate about accurateness, as it is very relevant for the empowerment potential in various ways.

But before starting this debate, it is important to remember two important issues:

1. First of all, that the evaluation of the actual accuracy of the AQ-data can partially depend on the expectations of the user towards the local air quality. In some cases, there might be discrepancies between perceptions and reality (see also chapter 3.3.4). Also expectations towards the tools in advance of the testing period might have had an influence. This means that the evaluation of the accuracy of the CITI-SENSE-tools is based on the opinions of users and therefore should be done very carefully (taking into account that it is not a formal and objective testing of the actual performance, but rather a subjective evaluation which still can be based also on objective and unquestionable findings). But from the perspective of empowerment, this kind of evaluation are very important because it might affect the overall credibility and relevance of the results and the final uptake of the CITI-SENSE-tools (see chapter 3.1 and 3.3.2).
2. Secondly, it is important to take into account the current state of development of the tools. It is clear that the lack of reliability was also partially caused by the many (technological) problems that have occurred when people were working with the tools, and these problems also made participants less confident about the output of the tools:

Quite early during the CITI-SENSE-project (after the first year), the Technical Advisory Group (TAG) that regularly provided the project with their advice, argued that people will not become empowered with "weak data". And also the participants were most often evaluating accuracy and reliability in rather absolute ways – e.g. it is accurate or it is not – without referring to a particular purpose that the data would be used for. Some of the participants did indeed see the lack of "accuracy" as a problem for taking concrete action:

- **Participant (volunteer):** *"Before I became aware of this project, I had already written to a number of local representatives in the city district I live in. The Green Party has been pretty active, and also the Red Party has made some specific demands on the city administration. But I don't really see that there's much I can do based on [the data from the LEO]... since the data is so obviously not really that reliable."*
- **Participant (from group of volunteers carrying the LEOs):** *"If it is difficult to interpret the results, it is difficult to change ones behavior if you do not know what is actually in the air that causes the issues."*

Participants' comments about the lack of accuracy as a barrier for action

Although it is definitely true that "better data" is always handy, there is much more to say about this discussion. What was seen in practice during the CITI-SENSE-project, was that the dominant focus on

accuracy really became a bottle-neck for the social goals about stakeholder-engagement, awareness-raising, co-design and empowerment. From the perspective of empowerment, this can easily become problematic. Some stakeholders might intentionally have unrealistically high demands towards the required accuracy, so that they don't have to take action as long as people will be waiting for that "perfect" sensor that might never be developed after all. By raising doubts about the accuracy, taking action can be postphoned. This problem was also addressed – for example in terms of "Waiting for Godot" – by the methodological support group on engagement & empowerment). In some situations (when it is clear that there are AQ-problems), waiting for much better (not to say "perfect") AQ-sensors might only be a waste of time.

When time is running out, striving for perfection can be a form of stagnation (www.pixabay.com)

Although accuracy is a good thing, it is more important to gather data that is "fit-for-purpose"). Also during the user-evaluation, many of the participants – both authorities and other stakeholders involved – have clearly referred to accuracy and reliability in a more relative way (thereby relating it to the purpose for which the measurements could or could not be used) (see also chapter 3.5.1). Instead of aiming for the perfect sensor in absolute terms, it was argued before that sensors should be "accurate enough" for the intended goals and/or for a specific target group (or "fit-for-purpose"). If the purpose is for instance limited to awareness-raising, then sensors with lower accuracy and reliability might still be suitable. The examples below show the different needs regarding accuracy in relation with the purposes the tools are used for (see also chapter 4.2.4).

- **Participant (from a group of volunteers carrying the LEOs):** *"For scientific purposes I am not sure about the reliability of the data."*
- **Participant (volunteer):** *"The LEO – as it is now – is mostly about awareness-raising. It's about starting to think about air pollution situations."*
- **Participant (from a peer group of students and scientists):** *"Since the reliability of the device [LEO] and the app [CityAir-app] is very limited, I am afraid [that] at the present time measures which go beyond awareness-raising cannot be established on the basis of this measurement campaign."*
- **Interviewer:** *"So in the current state, none of you would have any use of it?"*
  Participant 1 (volunteer): *"No."*
  Participant 2 (volunteer): *"Uh-uh."*
  Interviewer: *"But it has helped you as to be more aware of..."*
  Participant 1: *"Yes."*
  Participant 2: *"Uh-huh."*

Indicative examples that show that awareness-raising can happen without perfect tools

Besides that, if a CITI-SENSE tool is intended to be used for a particular target group, such as asthma patients or people suffering from pollen, then the data might also more easily become accurate and

reliable enough. An example would be when citizens with similar health conditions are using the CityAir-app to share their experiences specifically in relation to the symptoms that they feel) (see also chapter 3.5.3 about the strategical added value).

Regarding the **accuracy of the Personal Air Monitoring Toolkit (or LEO's)** in particular, many of the participants argued that they should become more reliable and accurate first. Overall it was often addressed that (at the moment) it is not easy to get accurate and reliable date from these small devices such as the LEO's. Thereby, also the need for calibration was mentioned.

- **Participant (from a peer group of students and scientists):** *"The unit must in any case be more reliable and more accurate!"*
- **Participant (other researcher):** *"I think that if you want to distribute the LEO's to everybody, then you have to improve the quality of the LEO's first. […] it is a real challenge to make good data with these small device."*
- **Participant (from a group of volunteers carrying the LEOs):** *"If it is not calibrated, it does not make sense to calculate any APIN…"*

Indicative examples for the discussion about "accurateness" of the tools (here: LEO)

But even when the data from the LEO's would not be comparable (with each other or a (static) reference station), they might still be used in a different way. Based on the relative changes in the values along well-chosen trajectories throughout the city), you might still be able to get valuable information about local air quality in terms of "more/less" polluted areas in the city (thereby visualizing possible AQ-hotspots only in a relative way without knowing the exact numbers). This utility has been touched upon by one of the participants, and it might (partially) solve many of the issues regarding data quality. This "plan-B-option" (in parallel with further improvements of the sensors) was also pointed at by the Technical Advisory Group.

- **Interviewer:** *"Do you know that the data from these PODs are not comparable with the data from the reference station?"*
  Participant: *"Yes, but they have an utility, haven't they?"*
  Interviewer: *"We have seen that these data show a daily pattern, but the value is not correct. We know the deviation of these sensors."*
  Participant: *"Do you think that this is a systematic error?"*
  Interviewer: *"No, each sensor has a different error, so all the sensors have been located for some week at a reference station to know this error."*

Measuring air quality in a relative way might have been a "plan-B"-scenario…

Although this idea might have opened doors, some of the other potential pitfalls might have closed them again as it was also mentioned that the sensors sometimes seemed to be working quite slow (e.g. needing some time to adjust to new environmental conditions when moving through the city). And also problems with measuring negative values (which simply cannot be ignored) and problems with the GPS-data and/or time-stamps were mentioned by the participants:

- **Participant (from group of volunteers carrying the LEOs):** *"If I change from heavy traffic location to a clean environment, I expect the device to notice that and provide me lower air pollution levels."*
- **Participants (peer group of students and scientists):** *"The device should be able to deal better with rapidly changing conditions that often occur in cities."*
- **Participant (from a peer group of students and scientists):** *"We often had to work with negative values. […] Partially negative ozone and NO_x levels were measured."*

- **Interviewer:** *"What didn't you like about the LEO's?"*
  Participant (from a group of volunteers carrying the LEOs): *"I also did not like that it wrongly showed that I was in the middle of the Pacific ocean or in the North pole."*
- **Participants (peer group of students and scientists):** *"In the case when the instrument [LEO] actually ran, several participants reported that the GPS data were wrong. Sometimes the device measured at times when the participants were not on the road or locations were recorded, where the participants were not at the detected time."*

Plan B might not work if the devices are to slow or place you on the Northpole

When it comes to the evaluation of the **accuracy of the CityAir-app**, many participants (and also the interviewers themselves) addressed that the subjective nature of this information might be a problem for the accuracy, reliability and/or comparability of these data. Some participants even had to admit that they found it sometimes difficult to judge air quality…

- **Participant (from a group of app-users):** *"I actually had issues with what color to choose. I was never in a situation where I would have experienced a terrible air quality."*
- **Participant (member of school):** *"The ability to give my own readings of air pollution, I found I didn't use much largely because I didn't feel I could perceive air pollution. I felt I could say that there was traffic around or no traffic, but not really to say that there was air pollution per se, so it had just been a proxy of traffic density. […] I can see how it might be useful for public engagement. But for me, my interest was in what the actual pollution levels are… "*
- **Interviewer:** *"It is not always clear if it's like… they are reporting more in general: 'I am worried about this place. Like, now in this moment there's a track in front of me.' That's a problem. It makes it very difficult for you to interpret what the people actually want to tell you. That's one of the points."*
- **Participant (from a group of app-users):** *"I noticed that in some cases you don't have the feeling that the air is polluted, were as in some cases you have the feeling the air is much more polluted than it actually is. It is difficult since it is a pure perception. For example cold air always feels fresher than hot and stagnant."*
- **Participant (from a group of app-users):** *"I do not sense the difference in air quality personally."*
- **Participant 1 (NGO health):** *"The problem is… It's very biased, so you can't trust it 100 percent. Someone can be coughing and say it's because of the air pollution, but it's not. But then again, if many people say the same things without knowing that others say it, then it's more trustworthy."*

Participants' comments about the accuracy of the CityAir-app

Also this participant explicitely questioned the subjective nature of the perception-based AQ-data.

- **Interviewer:** *"Is this as a product useful for you?"*
  Participant (scientist within the national authority): *"Ah yes, perceptions right… Not really. I think it looks good once you've mapped it, but I actually found my own perception was not the best."*
  Interviewer: *"How could you make it better?"*
  Participant: *"I think maybe if you, instead of focusing on air quality, maybe focus it a wee bit more on the sources around you. And to take away some of your own personal views of what air quality is actually like."*
  Interviewer: *"It's something we discussed with others, is that whole thing about perception and what we understand by pollution and quality. And that sometimes*

doesn't always match up."
Participant: *"No, I mean your perception in [city in country X] and how bad air quality is here, if you then compare it to, say, [city in country Y] or [city in country Z] and someone puts in their own perception, "It's ok in [city X]", it's probably twice as polluted as [city Y], it's poor there. So it's quite difficult that one."*

Participant's comment about the subjective nature of perception-based data

When comparing the CityAir-app (AQ-perceptions) with the LEO's, some of the participants clearly favored the potential of the data that might be gathered with the LEO, but again this was also related to the limited number of participants that would be using the CityAir-app. Others mentioned that the data from the CityAir-app should always be compared with measured values (because the subjective nature of the AQ-perceptions):

- **Participant (other researcher):** *"I think that at the moment, before you have a million of users, the better way to do it is actually to have good sensors – a better version of the LEO's – and then make the air quality modeling for the whole city. That way you can do much better work than with the perceptions. Because with 3 persons spotting their perceptions on a map [with the CityAir-app], it just won't work."*
- **Participant (citizen):** *"If the appraisal of the situation is only subjective, then it is difficult to communicate with authorities. Subjective feelings must be supported by measured values."*
- **Interviewer:** "*Is this an issue about sort of checks in the system, it's not a perception and what the actual pollution levels are?"*
  Participant (scientist within the national authority): *"Yes. If it was linked to something else and you could zoom in and say: 'Oh, those streets there are actually quieter than those streets there', because you can see the difference between people's thoughts. Maybe link it with the noise might be a good way of doing that. If you've got a noise app on the phone, haven't you?"*

Participant's comment about the combination of data

Other participants have recommended that data-quality of the CityAir-app might be improved already by increasing the number of users. This will also increase the comparability of the data:

- **Participant (other researcher):** *"If you have 20.000 people using the [CityAir-app] at the same time, then you can integrate and merge [their observations] together in order to form a continuous map then. That way you significantly improve the quality of your predictions."*
- *And maybe have some kind of a minimum that people have to…*
  I don't know, tap into the app to make that certain area very polluted or dangerous."
  Interviewer: *"Yes, like to say that one area it's polluted, it should be enough people participating."*
  Participant 2 (NGO health): *"Yes, a minimum to make it more representative. Not just one person who coughs, and then the whole city is in red."*

Participant's comment about the number of users

And it was also proposed that it should be possible to give clear and understandable instructions in order to avoid inaccurate registrations as much as possible:

- **Participant 1 (NGO health):** *"But if you have clear instructions on how you use it, clear instructions on what are bad levels, what is OK and what are medium levels… If people understand that, then they don't necessarily say it's red when it's not. So if the instructions are clear, and people understand it, that may help to have less*

misperceptions of how you interpret the air. So that's a good idea, at least to be able to understand… […] The criteria for saying 'today is bad', it could be like: 'Do you have problems breathing today? Can you feel it on your tongue?' and things like that. Instead of just: 'Does it smell?' Because the city center always smells of traffic. So there could be criteria for asking, before you press 'red'..."
Participant 2: *"And how long did it take you to notice your bad health. […] So if you can get parameters like that, then it is more reliable."*

Participant's recommendation to develop understandable instructions for data-input

Finally, also the **accuracy of the Long Perception Questionnaire** (or the accuracy of surveys more in general) was mentioned during the evaluation, for example in the comment below:

- **Participant (NGO health):** *"There are biases depending on how the people do commute…"*
- **Interviewer:** *"Yes. A lot of biases… And if people live in the center or around traffic avenues, the air quality is very bad and they can see it through their window, while others living close to the forest don't have the same experience. It is very polarized in [city X]."*

Participant's comment about the accuracy of the Long Perception Questionnaire

Besides these discussions about the accuracy of the tools, also the accuracy of citizen science in general can be questioned by some of the involved actors. In a very brief but interesting editorial – *"Rise of the citizen scientist"* in Nature (18 August 2015) it was argued that *"critics have raised concerns about data quality, and some studies do find that volunteers are less able to identify plant species than are academics and land managers"* (Anonymous, 2015). One of the readers commented that data quality is indeed a challenge, but that citizen science is nonetheless also very useful:

> *"Citizen science has all the data challenges of non-crowd-sourced data, with an additional layer of statistical and analytical complexity on top. Citizen science doesn't make one's science easier – it makes science possible that would not be so otherwise. […]"*
> (Brooke Simmons commenting on the Nature-editorial, message posted on 20 August 2015).

And there were also comments on the editorial in which it was emphasized that citizens are definitely able to produce good data, and that setting up and sharing common methods for data gathering by citizens – thereby increasing scientific rigor – will even improve these performances. One commenter also argued that citizen science might even produce the most robust science (because it will be more critically evaluated).

- *"The slightly condescending tone and the advice to stay out of politics aside, it's nice that Nature has noticed the fact that the quality of data collected citizen scientists is on par with data collected by professionals. For those with doubts on that score, see… [referring to a study by Vianna et al. (2014) about 'Acoustic Telemetry Validates a Citizen Science Approach for Monitoring Sharks on Coral Reefs'."*
  (Michal Bear commenting on the Nature-editorial, message posted on 26 August 2015).
- *"Careful selection of the tasks you assign to citizen scientists is critical. If the research team constructs a project with specific, uncomplicated instructions that do not assume any prior knowledge on the part of the volunteer they'll probably be surprised at the accuracy of the results."*
  (I. Lipman commenting on the Nature-editorial, message posted on 20 August 2015).
- *"[…] What really matters is the scientific rigor behind the data collection methods and an understanding of the limitations of the data set, not the motivation of the participants. We need to set up and share common methods for Citizen Science data gathering that run across national boundaries and will provide regional data sets that allow real performance comparisons to be made. Only then [we] will be able to encourage Government to tackle the environmental problems of our era with the*

energy and robustness that currently is all too lacking."
(Martin Brocklehurst commenting on the Nature-editorial, message posted on 21 August 2015).

- *"The fact is, statistical testing and good design are already used to identify and minimize bias in citizen science projects."*
(Greg Newman commenting on the Nature-editorial, message posted on 15 September 2015).
- *"One reason citizen science may end up producing some of the most robust science is because it is held to a higher standard than "traditional" science – data quality and transparency are explicitly addressed in experimental design and analysis and more critically evaluated by reviewers."*
(Sean Ryan commenting on the Nature-editorial, message posted on 20 August 2015).

Apart from these arguments about citizens ability to produce good quality data, also the disadvantages of this very strong scientific focus on data quality – in which *"scientists judge the performance of citizens who are only asked to fill in the blanks in a story written by scientists"* – were addressed. From an empowerment perspective, the arguments below are probably much more important as they can indicate possible barriers for achieving some of the overarching goals of the CITI-SENSE-project:

- *"[…] Most projects view data quality as compliance to scientific protocols (e.g. accuracy of species identification). In this sense, citizen science amounts to asking citizens to fill in blanks in a story written by scientist. This focus on predetermined, and possibly narrow, interests of scientists can bias data collection is ways analogous to the 'conflicts of interests' (among citizens) concern raised in the Nature editorial. Hence, there is more to the question of data quality in citizen science than these recent high-profile publications admit. As citizens generally lack formal scientific training, they view problems and issues according to their own knowledge and interests. This expands quality concerns beyond ensuring that citizen science data adheres to scientific protocols, to include the extent to which projects benefit from citizens' abilities to spot new phenomena, or capture local knowledge and individual perspectives. Illustrating the implications of this view, a recent study shows that the traditional emphasis on species identification accuracy comes at the cost of data completeness and discovery. In trying to hold amateurs to scientific standards, we not only ask non-experts to perform often unrealistic tasks but risk missing the opportunity to fully engage with people in the core objective of discovery. The hard problem of quality in citizen science is writing a story in which citizens contribute to the plot (Lukyanenko et al, 2014)"* (Jeffrey Parsons commenting on the Nature-editorial, message posted on 8 October 2015).
- *"[…] The editorial presents an all-too-common scenario where scientists judge the performance of citizen scientists. An individual's performance is defined by the attainment of their aims. Scientist's typically aim to secure high quality data. Motivations for participating in CS are numerous and diverse, and gathering data is a fraction of the process of CS. Understanding participant's motivations, factors driving satisfaction, and societal benefits derived from CS initiatives go a long way towards ensuring multiple benefits for all in society. CS initiatives directly and indirectly improve public health, build community cohesion, improve knowledge relevant to the public good, and deliver cost-savings for many organizations. They also galvanize scientists to collaborate with people in their local environments, and promote science as a valid and useful form of knowledge (increasingly important given the decline in public confidence of science). As this editorial demonstrates, professional scientists can, perhaps unwittingly, elevate themselves intellectually, morally and ethically above the rest of society, when they should be engaging more productively with it. When judged by these criteria, the performance of scientists, not citizens, becomes the greater concern."*
(Gail Austen and Andrew Knight jointly commenting on the Nature-editorial, message posted on 10 September 2015).

This idea was also expressed by the participants, who stressed the importance of engaging people more actively, for example:

- **Participant (volunteer):** *"It's interesting... Even my husband got interested in this... (laughs). Which is saying something. Our son also thought it was interesting, and people who I met with while I was measuring were also quite fascinated by the whole*

thing. I think it's important to involve people and to get them to find out more about their environment, not just receive information passively. […]And coming back to this awareness: I think it's very important for awareness-raising that people are engaged and can actually do [these measurements]... And even though the data may not be totally reliable, it has an impact to increase public engagement, I'm sure."

Participants' comment about the importance of involving people actively

Another participant even argued that other people might be triggered to become engaged if they see people caarying these tools, etc., and proposed that they might be made widely available (to buy or to borrow):

- **Participant (member of school):** *"If these [LEO's] were widely available either to borrow or buy, then I could imagine having more than one. One to use myself and lending or giving others to friends to use. Some people are interested in air pollution but others who would potentially have some interest in air pollution if triggered to carry one around by friends such as myself. So they would also see what air pollution levels were – this is assuming once all the issues about accuracy have been ironed out – for their own routes to work and just to highlight that as an issue. I think the time is right now to do that because air pollution is a bit more on the radar and gadgets like this could help bring that more to the fore."*

Participants' comment about triggering other people to become engaged

As an overall conclusion, it can be sais that "accuracy" and "reliability" can easily become pivotal topics in these kinds of projects, but in a much more nuanced way then often expected.

3.6 Facilitating and hindering factors for these kinds of projects

Facilitating factors are defined as any factors which stimulate, provide or promote a fertile environment for the type of participatory research that CITI-SENSE has been doing, for example:

- **interest from the intended target groups** (or lack of interest)
  (incl. interest from authorities)
- **good overall communication and collaboration** with the participants
- **user-involvement in system-development (CO-DESIGN / CO-DEVELOPMENT)**
- **user-expectations regarding air quality** (and expectation management)
- **user-expectations regarding the tools, science and citizen science in particular**
  (and expectation management)
- **user-expectations regarding (local) authorities** (and expectation management)
- **user-attitude towards the COs** (or towards a particular CITI-SENSE-tool or the project)
- **involvement of a "champion"** (e.g. persons who make a difference, such as engaged teachers)
- **internal organizational support and organizational structure** (within the user-organization)
  attitude of top management (towards implementation of an EDSS, towards citizen science in general), openness to new work protocols, allocation of new responsibilities (from one authority to another, or within the same institution), commitment to use EDSS, etc.
- **external organizational support** (from the tool developer and/or provider)
  (e.g. availability of user manuals, training, support with the maintenance of the system, etc.)
- **external pressure** (from NGOs or from the public in general)
- **earlier experiences** (incl. "ballast from the past")
- **starting simple and small** (e.g. with technologies that have already proven to be reliable)
- **flexibility of the project team** to adapt to unforeseen opportunities and challenges
  (e.g. plan B-scenario's)
- **availability of resources** (e.g. money, time…)

Some of these facilitating factors (or also potential barriers) are mainly seen as external influences that can go beyond the control of the project management (often referred to as threats in a SWOT-analysis): e.g. external pressure, experiences that participants had in earlier similar projects (both positive or negative ones), the attitude of some users towards the COs or towards particular tools (e.g. use of Smartphones), the internal organizational support and organizational structure within the user-organization, etc.

Some of the other facilitating factors can be – at least partially – anticipated upon: e.g. interest from intended target groups might be created (to some degree), user-expectations can be managed (to some degree), flexibility of the project team to adapt to unforeseen circumstances (at least to some degree), etc. Finally, there are also factors that can be definitely taken into account by the project leaders right from the start during the project-design and also during the whole process: e.g. good communication and collaboration, user involvement in the development of tools, the availability of resources, the recommendation to "start simple and small" in technological projects like CITI-SENSE (especially when stakeholders are involved), etc. For many of these partially manageable factors (which are also strongly intertwined), it is crucial to emphasize the importance of good overall communication with participants, expectation management and user-involvement when developing the tools and the engagement process. In order to avoid possible disappointments that might lead to an early drop out of some of the involved stakeholders, expectations need to be managed to some degree. To a large extent, participants believe that a project has succeeded (or failed) based on whether the project has been able to meet their expectations and/or needs. Most of the times, projects don't fail in an absolute sense, but they rather fail to meet individual expectations. Even when all of the original goals in the project were met, some participants might still say that the project has failed (based on their own perception).

Expectation management tries to deal with these issues. Of course, it is not always possible to avoid disappointments, but when expectations are too high then disappointments will occur more easily. Therefore, it is important to discuss what can be expected (for instance when setting out the specific goals and actions for the project) and to be careful about what is promised (on the project website, during public meetings, in more informal conversations with stakeholders and/or in project-proposals). Furthermore, it is also important to discuss openly the uncertainties that are still remaining (for instance regarding the accuracy, reliability, etc.) during the development of the CITI-SENSE-tools. It is often not so much of a problem if a measuring device cannot measure everything 100% accurately. However, this problem might become significant if people expect that the tool will be able to do this while it cannot. Managing expectations is also about giving participants a good overview of the overall process and how they fit into the bigger picture. Good overall communication with the participants is crucial and user-involvement in the development of the engagement process and the development of the CITI-SENSE-tools can help to manage expectations to because user-needs will be taken into account from an early stage already. This will also require some flexibility to adapt to unforeseen challenges (Verheyden et al, 2013).

Expectation management is not only about avoiding failure. A good insight in the expectations of stakeholders will also bring opportunities. A project can become very successful when it exceeds expectations, sometimes in unexpected ways. Especially when "normal" is the standard that is expected by the participants and the project delivers results that are much better than normal, it will definitely be called a success. This should lead to the conclusion that it might be a good strategy to "under-promise and over-achieve". Aiming too low is not a good idea either, because in that case people will not be very interested in the project then (and it will be very hard to find volunteers). But the recommendation to start "simple and small" (e.g. with technologies that have already proven to

be reliable) is very relevant when different goals – including social goals – have been set. As often, finding the right balance is important (Verheyden et al, 2013).

Expectation management can help to avoid taking the road to disappointment

The user-evaluation can also be analyzed in terms of these facilitating factors (and barriers). In the individual comments, many spontanuous indications were seen (for instance about the perceived lack of interest which seems to be somewhat in contradiction with some of the EU Barometer results, about the communication with the stakeholders, the user-expectations (in various ways) and the user-attitudes, etc. This kind of analysis still needed more research work to be done, so it was not (yet) possible to do this within the scope of this report.

4. User-evaluation of the overall outcomes of the project

In this chapter, the overall outcomes of the CITI-SENSE-project will be analyzed from an empowerment perspective. Evaluation checklists were developed in preparation of the empowerment evaluation. The target group for this evaluation consisted of local people collaborating with or contacted by those Empowerment Initiatives (EIs), such as individual citizens, members of local groups (NGO's), students, teachers, local authorities and other stakeholders involved. These persons were interviewed by the local project team members, either in individual interviews or in group interviews. The information collected during these interviews will help us to interpret and explain the empowerment potential of the CITI-SENSE-tools from a social scientific perspective. This chapter will build on the comments from the end-users themselves (during the participatory evaluation of the tools).

4.1 Introduction

Evaluating outcomes and impact of research in terms of empowerment can be very challenging. Societal impact is much harder to measure than pure scientific impact, and societal impact can often take many years to become apparent, and the routes through which research can influence individual behavior or inform social policy are often very diffuse (Martin, 2011; Rymer, 2011). First of all, there is the challenge of defining "societal impact" of research. Sometimes, these impacts are rather postulated than demonstrated. There are various problems that can arise in the context of societal impact measurements, for example (Bornmann, 2012; Martin, 2007):

- the causality problem: it is not clear which impact can be attributed to which cause;
- the attribution problem: impact can be diffuse or complex and contingent, and it is not clear what should be attributed to research or to other inputs;
- the timescale problem: premature measurement of impacts might result in policies that emphasize only short-term benefits, while ignoring other potential long-term impacts;
- the expertise problem: the evaluation of research in terms of societal impact might take scientists beyond the bounds of their disciplinary expertise;
- the problem of opposing visions towards the outcomes: societal impact of research is not always going to be desireable or positive, and various involved stakeholders might have very opposing opinions on this;
- the problem of unawereness: some scientists are actually often unaware that their research has a societal impact (or they don't perceive everything what they do to be contributing to the societal impact goals;
- etc.

Besides that, some scientists might see societal impact measurement as a threat to their scientific freedom (for instance because there is indeed a risk that the allocation of funds will be increasingly oriented towards societal impact issues). A strong focus on societal impact of research might contribute to the real danger that researchers and research institutions will intensify their efforts to participate in activities that can be easily documented in terms of societal impact (instead of participating in activities that are harder to document but that are in reality more useful for society). There is also the risk of the bias against publishing negative results (Bornmann, 2012; Erno-Kjolhede et al, 2011; Hanney et al, 2000, Stepenuck et al, 2015).

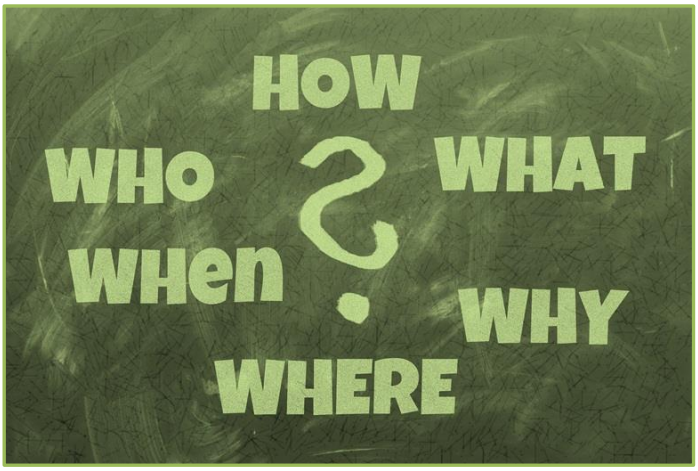
Regarding the evaluation of outcomes of volunteer environmental monitoring programs, the importance of reporting "null" or negative outcomes were also addressed by Stepenuck et al (2015), as these experiences can be very valuable for other practitioners. Regarding attitude and behavior changes for instance, it is also important to understand how and why they have (or have not) occurred, and to what extent. But it is also known that there is a bias against publishing negative of null results,

as there is also an inherent risk in sharing null or negative results because doing so may mean loss of support for the monitoring program. When published, such knowledge would give others the opportunity to learn from the reported outcomes and to avoid possible pitfalls (Franco et al, 2014; Stepenuck et al, 2015).

Based on the results that were described in 35 articles about volunteer environmental monitoring, Stepenuck et al (2015) found that most of the individual and community-level outcomes that were reported occurred within 8 years or less following the initiation of the moniroring activities. This means that some outcomes might still occur beyond the timeframe of the CITI-SENSE-project. Sometimes, some of the reported outcomes – such as for instance behavioral changes – might be more superficial then desired, and outcomes such as the improvement in particular skills related to diplomacy, public speaking, effective networking, etc. can be difficult to measure (Stepenuck et al, 2015). Many studies that have carried out societal impact measurements chose to do so on the basis of case studies. Although labour-intensive, it seems the best way of measuring the complex phenomenon that is societal impact (Bornmann, 2012). CITI-SENSE has been working with local case-studies – the Empowerment Initiatives (EIs) – which enables a local user-evaluation for the first (intermediary) outcomes and possible impacts of the project.

4.2 Framework for the evaluation of the project outcomes

For the evaluation of the outcomes and impact of the project, the "Expected impact"-chapter in the project-proposal in combination with the concrete (local) goals as they were set in the individual EIs are a good starting point to set up an evaluation assessment.



From ideas to concrete actions… and to the user-evaluation of the outcomes
(www.pixabay.com)

4.2.1 The expected impact (at project-level and beyond)

CITI-SENSE wanted to address the calls requirement for "new and innovative environmental monitoring and information capabilities for effective participation by citizens in environmental governance". In the "Expected impact"-chapter, it was described how the CITI-SENSE project wanted to empower citizens in the EU and in the partner countries in two ways:

1. by giving them unprecedented effective participation in the EU's environmental governance;
2. by providing them with unprecedented quantitative environmental information at citizen level, including quantitative estimates of the errors in this information.

For the evaluation of the empowerment aspects, the most relevant (social) impact that was expected was to provide support for evidence-based decision making for EU policies in the field of the environment, including support for the Resource Efficiency initiative. Besides fot instance the development of a platform to provide a flexible, transparent, effective and user-friendly information and service chain between providers and end users of environmental information (e.g. web-based techniques), the project also wanted to provide decision makers with models that can facilitate connections between environmental governance, global policy objectives and citizens' needs (e.g. based on the results of the EIs). The project wanted to have significant scientific, commercial, policy, urban, societal, and standards impacts. We will focus on the policy impacts, the urban impacts and the societal impacts (as these are most relevant from an empowerment perspective):

- **Policy impacts**: CITI-SENSE provides an opportunity to develop the mechanisms needed to implement the two-way interaction between policy makers and citizens fundamental to empower the citizen and allow him/her to influence environmental governance.
- **Urban impacts:** CITI-SENSE provides an opportunity to contribute toward the infrastructure needed to design smart cities and help design an urban environment where the citizen is empowered and benefits from timely, tailor-made environmental information, and influences the development of the urban landscape.
- **Societal impects:** CITI-SENSE provides an opportunity to empower the citizen, and by extension society, to participate fully in the decision making process concerning environmental governance.

Finally, CITI-SENSE also hoped to address the need for a European approach when it comes to the empowerment of the citizen to participate in environmental governance, as European environment policy is done at the EC-level. Therefore, CITI-SENSE aimed to provide in a framework for the European approach needed to address empowerment of the citizen to participate in environmental governance.

4.2.2 The (local) goals for the individual case studies

The earlier concrete project goals that were proposed at the local level – and which were partially different for the individual Empowerment Initiatives (EIs)) – have been summarized below, based on Deliverable 2.1 and 3.1 (Cole-Hunter et al., 2013; Kåstad Høiskar et al., 2013):
Summarized and clustered objectives mentioned for the **outdoor-AQ case studies** as they were mentioned in the beginning of the project (Cole-Hunter et al., 2013).

- **General goals:**
  - Testing crowd-sourcing mechanisms for reporting environmental conditions in cities;
  - Evaluation of the overall feasibility of citizens' observatories;
- **Specific technical goals:**
  - To develop and test infrastructure and sensor platforms (for environmental quality);
  - To develop a citizen platform that provides a detailed overview of the current air quality and weather situation within the city (e.g. denser and better networks);
  - To develop a situation- and location-based warning service for citizens that provides personalized environmental and health information;
- **Social goals:**
  - To engage with (local) stakeholders (e.g. local authorities, NGOs, individual citizens, local cycling groups, patients, schools, local business owners, etc…) to use personal sensors;
  - To engage with them so that they become more interested, involved and proactive with respect to air quality issues in their city;
  - To facilitate discussion (interaction) between the general community and policy makers about urban environmental quality;
  - To demonstrate engagement of the public in data collection;

    - To inform about health risk and quality of life;
    - To raise awareness of urban air quality and to broaden public interest;
    - To create a better understanding of related issues;
    - To provide tools to enhance public participation and to build capacity in groups with air quality-related health concerns;
    - To get people involved in urban planning decisions and environmental policy (based on the data that is produced);
    - To empower the public towards real implementation of legal standards of air protection;
- **Goals related to creating knowledge:**
    - To test crowd-sourcing mechanisms for environmental conditions;
    - To evaluate citizens' observatories;
    - To contribute to the knowledge about responses of the human body to air pollution;
    - To disseminate concepts and products for air pollution and exposure data (in the scientific community);
    - To evaluate how new sensors can help in urban planning;
    - To contribute to public discussions about the nature and origin of air pollution;
    - To get feedback on products and tools that will be used in main study (e.g. feedback questionnaires, instruction documents, data cleaning protocols, etc…)
- **Goals related to policy development:**
    - To give communities, decision makers and researchers an approach to work together;
    - To get citizens actively involved in urban environmental policy;
    - To influence interactions between local policy makers and major industrial stakeholders by broadening public interest and building positive pressure;
    - To suggest policies on how to decrease the air pollution exposure;
    - To evaluate how new sensors can help in urban planning;
    - To enlarge support to the broader public debate over air pollution issues and to enlarge public consensus;
- **In the end, this should be leading to… (outcomes):**
    - To improve urban environmental quality;
    - To (do the first steps to) establish a healthier and greener city;
    - To become one of the more "green-minded" cities in Europe.

The aims of the case-study in **Vitoria-Gasteiz (public spaces)** were somewhat specific, and related to the process of designing public places from an environmental point of view including comfort criteria:

- Allow citizens or local communities to share quantitative and qualitative information related to the environment of existing public places as well as their well-being in those places;
- Support a dialogue between citizens/local communities and the authorities to adapt their planning process to improve or preserve the environmental conditions in these public spaces;
- Provide information on how to manage the expectations arising from citizens empowerment;
- Testing the critical aspects of the technical side (i.e. performance of the application, etc.)
- Improving the participative processes of the citizens in the urban design of their city;
- Help decision-making processes.

Summarized and clustered objectives mentioned for the **indoor-AQ case studies (the schools)** as they were mentioned in the beginning of the project (Kåstad Høiskar et al., 2013):

- **General goals:**
    - Testing crowd-sourcing mechanisms for reporting environmental conditions in cities;
    - Evaluation of the overall feasibility of citizens' observatories;
- **Specific technical goals:**

    - To develop easy tools that are attractive and enjoyable to use: sensor-technologies, web-sites and applications must be easy to use;
    - To develop mechanisms for quality-assurance of data and content;
- **Social goals:**
    - To include all relevant stakeholders (e.g. pupils, teachers, janitors, etc…) in indoor air-quality monitoring;
    - To include these stakeholders in the consequential processes for identifying problems and solutions to poor indoor environments (e.g. collaborative governance);
    - To involve these stakeholders throughout the whole process (e.g. framing the risks with regard to poor indoor environments, generating a common understanding of the problems and risks, and enabling all stakeholders the opportunity to voice their opinion);
    - To offer shared online/offline spaces where experts, school stakeholders and authorities can meet, communicate and collaborate (in making sense of data, in generating a common understanding, in decision-making and in taking action);
    - To support citizens' participation;
    - To make it easier for participants to fulfil legal or job-related obligations (e.g. to ensure and document indoor climatic quality based on provided tools and data);
- **Goals related to creating knowledge:**
    - To provide tools and data on indoor air quality;
    - To prepare communication materials that are suitable for different stakeholders;
    - To use social media to create awareness of the pilots in the local communities;
    - To provide sufficient training and assistance;
    - To create opportunities to learn about sensor-technologies and environmental risks in a practical and hands-on project;
    - To explore the possibilities of integrating the technological and information solutions into the education of secondary age pupils;
    - To evaluate the process and the success of the products.
- **Goals related to policy development**
    - To take care that contributions (participation) have real impacts on decision-making and actions;
    - To address possible conflicts of interests, opinions and values;
- **In the end, this should be leading to… (outcomes):**
    - To improve indoor environment in schools;
    - To contribute to a better health and learning performance.

4.2.3 Checklist: potential empowerment outcomes from the literature

Although the “Impact-chapter” and the list of local goals for the individual Empowerment Initiatives (EIs) already gave a good overview of potential project outcomes that could be expected, the methodological support team on engagement and empowerment has chosen to compare them also with a list of possible outcomes based on the insights and best-practices that would be found in the literature. The lack of such a detailed overview of the various types of outcomes was addressed by Stepenuck et al (2015), who argued that in the past there have been done only rather limited efforts to synthesize the wide variety of outcomes that have occurred for individuals who participated in the monitoring programs or for the communities in which these programs operated. As a result, practitioners might lack knowledge to effectively model successful initiatives, which can lead to a waste of valuable resources or can limit external support (e.g. funding), and which might also potentially hinder participation if (personal) benefits are not recognized or promoted and volunteer motivations are not taken into account (Stepenuck et al, 2015; Measham et al, 2008). Therefore, various types of outcomes of volunteer environmental monitoring programs (both on individual and/or community

level) have been synthesized by the authors based on the analysis of 35 articles. This list – which covers the whole spectrum of outcomes that can be expected in the CITI-SENSE-project – will be used in the analysis of the user-evaluation (see Table 2).

Outcomes may occure in various ways and different quantities…

Table 2: Evaluation framework for the CITI-SENSE-project and the tools (part 2 – outcomes)

- **Gain of knowledge** at the level of individual participants and/or the community:
  - Gaining scientific knowledge
    - Knowledge gain reflecting the topic of focus
    - Knowledge gain beyond the immediate topic of observation
  - Learning new skills
    - Skills related to the process of monitoring
    - Skills related to community leadership
    - Skills related to activism
    - Skills related to media engagement
    - Skills related to advocacy
  - Experiencing social learning (e.g. learning as a result of interactions with others, which results in reassessment and potential change in an individual's underlying assumptions about a group or an issue)
    - Changes in personal feelings based on interactions within diverse groups (for volunteers, scientists, etc.)
    - Changes in assumptions based on interactions within diverse groups (for volunteers, scientists, etc.)
  - Increase in awareness of environmental issues
    - Increased awareness as a result of public involvement in monitoring
    - Increased awareness as a result of sharing results
    - Increased awareness as a result of media attention that resulted from citizen participation and subsequent broad scale dissemination of scientific information about the topic
- **Change in attitudes and/or behaviors** on an **individual level**
  - Changes in participants attitudes (often directly linked with social learning)
  - Changes in participants behaviors (active/passive)
    - Increase in political participation
    - Change in land-use management techniques
- **Change in attitudes and/or behaviors** on **community level** (which can be tightly linked with community awareness-raising)
  - Changes of views of citizens and officials in regard to decision-making about land-use management and policies (for example leading to different voting preferences).
- **Attainment of social and personal benefits**
  - Building friendships and social networks
  - Enjoying the work they do and being proud of their accomplishments
  - Having purpose (e.g. something tangible and meaningful in which to put their energy)
  - Having feelings of empowerment and self-worth
  - Becoming attached to (new) places (by getting to know them better)
  - Basing career choices in the experience gained through participation in such programs
  - Possible negative outcomes:
    - Having feelings of being overtaxed (due to increasing reliance on volunteers due to cuts in professional staff)
    - Having concerns about the state of the environment *[also often the aim of awareness-raising]*
- **Increase in social capital** (comprising the economic and personal benefits gained for individuals and communities by interactions among community members)
  - Increased size of personal networks
  - Development of partnerships
  - Community influence
- **Attainment of voice in decision-making**
  - Feelings of being empowered and feeling more confident to express their ideas to others (incl. managers, authorities, etc.)
  - Evidence of the integration of local input from volunteers when new natural resource management rules and regulations are being developed with (representing a change from past practices (e.g. top-down-development))
  - Possible negative outcomes:
    - Increased feelings of frustration because policy-makers fail (or refuse) to use citizen-generated data (even if volunteers have taken no action to share actively their results beyond submitting data to the monitoring program)
    - Increased feelings of being left out and/or manipulated when participating in meetings with policy-makers, etc. (e.g. one-sided outcomes or token exercises: see also Arnsteins' ladder of participation)
    - Increased feelings of frustration due to internal power differentials (as a challenge to effective citizen participation in decision-making)

Table 2: Evaluation framework for the CITI-SENSE-project and the tools (part 2 – continued…)

- **Influence on natural resource management practices or policies** *(which is often the ultimate goal that volunteer monitoring groups seek to achieve)*
  - Evidence of interim outcomes (which often parallel components of social capital)
    - Increased communication between citizens and managers, authorities, etc.
    - Increased cooperation
    - Increased collaboration
    - Increased trust among stakeholders
  - Evidence of improved natural resource management practices (after volunteer environmental monitoring data demonstrated negative environmental impacts)
- **Increase in the amount of civic participation and in the effectiveness**
  - Increased personal activities of volunteers and their influence on administrative decisions and processes (that help to minimize environmental impacts)

When an EDSS-tool would also propose possible solutions (or potential actions to be taken) to the end-users as a form of output, the (overall) acceptance of these solutions should be evaluated in a similar way (this in order to avoid undesired outcomes). This evaluation of proposed solutions should also take into account:

- social acceptability (e.g. “social justice”, legislation, etc.);
- political acceptability (taking into account that goals regarding empowerment can be contradicting to political acceptability);
- practical acceptability (usefulness of the solutions, etc.);
- economical acceptability (e.g. cost-efficiency, financial investment, time-investment, etc.).

In the end, the ultimate indicator of the CITI-SENSE-project and particular tools will be reflected by the uptake of tools, the outcomes and/or the impact of the CITI-SENSE-process and the tools. The actual uptake of the tools can be expressed by:

- The fact that a tool is used (in general);
- The fact that this tool is used by the intended end-users (e.g. vulnerable groups, patients) and for the intended purpose (e.g. learning, decision-making, empowerment, etc.);
- The number of individual users of a tool;
- The number of intended user-organizations using a tool (e.g. potentially having more impact on policy-making and having a multiplication-effect).

4.2.4 Intermediary outcomes as perceived by the participants

Within the timeframe of this project, it was not possible to evaluate all kinds of outcomes, especially not the outcomes that might require more time to occur. It was mentioned earlier that some of the results regarding volunteer environmental monitoring might occur years after the implementation of the activites, after up to 8 years or longer (Stepenuck et al, 2015). Nonetheless, in order to gather some information about this, the participants were asked which external factors that they perceived as a potential barrier for these outcomes. These barriers can range from individual limitations to unwilling authorities (see also previous section about barriers) and might help to explain why it is not always easy to directly relate the success of this project to the observed outcomes. Sometimes there are also complicated and somewhat ironic situations that can influence the outcomes, for example target groups (such as asthma patients or the elderly) who will definitely benefit from better air quality, but who are not always able to contribute to this improvement themselves (all the time).

- **Participant 1 (NGO health):** *"You have to weigh every issue against each other. And many of our members... On the worst days, if the app shows that today it is horrible air quality in [city X], they actually need to ride their car."*
  Participant 2 (NGO health): *"Yes, or take a taxi, and then you pollute more."*
  Participant 1: *"Yes, then you actually contribute to worse air quality. But then it's already bad, so… It's ironic, but still. That's how it is."*
  Interviewer: *"Yes. Because they are more protected in the car? You know that there are some studies that show that it depends on the model of the car and the ventilation in the car. But in some cars, you are actually more exposed, because you get the air. And then because you are in the traffic jams."*
  Participant 1: *"Yes, but you can of course shut down the outside air a bit. And it moves faster than walking, so they think at least that they are more protected."*
  Participant 2: *"It's not that exhausting as walking, either. With the lung capacity and the respiratory difficulties."*
  Interviewer: *"Yes, it's not the same to have a condition. Interesting."*

Examples of very specific conditions that might (negatively) influence the outcomes

On the worst days, people with respiratory diseases might be forced to take their car or a taxi: "It's ironic, but still… that's how it is…" *(www.pixabay.com)*

Regarding the outcomes that were expressed by pupils (in the Empowerment Initiatives in the schools), it is important to be more cautious. When interviewing the little children in group at school, often hints were given by the school teacher and/or by the interviewers (in order to find out what the children could think of as potential outcomes). Two typical examples are given below. The first example also shows the difference between adaptation (e.g. avoiding AQ-hotspots, which can also be disempowering) and negotiation (e.g. having a voice in the debate and asking to make air quality better

in some way). It is important to be very cautious with these statements, as they are only referring to potential outcomes (that have not yet been realized).

- **Participant (pupil of elementary school):** *"When I go somewhere, I check the map to see what other people think of air."*
  School teacher: *"And why were you doing that, what would you use this information for?"*
  Participant: *"What I breathe is an important thing to me."*
  School teacher: *"So, it is important to you what you inhale, and therefore does it mean that the map can be used to specify where you want to go for the weekend? Could it be used for that purpose? And for what else can this map be used?"*
  Participant (another pupil of elementary school): *"For example, for places that we know to have bad air, we can go around them."*
  School teacher: *"Yeah, to go around them. Good. And if it can be used for something more? What do you think? Do you think that perhaps in places where you have lots and lots these red little [markers], can you then request that something be done for environmental protection? Can the application be used for that? So that areas are marked, and then you can ask that the air is improved? To see why the air is polluted and to simply ask to make a better air quality in some way, can it be used for that?"*
  [Most probably many children nodding: "Yes."]
  School teacher: *"It can, good."*
- **School teacher:** *"What would you do, for example about traffic jams? Made mom and dad buy cars… to drive electric cars?"*
  Interviewer: *"To use public transport more?"* […]
  School teacher: *"Do you have any other ideas that you think could improve air quality? Perhaps the relocation of some roads out of the city, the main ones used by big trucks, which are big pollutants. And what can you do, can you instead of going to the market by car with dad and mom, go to them and say we'll go..."*
  Participants (pupils of elementary school): *"On foot."*
  School teacher: *"On foot, and we'll go..."*
  Participants (pupils of elementary school): *"By bicycle."*
  School teacher: *"So you'll help that the amount of exhaust gases which are toxic and are big polluters actually reduce. Imagine if we declare a day as a "No car day", or car-free day…"*
  Participant (pupil of elementary school): *"Yes, teacher, but if for example someone simply just not wants to buy an electric car, we can at least kindly ask them to buy the green petrol."*
  Interviewer: *"Well good. Bravo, bravo!"*
  School teacher: *"You should influence the minds of the people to realize that when they actually release pollutants during the combustion, that they are polluting the air for themselves also. So the awareness can be raised. Right? And what do you think about what we did last year? It was not related to this application, but we had a meeting with the parents where we showed them what we were doing. Does that raise awareness so that they can realize that the air is actually polluted partly because of our activities, kids?"*
  Participants (pupils of elementary school): *"Yes."*
  School teacher: *"Yes, that's one way to cast your vote for clean air in Belgrade."*

Examples from the interviews with school children, showing the hints that were given…

Although it is important not to overestimate the impact of the CITI-SENSE-project (up till now), the overall impact of the project should definitely not be underestimated neither. Also here it is obvious that perceptions of different people involved can sometimes strongly differ. This has been clearly indicated in the example below:

- **Interviewer:** *"I have the feeling that we haven't reach as many population as expected. It is true that we have 400 followers on Twitter and less on Facebook. When CREAL look for volunteers always find people interested to join in. But in my particular experience in CITI-SENSE I would like to have had more impact and arrive to more people."*
  Participant (authority): *"But you have to take a look to us, we spent lots of money in the equipment that measures constantly and also we have a lot of staff, [while] CITI-SENSE – in which low cost air pollution sensors have been used – has reached important media interest (TV and radio interviews). Another important aspect of this project is the participatory approach. Taking this into account, I think that the project has had a big impact. The project has reached the citizens, so you can be proud of what you have done."*

Example of differing perceptions about the achievements in the CITI-SENSE-project

Some participants concluded that – in general terms – the project was important, which is also an indication of the overall impact…

- **Participant (citizen):** *"I am sure that the project was important."*

Example of a very general comment regarding the (intermediary) outcomes

…but when analyzing the outcomes more in detail, it is important to look at the different categories of outcomes as they were described in the "methodological framework". First of all, indications of a gain of knowledge (both at the level of individual participants and/or at the level of the community) will be analyzed. Stepenuck et al (2015) emphasize the importance of focusing also on knowledge gains beyond the knowledge that reflects the content of the topic. Although many monitoring programs are also set up to educate particular audiences, it is very useful – especially when also empowerment is included in the project goals – to provide greater insight into the value of volunteer environmental monitoring as a public participation tool, by focusing also on improved knowledge and skills related to data synthesis, effective networking, public speaking, communication and/or diplomacy (Stepenuck et al, 2015).

Gain of knowledge, increased skills, social learning and awareness-raising

When looking for indications for the gain of scientific knowledge, a lot of concrete examples were found of participants expressing what they have learned (and how they have learned) from the project, and how they also start to look for possible (scientific) explanations themselves. But also the location officers have learned from the opinions – and knowledge – of the participants (see examples on next page).

- **Interviewer:** *"Do you think the data has helped you to learn? To learn more about air pollution? Like for example the questions you were raising: 'Oh, I see that in the afternoon there is more, is that right? Is it because it's not working correctly?'…"*
  Participant (volunteer): *"Yes, I think so. And also I didn't know before taking part in this project that there's good ozone and bad ozone, for instance. I thought we needed more ozone generally, but clearly not at ground level... [laughs]. So things like that I have become more aware of. And I also didn't actually know that carbon monoxide is much less of a problem now than it used to be. I guess I've seen too many movies where people kill themselves in their garage, so I thought that... (laughter)."*
- **Interviewer:** *"Did you learn something new, have you got new information within this project? "*
  Participant: *"What I mainly learned that it is possible to monitor a larger area, where thanks to those data, the information can be used, say, for determining the*

contribution of individual polluters to air pollution in a given location. […]"
Interviewer: *"From whom did you learn something new and gain new useful information?"*
Participant: *"Namely, from whom do you think? Unequivocally from you, and from every member of the team because everyone contributed in some way to awareness. The technicians who taught me to operate [air sampler], the people who came to maintain a smaller measuring station that I had also in the garden, there we discussed what it brings. I utterly hunger for such information. I also learned to use internet for searching and utilization of information."*

- **Participant (volunteer):** *"One thing I was surprised at when I looked at the data you sent me, is that in the evening... there seems to be more pollution in the air in the evening – on our balcony for instance – than during the day, when actually it feels less polluted. But I suppose it just accumulates during the day?"*
  Interviewer: *"Yes, it might happen, and... You can see in that the afternoon sometimes also in the reference stations..."*
  Participant: *"That they tend to rise? I guess it depends on wind and air pressure as well."*
- **Interviewer:** *"Did you learn something new, have you got new information within this project? "*
  Participant: *"Yes, I learned how to replace a [filter of an air sampler], this is also important information. What I mainly learned that it is possible to monitor a larger area, where thanks to those data, the information can be used, say, for determining the contribution of individual polluters to air pollution in a given location. […]"*
  Interviewer: *"From whom did you learn something new and gain new useful information?"*
  Participant: *"Namely, from whom do you think? Unequivocally from you, and from every member of the team because everyone contributed in some way to awareness. The technicians who taught me to operate [air sampler], the people who came to maintain a smaller measuring station that I had also in the garden, there we discussed what it brings. I utterly hunger for such information. I also learned to use internet for searching and utilization of information."*
- **Interviewer:** "Maybe you could tell how you have requested presentations *from us… what do you plan to do with them?"*
  Participant: *"I want to study them [so that I] have the information in my head and I could argue with them. And secondly, I want to use the presentations as evidence for prosecution which have already been filed."*

Examples of (intermediary) outcomes related to gaining new knowledge about air quality

Not only knowledge related to air pollution was gained, but also other many other interesting things.

- **Interviewer:** *"Did you learn something useful within the empowerment initiative? And from whom did you learn? Give examples!"*
  Participant (from a peer group of students and scientists): *"It was an exciting experience to participate in this project. It was also valuable to see that despite the professional character and competent people so many errors occur during this phase of the project. I have learned a lot in terms of own future projects. For me personally, the contact with students was valuable, to learn how to motivate them, how to communicate things better and respond to questions and problems. That was very instructive definitely."*
- **Participant (from a group of volunteers carrying the LEOs):** *"I did not know earlier that one can measure air quality in such small devices."*
- **Participant (from a peer group of students and scientists):** *"I have learned that there can be a variety of error messages. From the beginning we expected certain errors. However, over time new problems and combinations of these came up. We found out*

that there can be different solutions to these problems (e.g. the continuous lighting of the blue LED)."

- **Participant (from a group of volunteers carrying the LEOs):** *"I was happy to learn many new things. Not just about the device."*

Examples of (intermediary) outcomes related to gaining other relevant knowledge

Location officers were also able to learn from other countries that they got into contact with, and they also talked about these international experiences with the participants they were interviewing:

- **Interviewer:** *"We have a great problems with air quality but only few studies are performed in our country on this subject. I will show today that other countries have better air quality, but they do more studies and more issues are addressed there. For example in London, where I measured for certain time, they have improved air quality perfectly. Probably the only problem they have with nitrogen oxides, because there are a lot of cars. If the values of nitrogen oxides raise only slightly over the limit, people immediately call to the city officials, the media, the problem is on the front pages of newspapers, they fight for it, they do not want to live in environment where the limits are exceeded. This is a huge pressure, that is why they give the money to solve it."*

Indicative example of how people could learn from being internationally involved

Participants have also mentioned that they have learned new skills, although it is important to be more careful with these kind of indications (as it can be difficult to evaluate how much that these skills actually have been really improved, and if this improvement is also mainly related to the project activities in which these people have participated). During the interviews with one of the location officers (see chapter 5), it was also mentioned that some of the participants actively learned from each other (referring to the specific example in which the older generations involved were enabled to improve their Smartphone-skills due to the participation of younger generations).

- **Participant (from a group of volunteers carrying the LEOs):** *"Because of the LEO, I actually had to learn what is Bluetooth, as well more about 3G and Wifi, which I understand more now since I have used the LEO."*
- **Interviewer:** *"Did you learn anything in this project?"*
  Participant (volunteer): *"Yes, definitely. A bit about possibilities of new technology, I suppose. Clearly there's some way to go yet for this to be, but... Yes."*
- **Interviewer:** *"Did you learn something new within this project?"*
  Participant: *"Yes, I learned how to replace a [filter of an air sampler], this is also important information."*

Examples from intermediary) outcomes related to learning new skills

There were also participants who clearly expressed their opinion that they didn't learn much from the project, for instance because not all the CITI-SENSE-tools were working correctly, but also because they might have known already a lot about air pollution from earlier experiences:

- **Participant (other researcher):** *"Regarding the data, I did not learn anything from the data available on the web (the Dunavnet-portal). I work in research and I'm used to be critical. I expected pollutions levels much higher. But I couldn't check all the data generated by the sensor at the school. Only a month because the POD run out of battery and there were no options to download the historical data."*
- **Interviewer:** *"Have you learned anything new during the project?"*
  Participant (citizen): *"I have been fighting like this for 10 years. So it was rather a confirmation of my information."*

- **Interviewer:** *"Do you think the data [from the LEO] has helped you to learn? To learn more about air pollution?"*
  Participant (volunteer): *"Well, it... I don't think it has made any difference. I was quite engaged in air pollution before."*
- **Interviewer:** *"Have you learned something with your participation in CITI-SENSE?"*
  Participant (other researcher): *"Not much."*

Examples from participants who concluded that they didn't learn that much

Looking back at the abstract of the project description, awareness-raising was one of the central aims within the CITI-SENSE-activities:

> *"The project will develop "citizens' observatories" to empower citizens to contribute to and participate in environmental governance, to enable them to support and influence community and societal priorities and associated decision making. CITI-SENSE will develop, test, demonstrate and validate a community-based environmental monitoring and information system using innovative and novel Earth Observation applications. To achieve this, the project will: (i)* ***raise environmental awareness in citizens****, (ii) raise user participation in societal environmental decisions, and (iii) provide feedback on the impact that citizens had in decisions."*

Many direct and indirect indications for (the potential of) raised awareness were found in the interviews with the participants. Awareness can also be increased as a result of media attention for the project, which has been found to be useful. Following indications were found:

- **Participant (authority):** *"[…] CITI-SENSE – in which low cost air pollution sensors have been used – has reached important media interest (TV and radio interviews). Another important aspect of this project is the participatory approach. Taking this into account, I think that the project has had a big impact. The project has reached the citizens, so you can be proud of what you have done."*
- **Interviewer:** *"How would you evaluate the project activities?"*
  Participant (citizen): *"I am impressed that it helped to attract media attention so the problem came into attention, also of other people who did not participate in the project but who just saw the TV news. […] I am happy we cooperated a lot with the media thanks to the CITI-SENSE project, that is big plus."*
- **Interviewer:** *"How would you push the clerks, government, so they put the notices into practice?"*
  Participant (citizen): *"I think that media could help here, news, TV, etc..."*
  Interviewer: *"The TV was also at our seminar and the results were in the main news."*

Participant's comments about the media attention for the project

But on the other hand, raising awareness was not always straightforward. It is not because problems have not always been made explicit in the past (e.g. by speaking openly about it), that there was no awareness at all about these problems, for instance amongst the (young) participants.

- **Interviewer 2:** *"Tell me, before using the CityAir-app, how often did you think, if at all, about air pollution, the problems that air pollution can cause to humans, for example health effects and so on?"*
  Interviewer 1: *"Did you hear about it somewhere else?"*
  Interviewer 2: *"Did you ever hear about...?"*
  School teacher: *"Did you talk at all about it?"*
  Participants (pupils of elementary school): *"No."*
  School teacher: *"It is certainly important to you to live healthy, right? Your body... But before using these applications they were not thinking about it."*
  Participant (pupil of elementary school): *"But usually we smell it and try to get out."*

School teacher: *"So, you think about how much air is polluted or what kind of air you breathe only when you feel that it is not good (like the smell). That's what you wanted to say?"*
Participant (pupil of elementary school): *"I think, generally, and then I do not speak, but just ask my mom for example to go around the dumpster when we take a walk."*

Comment indicating that awareness-raising is not always straightforward

Besides that, people also need to be aware of possible solutions. Some participants have expressed their need to learn more from the tools in terms of possibilities to reduce air pollution (in order to enable people to take more concrete action). This shows that there is still room for improvement (e.g. for tools that are more solution-oriented), as being aware of possible solutions is an important step.

- **Interviewer:** *"If improved, what would the questionnaire help you do better?"*
  Participant (citizen): *"If the questionnaire was simpler and opened me up to other possibilities to reduce pollution I am now not aware of, I'd integrate them into my lifestyle and reduce pollution."*
- **Interviewer:** *"In your opinion, what conditions must be met to adopt the measures for air quality protection?"*
  Participant (citizen): *"I'd have to gain specific information on how I can improve air quality. I failed to gain such pieces of information. […] I'd appreciate concrete information on how I can be of any help."*

Participants commenting about the need to become more aware of possible solutions

Finally, participants have been emphasizing the importance of engaging people in these kind of activities in order to raise awareness. Even a simple questionnaire can help to change the mindset of people, and it can also be a step towards behavioral change and increased public acceptance of more concrete actions to reduce air pollution (as it was addressed both by an NGO and by an involved authority).

- **Participant (volunteer):** *"And coming back to this awareness: I think it's very important for awareness-raising that people are engaged and can actually do [measurements]… And even though the data may not be totally reliable, it has an impact to increase public engagement, I'm sure."*
- **Interviewer:** *"How would you evaluate the possibility of participation in the project?"*
  Participant (citizen): *"The citizens received a big possibility to participate in the fight against polluters, so only they could decide. Everyone has his own problems and work. I am enthusiastic about my participation which was used also in TV involvement. People see this and take care."*
- **Participant (NGO health):** *"The questionnaire itself is very useful for us as well, because this kind of project and these kinds of questions… If you have been asked, then your mindset is automatically changed. So I think people who didn't necessarily care when you ask them these questions, they automatically start noticing. So it builds awareness."*
- **Interviewer:** *"Do you think these kind of tools – like the questionnaires and apps to show air pollution – somehow also help to reduce the air pollution?"*
  Participant 1 (NGO health): *"Well, that's a complicated issue. You can change to electrical cars and everything, so there are a lot of ways to do better. But I don't think the app necessarily – or the questionnaire itself – changes air pollution, but it might change people's attitude towards legislation and laws. So maybe it helps the authorities to imply or to introduce new laws that are stricter in terms of what they can do and what kind of car you can drive."*
  Participant 2 (NGO health): *"Not maybe directly…"*

Participant 1: *"So I don't think anyone necessarily will sell their car after using the app. The people that are positive to these kinds of things, are already maybe outside walking or biking."*
Participant 2: *"They are more aware."*
Participant 1: *"Yes. So I think it doesn't change those things, but it changes the attitude towards new laws, I think, and the way we are restricted."*

Participants emphasizing the importance of engaging people in these kind of activities

Changes in attitudes and/or behaviors on the individual or community level

First of all, it might be seen as a first (preliminary) step towards potential behavioral changes when local people become more interested in the topic of air pollution (because they have been involved), but it was too soon to evaluate if these changes would really be long term changes. Nonetheless, the increased interest can open the door to other changes in behavior in the future, although this will take more time.

- **Participant (volunteer):** *"It's interesting... Even my husband got interested in this... (laughs). Which is saying something. Our son also thought it was interesting, and people who I met with while I was measuring were also quite fascinated by the whole thing. I think it's important to involve people and to get them to find out more about their environment, not just receive information passively."*
- **Participant (member of school):** *"So for it to change my behavior, I'd probably want to have used it more often."*

Examples of indications of people become more interested in the topic of air quality (which opens the door to other behavioral changes)

Also small practical changes in behaviors might be already expected...

- **Interviewer:** *"On the basis of the LEO, do you see any opportunities for you to improve air quality?"*
  Participant (citizen): *"I will improve my way of transport. I won't burn leaves in my cottage."*

Examples of (small) decisions that can be made in schools to protect children's health

Not all the changes that can be expected regarding participants behavior will necessarily contribute to their empowerment. As argued before, some of the outcomes might actually be disempowering too (even if they can contribute in a positive way to the health of the participants), because the only make people adapt better to (fundamentally) unfair situations (see also section about "ethics").

- **Interviewer:** *"This is a bit on the side, but like for example we are now preparing this proposal for kindergartens to also show air pollution, and the forecasting of air pollution to kindergartens. Do you also think that this kind of targeting information towards kindergartens, for example, for kids, can be useful?"*
  Participant (NGO health): *"Yes, that would be really useful, I think, because especially this winter there were lot of discussion about that and about how kids in kinder-gardens can't play outside in the most polluted areas. Maybe that will help the kindergarten teachers as well to have more activities inside, or maybe the parents can stay at home or maybe they can go to some place outside, plan a trip or something."*

Examples of (small) decisions that can be made in schools to protect children's health, but which may also be (or become) disempowering

There were no clear indications yet of changes in the views of citizens and officials in regard to decision-making about land-use management and policies (for example renewed points of view that lead to

different voting preferences). But the existing voting behavior of people was mentioned (as a possible limitation for solving air pollution or environmental problems in general).

- **Interviewer: "***About the limitations of the LEO - what can it not help you do better?"*
  Participant: *[…] "It can't help me to get people to elect politicians who actually take air pollution and environmental protection seriously."*

Small sample of participant's comments about the election of politicians

Attainment of social and personal benefits and increase in social capital

The importance of networking was emphasized by some of the participants. Being involved in the project could also help to develop social networks, as for instance researchers could bring them into contact with to other participants (thereby decreasing people's feelings of having to deal with the problems on their own):

- **Participant (citizen):** *"I push the city authorities, participate in the local council, make requests and complaints. Unfortunately I am alone, I do not know about anyone else!"*
  Interviewer: *"There are also other people, you should connect with [NGO X] for example. We have recommended this NGO also to other people who wanted to be active in these problems. It would be good if all of you can join together, exchange experiences and go further together so that you will be more powerful."*
  Participant (citizen): *"I also want to go to our senator. He should deal with my complaints. The air quality is really bad here."*
- **Participant (member of school):** *"If these [LEO's] were widely available either to borrow or buy, then I could imagine having more than one. One to use myself and lending or giving others to friends to use. Some people are interested in air pollution but others who would potentially have some interest in air pollution if triggered to carry one around by friends such as myself. So they would also see what air pollution levels were – this is assuming once all the issues about accuracy have been ironed out – for their own routes to work and just to highlight that as an issue."*
- **Interviewer:** *"Based on the usage of the LEO, do you seen any opportunities for others to improve air quality?"*
  Participant (citizen): *"Thanks to this new information, citizens should be more proactive, establishing citizen's organization and pushing state authorities more."*

Examples of bringing participants into contact with each other

Networking (from very local scale up to an international level by social media) can increase the opportunities to learn new skills… as individuals can actively help each other by taking up a role as trainer, coach, etc… *(www.pixabay.com)*

Some participants expected that local monitoring communities might be created, because people who have common experiences regarding air quality might start to talk with each other about their concerns and will become interested in the monitoring activities. This indicates that there is definitely a potential to start up these kinds of COs. Sometimes, just showing the application to friends was enough already (although this does not automatically means that it will become a real monitoring community).

- **Interviewer:** *"What actions have you taken (are you going to take within half a year) on the basis of this application?"*
  Participant (citizen): *"I showed the application to my friends and fellows."*
  Interviewer: *"Did they give it a thought?"*
  Participant (citizen): *"Yes, and now they are using the application."*
- **Interviewer:** *"Now it has been just a test of citizen observatories with a few volunteers, but as [another participant in the group] was saying: if the device was smaller and more people use it, do you think that it will create a community? Like, for example, you can also go to your neighbors and say: 'Hey, maybe we should think about that, and maybe we should make a platform, and maybe we should take actions to improve our neighborhood?'"*
  Participant (volunteer): *"I think so, actually, because I think if you start talking to people, a lot of people will have these concerns, a lot of people... When our son was in kindergarten just next to [the ring road], for instance, he had serious respiratory problems the first three or four years. These problems stopped when he started school. But he had to use Kortison-spray, which has never happened in either of our families. So it's not a genetic thing, it's just environmental. And I'm sure that this is a common experience, and a number of friends who knew that I was engaged in CITI-SENSE were actually very interested. One even asked me to come and measure in their back yard. So I think it would help. I'm sure a lot of people also were curious when we wore them around town. People probably wondered: 'What is this?'"*
- **Participant:** *"Now it is necessary to join forces and use that information to a common path and a common goal! To achieve something, one subject never reaches as much as a whole."*

Examples of (intermediary) outcomes related to an increase in (social) networking

For project coordinators or researchers, it is important to create these opportunities for participants, e.g. not only to disseminate the results at the end of the project (e.g. one-way-communication), but also to let participants ask questions (two-way-communication) and to enable them to network or even give them the chance to talk with politicians (at least if they are willing to do so). These kind of activities have been found to be very relevant. Also the willingness of researchers (or research institutes) to stay open to people's questions about air quality in the future can make a difference and is an aspect of (social) networking.

- **Participant 1 (volunteer):** *"One question, you [interviewer 1] wrote to us before that in August or in September there will be some kind of public event where you will share the data collected with the public somehow. Are you still planning that?"*
  Interviewer 1: *"Yes, it will be on September 1st. We have at least a date. We want to invite all of you who carried the sensor and also the kindergartens who had the static sensors."*
  Interviewer 2: *"We will also invite the authorities."*
  Participant 1: *"Very good."*
  Interviewer 2: *"We still don't have the agenda of how we are going to do it, but the idea is that it can be an open place. So we have presentations about the data, but we also want you to have the opportunity now that you all are together, that you can also talk with each other. Not only listen, but also raise your voice."*
  Interviewer 1: *"And maybe take a chance and talk to one of the politicians."*

Examples of (intermediary) outcomes related to social networking (part 1)

- **Participant (citizen):** *"I am very happy and positive that on this seminar about the project results also the mayor of the village was present, even if it was not until the end. I find out that also somebody from the municipality was here – this is perfect – so they know about the problems and it will be easier to speak about this problem with them."*
- **Interviewer:** *"You know that this [project] is finished, but you have our e-mails, so if you have any doubts about air pollution you can always contact us. Not only related to the project – our research institute is open to people, and we will try to answer your questions or redirect you."*
- **Participant (citizen):** *"I am very happy we have spoken about [city Z] which is close to [company X] and which has bad air pollution. The city mayor was there and had to discuss with us the problem."*

Examples of (intermediary) outcomes related to social networking (part 2)

One of the participants mentioned that he/she had a (secret) purpose from now on (in terms of convincing other people to become more environment-friendly) and having feelings of empowerment, but also warned at the same time about possible negative feelings of disempowerment if people would not be interested:

- **Participant (volunteer):** *"My secret hope is that I can pressure my husband now to use the car less, because actually he can see that it's affecting not only other people, but even the area where our son goes to school, for instance."*
  Interviewer: *"That's a good thing. […] And about the limitations of the LEO – what can it not help you to do better?"*
  Participant: *"Well, in its present form it can't help to measure other sources of air pollution except ozone and nitrogen monoxide and dioxide. But also it can't help me unless a lot of people take part in this. It can't help me to get people to elect politicians who actually take air pollution and environmental protection seriously. Because I like the idea of empowerment, but I don't feel at all empowered as long as people just continue polluting and driving when they don't need to and so on."*
  Interviewer: *"So your husband is keeping you from being empowered?" [laughter]*
  Participant: *"No, no, no… [laughs]. I refuse to drive... When he's driving downtown, I just refuse: "I'll meet you at the restaurant – I'm going to walk" (laughter)."*

Examples of having purpose and feelings of empowerment (or disempowerment)

Maesham et al (2008) argues with good reason that environmental programs which allow volunteers to pursue their interests, increase social contact and feel like they are making a difference, are more likely to be successful in the long term. But it is also recommended by the authors that environmental

managers need to recognize that labor alone is unlikely to match with volunteer motivations. In the most severe cases, there might even be some concern over the fine line between supporting and abusing volunteers (e.g. due to increasing reliance on volunteers to carry out tasks such as monitoring and restoration). No direct indications of these negative effects were found.

Attainment of voice in decision-making

Because the CITI-SENSE-results – for example the responses of people in the Long Perception Questionnaire – might be used in political statements, people can be given voice in these political processes.

- **Participant (NGO health):** *"So there is a lot of data in [the questionnaire] that is useful for us in our political work as well, so we can quote these things in our political statements and everything. So yes, it's very useful for us to have those kinds of data."*

Examples of (intermediary) outcomes related to giving people a voice (in decision-making)

But giving people voice in decision-making is definitely not enough. Important in terms of empowerment is that a lack of interest amongst other citizens and/or authorities – e.g. to listen and to actively search for possible solutions – might actually also contribute to feelings of frustration and disempowerment.

- **Participant:** *"[…] I like the idea of empowerment, but I don't feel at all empowered as long as people just continue polluting and driving when they don't need to and so on."*
- **Participant (citizen):** *"What can a citizen do against 'force majeure' sort of obstacles of state authorities...?"*

Participants' concern that a lack of interest might lead to frustration and disempowerment

Influence on natural resource management practices or policies and increase in civic participation

There were mentioned some (preliminary) results, although it is not clear if these were concrete outcomes from the CITI-SENSE-project (or from a much longer effort from citizens in raising the issue). But increased communication can also be one of the possible interim outcomes.

- **Participant (citizen):** *"I am happy that […] we can see small changes towards improvement, such as the bio bins."*
- **Participant (citizen):** *"I also want to go to our senator. He should deal with my complaints. The air quality is really bad here."*

Examples of (small) preliminary results

A general lack of interest in air quality or the unwillingness of people to really solve the (local) problems regarding air pollution can lead to feelings of frustration and disempowerment

Also authorities mentioned that an increase in communication would be beneficial, from their own perspective, for instance to make people more aware of the measures that have been taken already.

- **Participant (member of the authority – transportation sector):** *"If we do many projects but no one is aware of them, and the feeling among the public is that we ignore or conceal or… So it's a problem. The projects, people's suggestions… These things happen. Those are long processes, nothing is… In the field of air quality, nothing is immediate, yeah? These are things that happen. But it's good to know that it's not communicated enough, and that's what we mainly learn here."*

Examples of (small) preliminary results

Also possible positive impacts (in the long run) were addressed by one of the participants (at least if authorities are really willing to tackle the AQ-problems):

- **Participant (member of school):** "*I can imagine that for example, the online walking guides that if they had alongside them what the typical air pollution was for that walk, that would be something I imagine people would be interested in, in relation to the walk and also a means of highlighting air pollution. <u>And potentially a financial incentive for areas to reduce air pollution because if walks in one area were associated with air pollution, it could then potentially reduce tourism and income.</u>"*

Participant's comment regarding positive outcomes if problems would be tackled

Finally, the CITI-SENSE-project might also have contributed to an increase in the personal activities of volunteers with the aim to influence administrative decisions and processes.

- **Interviewer:** *"What did the questionnaire help you do better?"*
  Participant (citizen): *"It helped me to think more about air pollution issues in context with my lifestyle. <u>I'm pushing my parents to change the way our family house is heated. I'm trying to raise public awareness more than before</u>."*
- **Interviewer:** *"What opportunities do you see for you to use the project's activities for improvement of air quality?"*

Participant: *"Using the information from the project to spread awareness among people, to influence public opinion. This is the most important thing for me, because if we influence public opinion so that people will realize that health is a value at risk, then we can all move, bring politicians to accountability, as well as other people, officials who can finally take place, as they should."*

Examples of an increase in the personal activities amongst participants

4.2.5 Uptake of the CITI-SENSE-tools

Also the actual uptake of the CITI-SENSE-tools is an interesting indicator for success.

- **Interviewer 1:** *"How often have you used the CityAir-app? For example, during one day?"*
  Interviewer 2: *"Or during one week."*
  Participant (pupil of elementary school): *"During one week, 2 times."*
  Interviewer 1: *"Two, three times. Good."*
- **Interviewer:** *"What do you like about the CityAir-app?"*
  Participant (from a group of app-users): *"Some will use it also after the campaign and recommend to others."*
- **Interviewer:** *"What actions have you taken (are you going to take within half a year) on the basis of this application?"*
  Participant (citizen): *"I showed the application to my friends and fellows."*
  Interviewer: *"Did they give it a thought?"*
  Participant (citizen): *"Yes, and now they are using the application."*

Examples of the (potential) uptake of the tools

One participant also mentioned the idea to convince other actors to become involved in the AQ-campaigns:

- **Participants (group of volunteers carrying the LEOs):** *"Attach it on Google street view cars, on city bikes (with solar panels and GPS) and city busses."*

Example of improving the AQ-mobile-sensor-network (by involving specific actors)

Others have mentioned that they would not make any use of the LEO's (because of the current state that they are in, or because of other reasons such as being more interested in concrete solutions and not in monitoring the problem).

- **Interviewer:** *"So in the current state, none of you would have any use of it?"*
  Participant 1 (volunteer): *"No."*
- **Interviewer:** *"You have the opportunity to use the City Air app, how you evaluate this?"*
  Participant (citizen): *"I haven't been successful in using it much."*
  Interviewer: *"In general, you know how the app should works, do you think it is useful? Can this help to something?"*
  Participant (citizen): *"I am more for concrete solutions – regulations, laws, control, sanction!"*

Examples of the (potential) uptake of the tools

Current problems that might influence the final uptake of the tools.

- **Participant (citizen):** *"The [CityAir-app] is short on specific information on concentrations of pollutants. There is no specific benchmark that people can check out in terms of air quality to find out how things are. The application is underused and provides little information."*
- **Participant (other researcher):** *"I've tried several times to turn [the CityAir-app] on and off, but I couldn't pass the pop-up. What I've to say is that – and I'm not sure if I'm a representative person, but I'm not a tech person – the app didn't work for me. So I just gave it up. Maybe there are some people who may try to make it work. But for me, if doesn't work I don't fix it."*
- **Participant (volunteer):** *"If [the LEO] can be smaller, then more people can use them maybe for one week or a couple of weeks. So we can have more of them and you can start collecting data on a broader basis. So then it can add to the monitoring stations. Of course, ideally we should have top technology monitoring stations, but that's not realistic, so it's kind of an... It adds to the knowledge."*
- **Interviewer:** *"[Do] you plan to use the products or are there any opportunities for you or the organization to use the app."*
  Participant (scientist within the national authority): *"I haven't got plans to use the app myself, I must admit. I don't know if it's something that the organization will promote at this stage."*

Examples of factors inhibiting the uptake of the tools

Finally, one participant also acknowledged that ICT-developments can sometimes go very fast.

- **Participant (from a group of volunteers carrying the LEOs):** *"When I thought about it at the beginning, I thought it cannot be more user friendly or economic. But then I remembered that not so long ago also for example the GPS was used as external device and they were not integrated in the phones, and now everyone uses them. So it is possible. If it was a trend that they would integrate it in the phone or similar devices, then more people might use it."*

Examples of (very preliminary) indications of behavioral changes

5. How do experts look at the empowerment potential?

5.1 Introduction

In preparation of empowerment evaluation we developed evaluation checklists. The main target groups can be distinguished in two categories:

1. The location officers: the researchers responsible for the project work in local Empowerment Initiatives
2. Local people collaborating with or contacted by those Empowerment Initiatives: these could be citizens, members of local groups, stakeholders, students, teachers, local authorities, …

The first group was interviewed by one researcher from the project's methodological support group on engagement & empowerment. The second group was interviewed by local Empowerment Initiative teams, either in individual interviews or in group interviews, as presented in the previous chapter. In this chapter we focus on the first target group: location officers.

We did two separate rounds of interviews. The first round focussing on empowerment, evaluation of empowerment and on practical organization of the evaluation. This round preceded the evaluation interviews held by the location officers in their Empowerment Initiatives with local persons, and was meant as introduction, preparation of the practical organization of the local evaluation interviews. Apart from preparing the location officers for doing these local evaluation interviews, we also took the opportunity to ask them more general questions about empowerment and the evaluation of it, in order to get a view on how they understood and perceived related issues. We considered this important because location officers played an important role in the project's work, both on a project level and in the local Empowerment Initiatives. Furthermore it gave us the opportunity to get a view on how this group of experts, to some extent representing a specific expert community, view empowerment. In the second round, closer to the end of the project, we again interviewed the local officers for looking back at the project. This allowed us to look back with them on the work in the local Empowerment Initiatives and within the project at large. The information collected in these interviews will help us in interpreting and explaining the project's work over the years from a more social scientific perspective.

In the following chapter we will further introduce some more details about the interviews. Here we like to mention that all interviews were recorded, with permission of the interviewees, for further analysis. All interviews were transcribed. The analysis was done by two researchers of the project's methodological support group on engagement & empowerment, with the interviewer leading the analysis. All interview results will be dealt with anonymously, also when using quotes for illustration of particular issues. We mainly focus here on qualitative content analysis and will only give information about the frequencies of items and viewpoints, consensus or dissensus, overlap or diversity, when we consider this reasonable based on the small sample of interviewees and the fact that they did not have the opportunity to go into dialogue on the outcomes with each other or with the researchers doing the analysis.
The content analysis was done first by distributing the interview transcripts among the two researchers for first analysis per question. Then all outcomes of the first individual interview analysis were brought together under the main checklist categories dealt with in the interviews in order to get an overview of the key themes and viewpoints brought forward by the whole group of interviewees. The outcomes of that analysis form the core for the description of the interviewees' viewpoints in the following sections.
Because of lack of time (this work had to be done close to the end of the project), unfortunately, we could not get back to the interviewees to ask their feedback on the outcomes of the analysis. This may still be a possibility after the project's ending, for the purpose of follow-up publications building on the

results. The responsibility for the following interpretation therefore lies solely with the two researchers involved in the analysis.

5.2 First round interviews: location officers on empowerment, evaluation and practical organization.

Introduction

In total we did eleven interviews covering all Empowerment Initiatives. In this round of interviews mostly the location officers were interviewed together with the contact person from the project's methodological support group on engagement & empowerment dedicated to the particular Empowerment Initiative. The reason being that these contact persons were there to support the locations officers in their work, including empowerment evaluation, which at that moment still had to get started. In two cases there were two local location officers involved in the interview. The interviews were done over the period December 2015 to January 2016. Transcriptions were done by (or on behalf of) contact persons from the project's methodological support group on engagement & empowerment dedicated to particular Empowerment Initiatives. Transcripts were collected by the interviewer during the months following the interviews.

For the interview a semi-structured approach was applied, using a checklist with questions, while being open to additional discussion topics or questions popping up as being relevant during the course of the interview. One extra questions that popped during one of the first interviews, was included in most following interviews: included in the overview below. The questions touched upon the following issues:

- Definition of empowerment in the context of the project.
- Perception research & citizen science as potential forms of empowerment (extra question).
- Concrete project indicators for empowerment.
- The project's empowerment strategy.
- Opportunities & barriers for measuring empowerment in the project.
- Experience with assessing empowerment and participation.
- Important aspects for evaluation of empowerment.
- Inventory and application of empowerment enhancement activities/products.
- Planning of evaluation of empowerment.

In the following sections we will synthesize the interview results.

5.2.1 Definition of empowerment in the context of the project.

Difficult concept

What is striking is that several interviewee's struggle when asked for a description of empowerment, resulting in long pauses, qualifications like 'tricky' or questions for more clarification:

"*What are you after here?*".

This may mean that for some interviewees this only to a limited extent was a topic for reflection earlier on, even when the project is already in its third year. Or this may be a sign of the concept being complicated, strange to the background and experience of the interviewee, it is seen as something difficult to grasp, and quite a challenge:

"*I find the whole empowerment concept quite difficult*".

"*we tend to be practical quantitative scientists and we tend to think in terms of things you can measure. So we think of action as being a measureable output of empowerment. And I think what I'm trying to get my head around whether it's possible to have non-visible, non-measureable empowerment and I kind of feel it is*".

"*empowerment is a little bit ambitious*".

In general it took some warming up and inspiration from the interviewer to get the interviewee's ideas about empowerment crystalizing.

Empowerment definitions

Some characterizations of empowerment can be labelled as capacity building. What is interesting here is how in the different responses a distinction between a *potential* but *not a necessary* relation to action comes forward. Several interviewees point out that, especially in relation to air quality issues, the proof of the empowering capacity not necessarily only lies in resulting actions, especially when there is no need for change:

"*That we are in contact with people who we enable that they to do things they otherwise could not. Issues that they might not otherwise realise that they can act upon. Tools to act upon.*".

"*To make change were change is needed*".

We can't totally rule out that some of the participants are actually quite happy with their indoor environment at the moment, and just not have any very clear need or want to define goals for improving the indoor environment"

Also, one can also link empowerment to an informed freedom of choice. That is, if they have a choice: if there is no enabling environment there may not be much freedom of choice left. This may also be considered for another time or context:

"*You give them enough in terms of information or product or data, so that they can make a better informed decision on whether they want to take action or not*".

"*And even if we do not necessarily enable them to achieve a better indoor environment, (…) I think it's possible that we enable them to define this as a goal and something that they can pursue in this or other contexts. So it's perhaps a little wider than just improving the indoor environment*".

One interviewee alludes to the possibility that absence of action based directly on the capacity building does not necessarily mean lack of freedom of choice nor lack of empowerment as such. And, even if according to some there still is a need for improvement, individual freedom of choice may be more important:

"*I guess that there in general is a need for improvement, but I think that we need to put it in there that if we're talking about empowerment I think also people should be able to make their own priorities, but at a more informed basis I guess*".

What also is interesting is the distinction between personal competence and a role in decision making or governance processes. The social or institutional process perspective is e.g. mentioned in terms of empowerment as shifting from top-down to bottom-up governance. In this line of thought one may also consider empowerment in terms of knowing what others can do for improvement action:

> "*they maybe are able to divide what they can do themselves and what the other people at the schools are, that has to do something in order to change the environment*".

Further, capacity is not necessarily linked to the core issue of the empowerment project, in this case air quality issues. At the schools also more general capacity building was noticeable, e.g. in students building capacity in constructing their own tools.

The above mentioned perspectives come close to what in the literature is known as the distinction between agency (individual capacity to decide on and take action) and opportunity structure (the opportunities and barriers present in the context/living environment of the individual, or in other words the extent to which there is an enabling or disabling environment). It may e.g. be a mistake to consider individual capacity building in terms of e.g. knowledge or skills, sufficiently empowering to take problem solving action if needed. If the individual simply does not have problem solving action alternatives available, one can wonder of the individual capacity building can indeed be considered empowerment, or may perhaps rather lead to disappointment.

A diversity of target groups is mentioned in relation to empowerment, varying from individuals such as patients or students, to members of specific groups, like bicycle commuters or no-governmental environmental organizations, to members of a local advisory group with mixed membership (including e.g. local experts from science and policy as well as local stakeholder group representatives) and to authorities.

Further (see below) several activities or tools are mentioned in relation to the definition of empowerment, but perhaps better can be considered as activities or tools being instrumental to empowerment. This may be considered a sign of a limited understanding of empowerment, which could be the result of lack of experience of interviewees with the concept of empowerment. But it could also be the result of high belief that the project's activities or tools considered supportive to empowerment, will automatically lead to empowerment.

Communication of information is mentioned quite a lot in relation to empowerment, and seems rather close to what seems to be the core of the project's design: providing tools for collecting air quality data & providing sound air quality information as a means for citizen empowerment. Largely here one-way communication from experts to lay-people (citizens, students) is meant: even if the data collection tools are in the hands of lay-people, responsibility for the quality of the information building on the data largely is considered a scientific responsibility, and so is the communication of that information. The latter in an understandable manner in order to be useful for end-users: citizens, students, decision makers. Next to air quality information and potentially also related health effects, this communication of information is also mentioned in more general terms, e.g. as knowledge, as access to information, and is mentioned also in terms of education. Closely related to communication of information is awareness raising. Another element, the governance process, is mentioned as an element of awareness raising:

"(…) *tools or sensors that might be outdated anyway next year (…) empowerment would be more in the direction of people awareness and that they can play a role, that they the power to be part of the process*".

Apart from communication of information, the supply of information tools or capacity building for building tools is also mentioned several times in relation to empowerment.

Several project related limitations are mentioned as constraints to the project's capacity to draw generic lessons about empowerment. The scope of the project has several built-in limitations. First, the limited sample of participating case studies and participant groups. Second the topical focus, which is largely limited to a limited set of air quality issues. Third the project tools, largely limited to air quality sensors. Regarding the tools, it was already mentioned, that their usefulness may be outdated in the longer run. Related, it is mentioned that also the number of available sensors in the project is limited, but also that the development of the functionalities of the sensors hampered during the project's working, as was also mentioned earlier. The latter resulted in a shift towards the scientific development process aspects regarding the sensors rather than to the sensor-data based information supply side of the project:

"*I think this goes back to the first ideas or objectives of the (…) project, when we wanted to provide quality information to the people and people should be able to use this air quality information to have an influence on decision-making, or to get active in policies concerning their environment and air quality. But nowadays I would say it is a bit different as we do not provide air quality information at all, but we do provide scientific methods which could be used in the future to achieve this.*".

Perception research & citizen science as potential forms of empowerment (extra question).
This idea of perception research & citizen science as potential forms of empowerment was not included in the original checklist developed for the interviews, but originated from one of the first interviews and was then also used in most other interviews. These two potential modes of empowerment were introduced in more or less the following manner: *Two potential forms of empowerment that I did not hear you mention but may be relevant for the project. One is that by means of perception questionnaire we can try to give voice to views of the people in the cities or in the schools, e.g. on air quality or governance issues. And the second is empowerment in the terms of citizen science, meaning the involvement of the local people in the schools or in the cities in the research itself*.
The fact that this question was asked also means that none of the interviewees spontaneously and specifically mentioned these two potential forms of empowerment in relation to the previous question. When brought to the attention of interviewees, for some the question for sure was not perceived an easy one to answer: some could only relate to the question after more elaboration, explanation, or examples from the interviewer. Whether this means that they initially do not consider these perspectives to be empowerment relevant or whether this means that these are really blind spots in their view on the project's work is difficult to tell. Clear is that after some dialogue they seemed to consider these options reasonable or recognizable from their own experiences in the project. Nevertheless, some of them only generally acknowledge the potential, without giving detailed ideas or experiences.

Perception research as empowerment potential
Mixed feelings can be noted here. Perception research can provide a channel for expressing concerns, but, this is also questioned. Perhaps it depends on whether a connection between citizens and authorities is provided:

"*if an individual had some concerns or interests or awareness of air quality but they don't quite know how to communicate that or how to pass that information on or how to express their concerns*".

"*Do people feel empowered after they have answered the questionnaire?*".

"*putting the people together and collecting the different voices that then they can be transmitted for example to the municipality*".

Still, it can be considered too passive to be empowering to the fullest, especially without supportive actions, which will be aimed at the uptake of perceptions in e.g. governance.

Citizen science as empowerment potential.
It is striking that most do not mention citizens potentially having some form of decision making power in the research when engaged in it. Some even consider research not as part of empowerment:

"*I don't think someone just participating in the research project is empowering them. Certainly I'm thinking of other projects where we've had people participating for multiple reasons and I've never thought of them as being empowered to do anything as a consequence of that*".

A diversity of participation modes of citizens in research are mentioned, ranging from one-way communication (receiving information or education) to more a collaborative co-design mode of operation:

- Receiving information or education
- Asking questions for clarification
- Giving feedback on what is presented
- Giving concrete ideas for the research
- Involvement in adapting the research to their needs
- Co-design:

"*It's been a big change for me, just in terms of – you know – you're used to running research projects where you're saying "this is what's going to happen". - You might not get as clean research, but [laughing]. It's… I think it involves people so they've got a bit of buy in in the process. And that is important*".

Further it is mentioned that jointly taking part in the research with others may be empowering in the sense of some form of local community building & interaction:

"*They said that they more or less created the community of users. So they didn't know each other before, and after the workshop in fact they went to have some beers together. So yes, with the project we built this kind of small, soft community*".

Also the feeling that by taking part in the research, they are taken seriously, is mentioned as a potential empowering effect. The opportunity to express concerns is in line with this reasoning.

Both bottlenecks and benefits were mentioned here, sometimes in combination:

"*we already know from working in the occupational side that it's not easy to run very clean and controlled experiments in work places, so it's the same if you're engaging people in this process I*

think. But to be honest I think the richness outweighs, can be a big thing here, and I think we've got an awful lot of mining to do on that in terms of sort of getting into the depths of things".

As main barriers were mentioned: lack of interest among people to participate and the project's problems with the sensors.

The project's empowerment strategy.

We also asked interviewees to describe the project's empowerment strategy. Empowerment is in the name of the case studies (Empowerment Initiative) and well-recognized as important part of the project, i.e. the main expected impact mentioned in the call funding this project (see Chapter 2). So one would expect, in the final year of the project, to have a common, shared well-defined conceptualization of it. At least one interviewee mentioned explicitly to have been working rather disconnected from the others and rather context specific, and even without sharing experiences with the other locations. Now, this perhaps is an exception, as most interviewees were in closer contact, sharing experiences, as we will also see in Par. 3.3. Still, of a shared and common strategy, there seems to be little speak, also according to several other interviewees. As contexts differ quite a lot, as such differentiation is sensible of course, as is an iterative, adaptive way of working, dealing with context specific practical circumstances along the way. An example is that local culture may demand adaptive management of engagement approaches:

"*Yeah , I want to point out that we recognize from our stakeholders that they don't want any official meeting, that follow-up meeting should be unofficial. It should not be that we now try to organize a meeting. (…) that we should combine them with other activities. Also when it comes to interviews (…) Otherwise they feel uncomfortable*".

A colleague adds:

"*People they don't like to be with official staff. They want to talk. But as soon as you come with a piece of paper and some questions, they start to behave differently and some of them would make it clear to not make it official. They can collaborate, but more like friends not officially*".

Being open to what the local contexts needs in general is considered relevant, but potentially comes with a risk in the project's history of having to adapt also the project's ambitions:

"*to start the process by going to speak to the schools and to find out what they wanted from the project, which I think is empowerment, that's the sort of co-design citizen science aspect of it. But then I think that got a bit lost because we got terribly focused on trying to keep them on board when we couldn't give them what we promised them a year and a half ago, so I think our strategy or our focus changed more to a kind of, an engagement how in the heck can we keep hold of these people, and maybe we lost sight a little bit more about a strategy for how we would empower them*"

Here also involvement of citizens in the research as such and co-design are often not spontaneously mentioned, yet acknowledged after being put forward by the interviewer. This mainly means that somehow such examples are not easily understood as potential empowerment activities. Nevertheless, with the development of the perception tools, the project's methodological support group on engagement & empowerment was able to inspire co-design or user-centred design initiatives for fine-tuning these tools before putting them out for real use.

Collecting the views of local groups and individuals in interviews and through questionnaires are mentioned as part of the project's strategy, which is thus is not limited to the air quality sensors at all. In fact, due to the development delays of the sensors, alternative engagement activities and tools were needed and developed, among which the perception tools. Alternatives in general developed late in the process, except for some local examples, mainly the school cases. From a project wide perspective, there was clearly a difficulty with responding to the technical development problems:

> "*When you look at the first promotional video, the first I have seen when stepping into the project, this was all about sensors, devices and maps we would provide. I think this is still an issue. (…) I think (the interviewer) tried to raise that point at every meeting from (the project's methodological support group on engagement & empowerment). There isn't anything to complain about, you raised your flag all the time. It is more about that nobody knew how to handle the technology-problem so far. We have far more people concerned with the technologies within this project, and this has dominated still*".

When asked about potential additional empowerment strategies, a clear recognition of closer involvement from the start of target groups in the design of the project's workings is mentioned by several interviewees:

> "*we used only this top-down approach which makes it a bit difficult for engagement or empowerment activities I think, because you don't really look at the... we don't really ask the people about their needs or requirements... We just assume that we know what they need or what they want. And then trying to convince the people to participate and to change their behaviour and to change their attitude and to keep on this new attitude or this changed attitude, this is a bit, can be a bit challenging*".

Even the belief in the empowerment potential of the air quality sensors, even if functioning well, is questioned in hindsight, as this discussion between two interviewees during the interview illustrates:

A	*"probably we should have had a better empowerment strategy from the very beginning, like "sit down more and talk about"... not only saying like "we're going to empower citizens and"... but ask the question "How are we going to do it?" Yes. We didn't realise it was that difficult probably. I don't know."*
B	"*No, because we focused only on the sensors and the technical equipment – and as we know, this did not work the way it was intended to, and so we still kept on focussing on the technical equipment.*"
A	"Yes, I guess we did the mistake that we thought that if we have the right technical equipment, that we monitor air quality and we will empower citizens."
B	*"Yes."*
A	"And I just now start to realise that even if we had the right equipment, measuring with high precision, probably won't be enough to empower anybody. I think you need more things, you know? It's like .. but, yeah, I think it's a learning process."
B	*"Yes."*

5.2.2 Empowerment evaluation design

Like with the definition of empowerment, most interviewees also struggled with elaborating on empowerment evaluation issues. An apparently straightforward question, what are concrete

empowerment evaluation indicators, did cause quite some confusion with some interviewees, or even considered this question beyond the scope of their expertise:

> "*I'm not sure if I understand that question correctly. Could you explain it a little bit more?*"
>
> "*Key indicators it's a tough one. Yeah, yes you could look at air quality measures, but I suspect that's not going to show much in the very short term…But it's… it's difficult*".
>
> "*I'm sitting on the fence here (…), because I'm thinking is this is a science question or is it a social science question [laughing]?*".

Self-evaluation?

As in an earlier phase of the project the use of key performance indicators (KPIs) was introduced in the project to assess the project's performance, discussing indicators seemed a good entry point for discussing empowerment evaluation. For information: the KPI's were only implemented as self-evaluation instrument even regarding assessment of the work with local participants, stakeholders and authorities. This was criticized from the start by the project's methodological support group on engagement & empowerment, because of excluding the views of the external groups that were engaged in the project's work. This highlights different evaluation preferences and cultures within the work of the methodological support groups in the project. When pondering about empowerment evaluation, several interviewees spontaneously proposed a different take on evaluation, opening up to more qualitative and interactive forms of user evaluation.

Quantitative or qualitative evaluation?

The interviews show that whether to think mainly of quantitative indicators, closer to the experience of most interviewees, or (also) of qualitative evaluation is clearly food for thought and shows differences in appreciation. Some prefer the qualitative approach:

> "*I think it is very hard to measure it in a quantitative manner. We try to do this in (…) schools and we have questionnaires we examined contacted knowledge and attitude and behavior of the students. And we saw somewhat differences between pre and the post, but I think those indicators aren't enough to say that the kids were empowered. If you raise their knowledge it still doesn't mean they were empowered. Empowered is something that, I feel, only get from responses from people and analyzing in a more qualitative manner.*"
>
> "*when I hear the word 'indicators' I tend to think of something that we can measure, and I think there's relatively little we can measure as an outcomes in the schools because I don't think that the impact of what we're doing is going to measurably change the environment in the schools. But I think we can look qualitatively at change: (…) is anything being been done differently because of taking part in the (…) project*".

The type of more quantitative indicators proposed were very much characterized by rather superficial information when considering information about empowerment: e.g. number of participants (in the project - questionnaire response) and number of tool-uses (app downloads - app use - website use - internet traffic).

The type of more qualitative indicators that were proposed, can be considered more informative about how people appreciated participation in the project or the products of the project. Indicators of appreciation of participation in the project were e.g. willingness to collaborate, communication with

interested groups, and more concretely participant feedback on involvement in the project: did they feel properly involved? Were their expectations met? Participants not being limited to citizens, but also including e.g. a local advisory group to the project. Also as an example of appreciation of project activities, it was mentioned that on the official webpage of the municipality the project was referred to. Regarding the usefulness of products of the project, indicators such as '*user perception of tools*' and '*information being used'*, were mentioned. Qualitative indicators closer to awareness raising were e.g. raising interest in the topic, clear participant interest ("*chap leaving a note*") and analysis of social media, e.g. topics people search for.

Qualitative indicators more informative about empowerment that were mentioned: individual indicators such as behavioural change, learning, concrete solutions (e.g. how visualization of indoor pollution leads to ventilation), and more governance type of indicators such as participant's appreciation of involvement in governance or uptake of specific issues in policy plans.

Evaluation framing

Evaluation design, including the choice of indicators, is considered dependent of other framing choices, such as context, goal definition, interests and preferences. Some illustrations.

> "*(…) we might see that the setting of goals may result in actually conflicting goals and interests, already quite early in the project*".
>
> "*I think if you are only measuring achievements then you must be pretty sure that the achievements that you measure are in accordance to somebody's goals, and if the goals are conflicting then success to one party will perhaps mean disaster or at least failure for some other stakeholder*".
>
> "*Uncertainty and knowing to what extent you can trust your data and so on is quite simple in what they're actually teaching and learning. (…) that might be quite different from empowerment initiatives when the participants are mainly interested in identifying and solving an environmental problem*".

The last quote introducing different interests related to measurement uncertainty of sensors, which may not so much be appreciated by those who really care about improving the environment based on measurement data, whereas:

> "*if you are a nerd and doing science projects it's more fun to deal with it*".

Evaluation measurement challenges

Some measurement concerns are raised: are we measuring what we want to measure? Some illustrations:

> "*Empowerment you can't just check by asking questions*".
>
> "*they will measure an awareness of our project but whether they will measure an indicator of empowerment I'm not so sure*".
>
> *"I'm still looking puzzled. The things that are coming into my mind are more assessing participation or evaluating participation than empowerment".*

Other measurement challenges mentioned relate to the question whether we can highlight direct linkages between empowerment and our project, which is also a question of timing, of sustainability and of the risk for socially acceptable answers:

> "*what we want to know is what are we, have we added value or have we, has participation in the study resulted in something being done differently*".
>
> "*we need to have this baseline. Like this before and after*".
>
> "*I guess after you're participating in a project, it's like you're more excited, and everything is new and then you are very much into it, but then maybe after one year or after several months, if you are not listening anything more it's like – you just relax yourself again*".
>
> "*if we're asking for people's subjective opinions on how they've been empowered, my guess might be that people might overemphasise the changes they've made because they want you to, you know, they want you to feel better about it – and you know they want to make you think it's all been a great success*".

Again the question comes to the fore whether empowerment can only be measured in action:

> *"Empowered just makes me think you do something with that information. But probably that's more a concrete indicator that something has happened. Because otherwise how would you know that that individual had been empowered through being involved in the (…) project".*

Further the question of representativeness pops up again:

> "*who are actually involved in the project as it is. And who are kind of around it and are not very informed and not very part-taking. Obviously there is a selecting and we work with quite narrow groups*".
>
> "*there are always participant who don't want to participate on this evaluation and we cannot measure their opinion*"

This is also very dependent on whether people are interested in the topical focus of the project, which makes it also an engagement challenge:

> "*There is general lack of awareness within in the city. Obviously the air pollution levels in Edinburgh will vary from day to day but I don't think anybody, including me, could tell you if it's a good day or a bad day. There's nothing visible or apparent - on the whole it appears to be a good atmosphere and I don't think people think about it until you talk to them about it. And I suppose what we are doing in Citi-sense is we're maybe making people actually think about it, but I suspect when they do think about it they kind of think "yes, it seems ok" unless you are standing beside a bus or a taxi that's belching out black smoke or something*".

Here also the question is, whose empowerment do we measure:

> "*empowerment is very personal. Two people can go through the same process and one will feel empowered and the other won't*".

Empowerment in terms of participant's influence of governance will be difficult to measure as in most cases there was no commitment of local authorities to do something with the project's outcomes, nor was there, due to delays with sensor developments, a lot of time left in the city Empowerment Initiatives to put tools into practice:

> "*in terms of empowerment for the influence in public issues or in public decision making processes, this should be just theoretically because it is just not real so*".

Also, we should even consider terminology and wording in general when engaging with people:

> "*I'd be very cautious using the empowerment word, unless I had to claim it later on, because I think it means different things to different people. I'm not sure I knew what it meant until I start CITI-SENSE, and I'm still not sure I know*".
>
> "*it's always very careful question wording, but the question is what have you done as a result of being involved in this research project? And, I think leaving something as open, I know it's a nightmare for our analysis, but you can actually get some very interesting response with that*".

Finally a measurement challenge is to clarify whether we measure empowerment or rather engagement in the project:

> "*The things that are coming into my mind are more assessing participation or evaluating participation than empowerment - did they feel properly involved, properly informed, did they feel there was a 2-way exchange of information, did they feel that they got what they needed to empower them*".

Product challenges

A major bottleneck regarding empowerment evaluation, indicators and the project at large, concerns the project's difficulties with the technical development of the sensors. This is mentioned several times by most interviewees and it is underlined to have severly hampered engagement and practice in the Empowerment Initiatives, and especially the relations with local groups:

> "*it's a bit hard to sell something when you've got nothing to sell, and you can quote me on that one, I don't mind – because it's difficult to be able to encourage, participation, engagement, empowerment using various tools when 1) you don't have them and 2) you're not confident about what they are actually able to do. And so because of that, and because I don't want to waste people's time or to let people down, we've taken a little bit of a step back with respect to what we've been doing in relation to other cities who have been a lot more active.*".

Lack of experience challenges

A barrier to empowerment evaluation may be the interviewees' lack of experience with empowerment assessment: none of them indicated to have any such experience. Similarly all expressed lack of experience with assessment of participatory approaches, an approach potentially close to empowerment evaluation.

> "*we produce stuff and we produce guidance documents as well as academic reports and things, that there's limited opportunity to go back and find out what the impact of that was*".

While some mentioned that their interest in these topics and analysis grew during the project and that they picked up experience with it through learning by doing, but also that most of them the needed guidance:

> "*But it's something that in the course of this project has been becoming more and more interesting to me, I have to say, so I do feel like reading and do my best*".
>
> "*we lack some sort of guidance from the main (…) project. We are often left quite alone with these issues*".

The lack of experience was not a surprise from the perspective and experience of the project's methodological support group on engagement & empowerment. But somehow the indication of lack of guidance was surprising, as already from the start of the project supporting initiatives in the direction of empowerment work were initiated. But clearly without percolating so easily into the interviewees' practice and thinking. In fact, this very interview where this question was asked, was part of an empowerment evaluation strategy that was already introduced to the interviewees about half a year before this interview. The checklists to be used during the empowerment evaluation have been ready for reflection also for half a year previous to this interview. This followed in the footsteps of other supportive work in relation to engagement and empowerment from the beginning of the project, as one can read in Chapter 2. It mainly shows that capacity building is far from straightforward when the type of capacity is strange to the end-users and their daily routines. More discussion and reflection on related issues can be found in the Par. 3.3 where we look back at the project with the interviewees. A positive to conclude here is appreciation regarding the opportunity for this type of evaluation in this project:

> "*we, have very little personal contact with people providing us with data. We may have contact at the beginning to set up data collection but we very seldom or never have a feedback loop where we then talk to them afterwards about their experience of participation or about their experience of data provision or anything like that. It tends to be more of a one-way transaction. They provide data, we analyse it and write a report and we might give them the report but we don't actively evaluate with them their participation*".

Resource challenges

An often mentioned resource challenge is lack of time due to other work and obligations in the project, largely due to technical sensor development problems which demanded a lot of technical tool-testing time from the interviewees in their locations and caused operational confusion:

> "*that is for all the location officers, we have quite our hands full because we are the base of this project so far, so this is true for all the locations that it is very demanding and sometimes confusing*".

Further time constraints due to local contextual factors are mentioned, mainly for the school cases, where the school calendar was restrictive.

Opportunities

Experience with local groups built-up during the project is mentioned as an advantage for evaluation. This concerns both knowledge about local groups and collaborative relations, both with participating citizens, other groups and local authorities. Similarly, several Empowerment Initiatives already initiated and/or planned activities that are suitable for collecting data informative to empowerment evaluation:

"*we could try to use what we had experienced in the work and cooperation and the selection of tasks and topics used. I think that could be raw material*"

"*we do have the questionnaires that we will ask the students to fill in before and after the start of the campaign*"

"*in the questionnaire that we did to the participants in the project one of the questions was the usability for the improvement of environmental conditions in the city (…). And we also asked them if the solution was applicable in the participatory process*"

Further specific occasions for interaction with target groups are mentioned, such as communication events like science festival, bicycle events. Finally, even with imperfection one can see the bright side of it:

"*bad data is better than no data, as long as we're aware of the limitations of what it is, we don't pretend it's good data*".

5.2.3 Planning of empowerment evaluation.

As a final part of this interview, the practical approach to empowerment evaluation for the months to follow was discussed. This was not completely new to the interviewees, because it was introduced earlier by the interviewer in internet-meetings in which the interviewees, location officers responsible for the work in the Empowerment Initiatives, met to discuss progress of work. Moreover it was, in preparation, extensively discussed and agreed upon with the coordinators of the project teams in which the locations officers were grouped according to sub group specificities of their locations: schools, cities, public spaces. To some extent moreover, the design of the approach was negotiated with some of the coordinators. Still, it was clear, that for some interviewees, discussing this concretely at the end of an interview about empowerment evaluation, and, almost at the end of the project (the final year had already begun) almost came as a shock:

"*I still have a problem with the words "empowerment initiative". What exactly do you mean by this here?*".

"*And you want locations to provide ideas of when or how it could be done?*".

Some also questioned the effort that was expected from them (doing individual interviews and focus group discussions with local people, using the checklists developed for that purpose):

"*But it is better that it is a questionnaire and not an interview*".

"*I'm just a little bit worried about the .. about the time and that .. it's a lot of tasks to do*".

In the end, especially after more explanations, most interviewees were constructive in their response:

"*I think it's been useful to start really thinking about the empowerment aspects of the project given that we have been, as you're very aware, more focussed on the whole sensors and the issues that they present us with. So it's good to take a step back from that and to look at this particular aspect of the project*".

"*I like this focus group discussions. They may be useful for example with the kindergartens*".

"*But what is true is that we have to do is the part of the city authorities, so we can use this for them. The thing that I have in mind is, I am not sure how to do it with the city authorities, if it is better to show them also the responses from the citizens speaking about them and later ask them about their opinion, like trying to, a kind of indirect dialogue between the two parts although they are not together*".

5.3 Second round of interviews: location officers looking back on the work.

Introduction

In total we did ten interviews covering almost all Empowerment Initiatives: only one school EI is missing due to practical circumstances. In this round of interviews mostly only the location officers were interviewed. In three interviews there were two local location officers involved in the interview and in one case the local contact person from the project's methodological support group on engagement & empowerment joined spontaneously. The latter being an exception: we were mainly aiming for interviewing the location officers in order to get a view on the viewpoints on how environmental health experts view (collaboration on) empowerment. The interviews were done over the period June to July 2016. Transcriptions were done by a student in the first two weeks of August 2016.

For the interview a semi-structured approach was applied, using a checklist with questions, while being open to additional discussion topics or questions popping up as being relevant during the course of the interview. Originally it was foreseen to use the same type of questions for local participants in the different Empowerment Initiatives in order to also get their views on the issues listed below. Due to lack of resources (time and financial resources) we decided to only propose this as optional in the framework of local empowerment evaluation. Unfortunately it appeared only feasible for a very limited set of Empowerment Initiatives. The questions in the checklist touched upon the following issues:

- Collaboration in the project and in the Empowerment Initiative.
- Opportunities for Empowerment Initiative participants to influence the project.
- Learning within the project: the interviewee, others.
- Responsibilities within the project's collaboration: scientists citizens and authorities.
- Opportunities & barriers for actions based on the project's collaboration: the interviewee, others.

In the following sections we will first synthesize the interview results according to main categories following from the analysis.

5.3.1 Collaboration in the project and in the Empowerment Initiative.

Collaboration in the project

Regarding collaboration among the project partners, what was mentioned as positive by most interviewees were the collaborative attitude from most partners in the project and the opportunities to learn from other forms of expertise and experiences from different countries.

"*I think overall my experience has been positive and I think… you know everyone has been trying to work together, trying to ensure that the end of objectives of the project are being achieved and within the various constraints that we have*".

"*interesting to work with the different disciplines*".

Nevertheless, clearly collaboration was also under pressure, as was mentioned by most interviewees, mainly because of the size of the project and the technical problems with the air quality sensor development. We highlight some examples of collaborative difficulties in the project.

First the difficulties due to the project's size, its complexity in organization:

"*it was definitely useful, for everyone involved it was useful in terms of lessons learned. but in terms of the success of the project sometimes it seemed that the size of the project was not a barrier but a very big challenge*".

"*I think we were a little bit too focused, each work package working alone for a little bit too long in the project; we should have been much more interconnected from the start*".

"*I don't see it as a clash of cultures, because I never experienced any cultural issues there. I think that worked pretty well, from my side, from my point of view. (…) I was surprised, people weren't surprised by the complexity. Because If you look at the project as a whole, there are so many different branches and so many different levels of project partners. It's quite clear that there is a certain level of complexity behind it*".

Second, and related to the previous, disciplinary differences:

"*So it's hard sometimes to agree, to understand each other. So that I think it takes time. And one example is like exactly with (…) the social science. I think it took, at least for me, a long time to see what was the goal, and what actually you wanted. But then once you get it, you get all this (…) that is very rich*".

"*we go to these meetings as individuals and we try to defend our part, and present our part. But I'm not sure… it takes time, you know , to understand each other*".

"*the communication with the people who more did the technical parts (…), we didn't really find a good way of cooperation so the project can work in a good way at the end. This I see as the biggest problem. Otherwise I think that if people really want to work together like the communication with (the project 's city work package with the Empowerment Initiatives and the project's methodological support group on engagement & empowerment), we find a way at the end how to communicate in a better way, more functional, than at the beginning. So if people really want to, it can work*".

Third the technical difficulties which put pressure on the collaboration, or perhaps rather the management of those difficulties…:

"*I suppose a negative would be the frustrations that we've had with the delays with the sensors and the fact that the sensors haven't been performing as they would. And I think our expectations were probably higher than they should have been*".

"*And speaking internally, obviously the negative parts were the, let's say, technology challenges we've met during the project and then the obvious lack of a proper product developments process management I would say. There was, I think, a some kind, too many different groups tried to develop too many different things and there was no integration at a certain time, so we always had a good*

struggle with. Especially at the local level, to keep up what, who was responsible for what kind of tools and who was responsible for certain data transfers didn't work, and so on".

…and related a lack of end-user understanding…:

"*Problem now is of course that we have 'SMEs' that are making their products, and they are not tailor-making them to the (project) applications. But still it think that it is too bad we didn't have those kind of workshops, because I think the SME's really could have improved their products as well, if they understood better who they are making the products for. Because I'm a bit scared when I see that these are professional companies now, they are going to be commercialized and selling these products, (…) but they seem to have very little understanding of who is going to use these sensors and the date, and how are they going to use them*".

…and also related what one may call too big a dependency of the project's performance on the expected air quality sensors' functioning and a lack of a timely plan B to overcome such dependency:

Interviewer	*"in my personal recollection (the project's methodological support group on engagement & empowerment) already in (referring to the project meeting halfway the second year of the four year project period) took initiative (…) to consider the option that the sensors maybe would not work in time. And that we should find alternatives. But it should come from two ends, the openness to cooperate. And like (name interviewee) mentioned, this takes time, to appreciate the value of opening up to each other. But you also need some contextual factors, and the fact that people were mainly making themselves dependent in the technical sensors development maybe that was a barrier in a sense; because if that got delayed, everything else got delayed"*
Interviewee	"*Yeah, that's true (…) the first years I would say, everyone was just focusing on the sensors. And I think also the location officer… they were too much focused on the sensors because… I mean, they really didn't know better what else they could do. And it took a while for them also to find out what plan b's there are available. And that they actually could do different things then working with the sensors*".
Interviewer	*"the technical challenges were enormous and this was unexpected, so there were many delays. Or do you also think that some other choices could have been made throughout the project, in which direction to put the efforts".*
Interviewee	"*I mean that if the people who are.. who take care about the technological part from the beginning to the end. So from the instruments to the visualization of the results. So if they really give us the correct information about what is possible, and what we really can get when… the work will be different*".
Interviewer	*"(…) if it would have been sensible for the projects to think about alternatives. And they could be technological or else for putting the energy in throughout the project. Or do you think well, it's only a matter of effectiveness, it could have gone faster. But in the end the trajectory that we went in together, this type of development was okay (…)*".
Interviewee	"*No, I think that the people who are doing the technology. They knew at the beginning the level of the development right? So they should not promise something that is not realistic. So for me this is the biggest problem (…) if they would be realistic enough, and say that what is really possible and what not. We could define our design of our studies and project much better. And put forth different activities, and have better results*".

Interviewer	*"So in a sense you were blinded. So you never knew what was the real situation. So even considering alternatives was difficult because all the time you heard stories like next month it will be okay"*.
Interviewee	*"Yes, so the whole planning was wrong"*.
Interviewer	*"So does that mean that you feel a bit hijacked? That all your activities and energy and good intentions were hijacked by this technological promise which all the time was kept alive, but did not result… did not bring what was promised"*.
Interviewee	*"Yeah"*.
Interviewer	*"If you for example like in the schools, they had to make urgent decisions, simple because the timing of the schools, and the context of the schools is very.. how you call it, well defined"*.
Interviewee	*"But this is about learning for children, the work was adults, with city, authorities and citizens was much more complicated. Because they are expecting results which they can use to solve the problem. So here you have really, what is the word for it…"*.
Interviewer	*"The stakes were higher so the speak"*.
Interviewee	*"But you also have (…) a big responsibility for a big and expensive project. That they're expecting (…) results, which can help them to try and solve the problems. So this is much more difficult"*.
Interviewer	*"So it was much more difficult to come up with alternatives that could…"*.
Interviewee	*"But no, I think that we could find the alternatives from the beginning. But we didn't know the right situation. (…) they told us that we will have the technology. That we will have the visualization. They're always were saying this, and it's not true. (…) Because at the end (…), we did not have what they promised to us. So this is the biggest problem"*.
Interviewer	*"But I also mean that for the schools it was maybe easier to switch to say, okay we cannot longer wait for this. We will do something else. It was easier for them to come up with an alternative activity that was still living up to, at least, part of the expectations of the school. As you mentioned in learning activities, that's to a large extent what they did. But this alternative was not easy within reach for the city context. There the stakes were higher, and you had to come up with a very strong alternative to…"*.
Interviewee	*"Yeah but I think that we have a lot of possibilities that we could do. So if we knew this from the beginning, we can find also other alternatives for what we can do"*.
Interviewer	*"Yeah this was discussed in (the project meeting halfway the second year of the four year project period) already. It was initiated by (the project's methodological support group on engagement & empowerment), an exercise were we brainstormed together"*.
Interviewee	*"I see it differently, I think that the technology (…) was always pushed as it's good enough. (…) if they say that we are really not able to deliver what we promised at the beginning, I'm sure we still could do a lot of good work. And interesting work for (the project)"*.

The technical challenges led one interviewee to the conclusion that perhaps another setup of the project would have been wise:

> *"For me – and I mean hindsight's always a wonderful thing – the project would have been better of it had been a two stage project. You know, stage one as a separate project was the sensor development. (…) Getting those to a state where people are happy to use them, they know and understand what their capabilities are. And then stage two being: citizens"*.

Fourth the tension between the general project perspective and the specific local needs of the different Empowerment Initiative locations:

> "*every place is unique and we have to find the things that are unique about those places to sort of guide the project towards that*".

Collaboration in the Empowerment Initiatives

Collaboration within the Empowerment Initiatives was considered mostly positive by interviewees when it comes to local people's and groups' willingness to collaborate:

> "*the groups we were working, were always very eager to learn about the tools we could offer and the possibilities we could show them to use those tools and were quite interested to learn as well about the research approach we were focusing on about air quality and different kind of strategies in different cities , so I liked that a lot. And I think, there's not much I could say in negative way in cooperation with the empowerment groups*".
>
> "*It was easier to recruit to schools then we maybe have foreseen. And the schoolteachers have been very positive. And really more keen to collaborate then I also expected. Because they have a busy schedule, and so on. But it turned out, that since we could offer something that was in line with what they needed*".
>
> "*And regarding the citizens, (…) they felt even empowered, yes, because we were interested on their ground or public spaces or whatever. I think this cooperation was very good*".

Collaboration was mentioned to build trustworthy relationships between experts and local people:

> "*I got emails from the people that were carrying sensors in relation to other problems they had. Like there was now, in an area in Oslo where they are building a new industry, one of the volunteers just contacted us "well, I was volunteer, and I was ready with air pollution, and now we have this problem. Can you say something, can you give me some advice". And that's good, that means that they trust us*".

Collaboration with local authorities was not always straightforward:

> "*We know that they were afraid of being taken a commitment with the citizens they could not answer to. This was known from the beginning and we tried to be very cautious with that*".

Over all, the technical development problems with the air quality sensors were mentioned often as burdening the (potential) relations with local people and groups and (potential) empowerment:

> "*we were trying not to raise expectations. We didn't want to get lots of people all enthusiastic and excited about our project which was being delayed and delayed and delayed and delayed because that would just cause tensions and disinterest actually ,from those that we would be wanting and partner with*".
>
> "*we have obviously changed and limited the scope of the project. And we tend to blame that a lot on the quality of the technical equipment. We haven't really had any opportunity on a broader scope and more actual empowerment of the participants in the meaning, being able to make protests or*

demand improvements or start involving the other stakeholders to change their behavior, because of the limitations both of the actual work by the students and the technical quality. So there are hypothesis in bringing them good air quality data would empower them to improve their environment. That hasn't been in any meaningful tested in this project I think".

Also the mismatch of the type of measurements the sensors where aiming at with local expectations was mentioned as problematic:

"*I get a lot of replies from people to the website, or comments about seeing it wanting to get more involved. I think that is a very positive thing. However since we have all kind of sensor problems and since the sensors only monitor very specific tools they are not always the things that are of interest to the people in the city*".

Earlier consideration of alternatives for the project sensors was even mentioned in school cases where in fact alternatives were used after a first period of disappointments with the project's sensor development quality:

"*if we have started out in the start with a set of air quality sensors and a data flow and a visualization that was working fine, I think that then we would not have limited the project as much as we did now. So we would have been able to be more (..) active towards likely the janitor to sit down and work with the air quality issues, and what is the stages in the new school, and what could you do. So you could have been much more sort of active towards different groups in the schools. (…) So looking back, I just wished we at a much earlier stage would have said "let's buy the off-the-shelf sensors", install it and not be so dependent on the (project) sensors. But that's of course difficult, I mean, we couldn't say that at that time of course. We were hoping for the (project) sensors to be coming along*".

Some have met with difficulties in their local work more generally with the project's tools, not only the air quality sensors…:

"*as location officer, it was quite challenging managing expectations of others and trying to encourage people to use or review certain products when we, as you know researchers within the team still didn't know how to really good handle on what the products were capable of doing (…) I mean it's good to get, obviously, input and feedback from end users but I think it's good to be able to go to end users with a project that you have some level of confidence with. Rather than going to them with a project where you really don't know whether it's actually going to work (…)in all honesty, I think for many of the products which we were having to test, I wasn't comfortable with the stage of the development that they were at in order for, to go and do the empowerment evaluation (…)*".

…yet the same interviewee continues with more precise reflections for specific tools. Clearly the interviewee expressed to be more at ease with the ones the interviewee had a better view on and was more closely involved in the development of those tools, particularly the perception tools, and less with the air quality sensors and related visualization tools:

"*I think it has been more challenging for the sensors and the data of the visualization webpages there because, I suppose in one respect it's because we haven't – or I say I haven't – had that much involvement in the development, I don't have the full understanding of what is going on in the background with it and what's been done, what's been tested, how everything all works (…) for the CityAir app and the long air quality perception questionnaire, they're more simple and so they're*

easier to understand and to grasp and so that I don't think there were as many challenges there. I mean, there certainly are, but I have to admit I don't think it's the most useful product (…) I have a better understanding of it, I have a better understanding of how we got to that product and so I have a better understanding of the results that are coming out of it as well".

5.3.2 Opportunities for Empowerment Initiative participants to influence the project.

Picturing local participant's possibility to have an impact on the project, on the research process as such, appeared to be difficult for most interviewees. Mostly further explanation or concrete examples were needed. Several interviewees nevertheless confirmed such opportunities from their experiences in the Empowerment Initiatives:

"*I think we have been pretty open to the idea that they should have a big influence on the activities form the start. Perhaps with a limitation that, well, we wanted the activities to be related to air quality or indoor environments. That's been almost the only condition that they have presenting them with. And of course the limitations that we had*".

"*I think they had an impact in the development of the project (…) we invited them for a really kind of co-design workshop on the visualization of the sites and the data*".

Others were a bit more modest about such opportunities…:

"*I think at large not as much as I would have hoped for. Because I think the project should be much more influenced by people; I can say that there were a few things that we really did in collaboration with the public. So building our local platform is one thing we did*".

"*regarding their opportunities to influence the project, or the work of the project, I think it was rather limited. Because we gave them the tools and said "use them or test them for us". And that was basically all they could do within the project or within the work of the project. For instance they came back to us… we developed this evaluation form for all the products as you know. And most of them filled in these forms, and then they came with suggestions on how to improve things. But this will not influence the work in (this project), this will not influence the further procedure. (…) If we just have had this co-creation and had more focus groups before, and yeah. But it was too late, we just give them and then… but I hope that they might have influence later in other research*".

…describing the research part of the project to be mainly driven by scientists…:

Interviewer	"*Are you then referring mainly to things which have to do with visualization and communications, so pretty much information oriented. And not so much the research side of the project*".
Interviewee	"*Right yeah, that's exactly that, exactly that. Also in terms of sensor location. So the lodge prior to our sensors was located by scientist decisions*".

…some rather pessimistic…:

"*Influencing (the) project? (…) So the people then say: okay, so you are not helping us, because you don't give us any information about air quality here. So how can we then push the authorities to do something, right?*".

"we've given people the opportunity to comment now on the various tools and I think that it would have been good if were able to do that a lot earlier in the project and have more funds available to do it more widely. Obviously because of the issues we've had with the sensors, a lot of the time and money was spent on trying to deal with all that. (…) So, I think it's probably a bit late in the project but hopefully the information that we do get will be useful for any further stages of the project or (beyond the project)".

…but, also a positive learning aspect for the future of the <u>importance of early end-user involvement</u>:

Interviewer	*"But it could also have do with the order of things. You could also start working on visualization, and testing this with potential end users while other technical issues are still in the process of being solved*".
Interviewee	*"I agree with you (name interviewer), and I'm sure you're right and that it was mentioned before. But as I was saying, we spoke different languages and we had different goals in our minds as participants. Even if you mention something, it is not enough, you know. You need to maybe show it in another way. It was not enough to open our minds fully maybe, I don't know. I don't know what happened. But certainly for me, I discovered it too late the project when I had no opportunity. Even if it was mentioned before, I didn't know how to do it, I didn't know what to do*".

5.3.3 Learning within the project: the interviewee and others.

<u>Interviewee learning</u>

Several interviewees mention <u>work on the involvement of the public</u> as something they learned within the project:

"I think the whole concept of involving the public (…) It really should be collaborative. (…) I think that's very important, I think I found a lot of this trust issues within the public especially toward the different governments and local". *"I think also that very good point was that we tried to connect a lot of people really different stakeholders in the city*".

Also learning from <u>being part of a big international project with different forms of expertise</u> was mentioned:

"I suppose I learned more about (…) regression. You know we had the session on that so, that was new to me so, (…) I came to the realization I knew very little about it". *" I suppose the complexity of actually carving out such a big project and the difficulties that there are and trying to get everything aligned for to achieve the project objectives*". *"it helped me to get a more holistic view in this things, and other things as well. On the whole project. Learning to look at things from different perspectives, and especially the user perspective*". *"at least in the beginning try to understand what are the different partners trying to achieve, on a quit detailed level, and spend time listening to them. That would be something I try to do next time*".

And learning about social scientific aspects of the work:

> "*I also learned a lot the language the (referring to the project's methodological support group on engagement & empowerment) people speak and so on. And now looking at the description of work of a more classic project. I find the approaches there quite naïve, and not very scientific if you know what I mean (…) I really learned a lot of this… what we called quite a lot sociological aspect*".
>
> "*I learned in this project very much about citizen science, even it was not the main scope of the project as it was not a citizen science project. But it opened a bit more about citizen science (…), how to involve people in the research and co-design, and organizing focus groups*".
>
> "*We have learned quite a lot on the cooperation with you and from your qualitative methods that are a bit different then we are used to. And I like to mention that as something positive, with some - I would say - constructive frustration. Different habits than in our work. That's been good I think, and I hope some learning has taken place both ways*".

Further learning about the local social, research and institutional context and the role of a researcher in such constellation:

> "*Another thing that I learned, there are a lot of like social organizations in Haifa that are trying to do different things to increase the air quality. (…) They all have the same kind of goal to increase the air quality in Haifa, but they all have these internal little things that they don't talk about and little fights. (…) So instead of you know bringing all their power together, and be really able to do some kind of change, they each want to like keep their own ego. (…) Just kind of be a very objective outsider. It's not always easy, but that was very important for me, in order to stay, you know, to have this credibility*".
>
> "*it gave me more of an insight and certainly locally about other activities that are happening which are very similar to what we're doing*".
>
> "*from a sort of personal development perspective it has been quite useful from that because I've now got contacts with other researchers in this area, which will hopefully be beneficial in the long term when we think about any other projects which may emerge or be linked with (the project), who knows. Or anything else which has to do with air quality*".

And learning about air quality: some interviewees also indicated to have learned about air quality, in general, and locally.

Learning of others

Did, according to the interviewees, others learn from them? Some mention colleagues learned from them, or they hope they learned from them. They referred to either colleagues collaborating with them in the project or beyond. This was both mentioned in general terms as well as in specific terms:

> "*for example the (…) electrical engineers, they were not before in air pollution. But they learned that*".
>
> "*I hope… I don't know but I surely hope that (…) the ones that made the instrument at some point have understood that it is important to talk with the users. But I'm not sure*".

Yet, clearly missed learning opportunities were mentioned, due to the technical development problems with the sensors:

> "*I think because we had so many problems, we didn't really work together on the scientific level much*".

What was striking is that learning between Empowerment Initiatives was hardly mentioned spontaneously by interviewees, even if especially in support of the project as a learning organization, the project's methodological support group on engagement & empowerment arranged for two-weekly internet meetings in order for these case studies to share their experiences. Still, after introducing this learning perspective by the interviewer, it was recognized:

> "*I think we are collaborating very well, if that was your question. Because we are also trying to do, that we are doing as comparable as possible; but then again of course we are doing something which is specific for specific environment*".
>
> "*people from other cities send me e-mails if I could explain them how we do things*".

Apart from colleagues learning, also Empowerment Initiative participant groups were mentioned…:

> "*in the schools you could really see that the kids that I worked with have over gone sort of a process and understood many more concepts of air quality*".
>
> "*people in the locality because we discussed the problem of air quality pollution with them quite a lot*".
>
> "*Yeah I think the local people they even told us clearly on the workshop that was… well the most direct way of telling us their feedback. And for instance they were quite surprised about the conclusions that we showed them about the impact on their emotions of being in a public space in the city. So yeah, some of them also learned about how to play with the smartphones, and not only because we teached them, also because the young people teached them during the observations how to work with a smartphone; so yeah they learned about the technology*".

…be it that this was not unfortunately not always evaluated properly with these groups:

> "*I only wish that… I think that the participants have learned and some of them have told us like I'm more inspired now in learning about air pollution. And that's a good thing*".
>
> "*It's always difficult to know what others learned. But, I hope, when it comes to the case study that I do, of course I hope that some of the students have learned a little bit more about the air quality. And a little bit more understanding about measurement, that there are uncertainties*".
>
> "*with the adult people it's hard for me to say, because it's something I didn't examine yet. I would hope that these people, you know, look at all the data that's been presented in the platform*".

Still, from a methodological perspective the project's methodological support group on engagement & empowerment promoted such participant/participatory evaluation already early on in the project in two methodological project reports and several presentations and discussions during broader project meetings. The lack of robust evaluation of learning probably is best explained on the one hand by lack

of and severe delays in Empowerment Initiative practice due to the difficulties with the air quality sensors. On the other it can be explained by lack of familiarity with social science.

Further beyond the Empowerment Initiative participants, a broader audience is mentioned learning from the interviewees:

> "*I think we made a good presentation of (the project) in terms of citizen science approach and I think a lot of them are quite interested to see what kind of citizen science projects are there in Austria, we just preparing the second citizen science conference next year. And it reaches out to a much broader audience already*".
>
> "*Well we did have a presentation with the national ecological board on invitation, because they wanted to learn more about (the project). So you could say that was something we were able to contribute on an educational level*".

5.3.4 Responsibilities within this collaboration: scientists, citizens and authorities

Even if one can discuss whether the project in its original design and ambition was to some extent a citizen science type of project, many aspects one can consider relevant to citizen science somehow are relevant to discuss when reflecting on how the project evolved and on its potential. We focus here on the entry point of responsibilities for three categories of actors potentially relevant to citizen science, as well as to this project. As with several other questions, for some interviewees this angle was not easily understood and needed some further explanation.

Scientists

A wide array of responsibilities, roles, activities is mentioned regarding scientists. A larger part can be framed under science communication. Several aspects are mentioned in that respect. Supply of information of good scientific quality to society, understandable communication about scientific information and scientists should also be open to two-way communication and to co-design of research and for opening up to the broader public, also it should become more attractive:

> "*to give to all the stakeholders enough information to be able to work with them, and to understand the situation*".
>
> "*the responsibility with the quality of the data*".
>
> "*present the data in a way that people can understand it. Not only collect it for their own use*".
>
> "*also listen to certain things coming from the public*".
>
> "*integrate questions which do really matter to, let's say, now the user groups*".
>
> "*you have to make it more attractive to them to participate. And then you would have the responsibilities of the scientists and the authorities to do that, to make it more attractive to the broader public*".

Honesty and transparency are two other key responsibilities mentioned, throughout the whole process, not only at the beginning and end:

"*honesty. Being very open about what we are doing. (…) in the beginning we were all a little bit blinded with things that are written in the description of work, and things that we never experienced and tested ourselves (…) looking back, it looked like promising something that we could not deliver (…) For quite some time we were having presentations about things that we never had in our hands actually. Promising things, like we spend one school year with promising and promising. And we never delivered that*".

"*I think the responsibility of scientists is to be as open and honest about the projects and the products which are being developed and used in the project as they can. And not to make any sort of, you know, false promises and to manage expectations*".

"*Keep then in the loop all the time. Not only at the beginning and the end, but try to keep them on the loop. And in our case, because we are working with a very sensitive topic, air pollution, we need to try very hard to communicate the data quality, the importance of the data quality, the importance of the certainty of the data that we are managing, so a little bit about this risk communication it probably is called*".

For information, likewise recommendations regarding science/risk communication and co-design were already communicated in the beginning, but also throughout the project by the project's methodological support group on engagement & empowerment. This only shows that conveying and potentially agreeing on such approaches (as they were also part of the project description when the project started) does not guarantee implementation in practice so easily.

Interestingly awareness raising is mentioned by one interviewee as a scientific responsibility:

"*I thought also try to encourage them to reflect upon how the environment or the indoor and outdoor pollution can affect you. And also through the science projects that they did, I think that kind of encouraged them to reflect a little bit on the environmental issues*".

How far this awareness or issue raising should go, is food for discussion about how scientists should take position in societal debate on the importance of specific issues (which information is relevant for society), interpretation of the societal meaning of information (what does the information imply) and potential actions based on that information (how to act upon the information):

"*I see my role as a scientists mainly to give them access to as accurate information as possible about the relevant air quality health issues. And do that in an unbiased way more or less. And also emphasize the topics that I, in my best professional judgments, see as most important for them within that field. (..) I think that would be our main responsibility to give them access to the relevant knowledge. Mostly about the exposures and effects. Also a little bit about the relevant actions and what can be done to remediate any problems that they find, but not to spur them into action and be there as an activist and say: 'you should refuse to go the school before this is remediated'*"

Should scientists stay objective?

Interviewer	*"that in your context with local groups, that were having the same goals: to improve air quality in (name city). They were sometimes quarrelling a lot or having competition or whatever. You took a more.. how you call it, independent or outsider role. Do you do this just personal, or do you see also as something that is responsibilities of a scientist".*

Interviewee	*"they have to sort of stay objective and not take a role in any of these other organizations".*

What if we consider methods are not necessarily neutral and of good quality?

Interviewee	*"I see that a lot of citizens are really not informed enough, they do not have enough information about the problem, about their rights and about what can be done. So they really don't know exactly how big responsibility they have, and how big things they can do if they are really active. So I think this type of projects to try to connect all the stakeholders together, and to speak openly about problems is really good in (name country)".*
Interviewer	*"Would you then say that the scientists play a very specific role in that sense? In maybe not being political, or maybe they should be a bit more political?".*
Interviewee	*"I see it as the scientists should be accurate, non-political at all (…) so in (name city) there are really a lot of studies and also contra studies. So then citizens are really somehow not clear about the problem. Yeah, it's why I think that scientists, like good scientists really should inform a lot and publish the results also for public, not only the scientific results. Also more easily for public, so everybody can understand".*
Interviewer	*"Is it then a matter that they are wrong, and you are right? But it's only used to confuse people, or is I that they just simply have a different method or different interpretation of the same situation?".*
Interviewee	*"In science you have a lot of methods, so if you want to publish some results that you want, you can always find analysis how to do it; so this is about money, yes".*

The latter connects to what some interviewees consider a general responsibility of scientists, scientific quality check, e.g. in education:

"*I think the only times when I really felt like a scientist in this project… again I'm coming from this direction that this was new type of project to me. Was when I had to check what kids wrote in their research assignments. So, I had to give like a scientific feedback on the charts on the data treatment on the discussions and the interpretations of the results*".

How to deal with power relations is mentioned, be it limited to the confined context of a school:

"*I think there is an issue that is a little bit important, which relates to the power relation, or power distribution between the teachers and the pupils and the other stakeholders here. Because, we provide them with some suggestions on projects, but the teachers clearly have some power on which projects, what rules*".

Support with scientific infrastructure/equipment is also mentioned…:

"*stakeholders who wanted to establish a network of sensors. but they don't have the financing or the support (…) they can benefit from the established network that is there now*".

…and apparently being 'cool':

Interviewer	*"And what makes you different then, let's take another example of people who sometimes can come to a school (…) to offer help from the outside. Could also be grandparents of one of the kids. What makes you different as a scientist?".*

Interviewee	*"We have cool equipment".*

Regarding research projects, seeking project funding, project realization and data protection are mentioned as responsibilities, but also staying true to one's expertise:

> "*As scientists I think we can stay true to our discipline, or our subject. So I wouldn't see it as my responsibility to say "let's not do research on air quality, let's do it nutrition instead", because that's not my field, and (…) I expect other scientists to do the same in their field*".

Further the responsibility to initiate citizen – authority dialogue is mentioned in one interview:

> "*I think that the scientists should be sort of facilitators between citizens and authorities. Or that they could be initiators or facilitators or however, to initiate a contact between these two groups*".

Citizens

The responsibility of citizens varies according to different interviewees, from no responsibility to a varying responsibility according to context or preference to awareness dependent:

> *"I struggle a bit with this, because I don't think they have any real sort of responsibilities. You know, they're helping us in a collaboration that they don't need to do, if that makes sense".*
>
> "*What people, what kind of level of participation people decide to do, to take. And it can vary. And I don't think there is one way that is correct or right. Every person has to find their way*".
>
> *"I think that while citizens receive more information (…) also about everything they can do (…) even the responsibility goes up".*

Following concrete attitude responsibilities are mentioned: honesty, carefulness, seriousness and curiosity:

> *"do this in an honest way, and not manipulate results".*
>
> *"that they use whatever information (…) from the project in an appropriate way. And (…) I would like the equipment back in one piece".*
>
> *"But if they agree to participate, I think that they should take their role serious enough".*
>
> *"I don't know… maybe to stay curious and to communicate with the scientists on their doubts or the questions they have… I don't know".*

Authorities

According to several interviewees authorities have the responsibility to be open to science…:

> *"At least they should like listen to us. Like if we would ask them to meet with us, they should do so. And they have done so".*

"I think they should be open and receptive to the possibilities of collaboration. And to, even though they might not agree with things (…), I would like to think they have a responsibility to be able to view and look at things impartially. That's what I would like local authorities to do".

…and open to the public:

"I can tell you that in the citizen science conference that we were at (…) I was shocked, but really shocked to see the… one of the… one of the people from the environmental protection agency from (name country) came to speak, and he was like so close to these science. And he was like we are inviting people to comment, to contribute and to be this and that. And I was literally shocked because that is so, so far away from where we are in (name country) (…) What I think they should do in general. And this is not really specifically related to citizen science but… just involve the public in different aspects of this issue".

"They should also listen to the people, and hear if we can be of help with all the tools that we have for example. With the (air quality perception) app. We have the peoples voices heard through these applications that we have provided. So they should get to know what is happening in their city".

"they have the responsibility to at least do what the citizens want and are asking for. And then also to have to follow up things in discussions with citizens. And not just lean back and exclude citizens completely from their agenda, but have more direct contact with them. And maybe also seek it a bit more actively".

Regarding air quality issues, authorities have a big responsibility in such connection with science and the public as they have decision making power and they have vital information:

"I would say that like for certain authorities they have the biggest impact in the decision making. So it's very good to cooperate with them; and also what we found out is that they really have a lot of information about the locality. What is going on, what are different projects, what they really tried in the problem that we are looking for. So, they to some point, their responsibility is the biggest. If we are looking to really do something with any problem".

The strong responsibility of authorities, can also be characterized as a facilitation responsibility:

"to facilitate for us to have the contacts and to organize - and if they want to take the next step - also organize things. And a step further would be that they also take contact with citizens. But in the framework of our project, they should be at least the ones helping to the success of the project, like not closing doors but opening doors".

5.3.5 Opportunities & barriers for actions based on this collaboration: interviewee and others

We asked interviewees if they themselves felt empowered by collaboration in the project, to the extent they could develop actions based on the collaboration, and if they felt others were empowered by the collaboration.

Researcher empowerment

One interviewee is rather pessimistic about this, both for the interviewee and for citizens:

Interviewer	*"And the example that you mention of personal potential of actions. Do you think for yourself that your opportunities to use that potential are increased based on your collaboration in (the project)?".*
Interviewee	*"Probably not".*
Interviewer	*"So it doesn't make a big difference".*
Interviewee	*"I think it could make… the biggest difference is in awareness and personal exposure. But not like in action and things like that".*
Interviewer	*"And would this be different for other people who were involved in the project. Including the local people. Do you think their capacity to take action air quality improvement action is higher now. Because of their involvement in (the project)".*
Interviewee	*"I think it really depends where people participated. I think in a place like (name city). Where the (political) party is really, doesn't want to hear and talk to people. So really the actions are very limited, really the only action that people have to make a difference is to go to the press. And that is what all these environmental organizations try to do. Without connection to (our project). I think, again, the personal actions of driving less with your car, things like that. I think are more the real things that people can do".*

Others feel the same regarding personal empowerment, when it comes to private actions:

"as a citizen I do what I did before. It hasn't had any effect on my behavior, but in a way I got a bit more aware on this issue".

"I've been working more or less with air quality and air quality improvement for, like, 25 years. So on the practical issues for my own environment I don't think the project has done very much difference".

Other interviewees, perhaps mainly those with less expertise or previous experience in air quality research, are more positive about personal empowerment, in their daily life regarding air quality, awareness raising and regarding air quality at work:

"I have learned a lot about air quality I have personally changed my way of commuting so I got now an electric bicycle on duties such as commuting".

"I was carrying (the air quality sensor) with me in a car all the time. With this shared rides crew. (…) I meet a lot of new people every day. And I if I end up telling what do I do. And I mention air quality".

"As well talking to the scientists for example from different institutes in (name city) about air quality, the possible. Trying to convince now everyone to do the same (change style of commuting)".

"I notice that when I enrolled in this project, I pay more attention to the air that I breathe wherever I am. It has happened quite a few times, that for instance we would have meetings, and I would insist on ventilating the room. And I always explained that I'm enrolled in this project now, and I would be ashamed not to mention such a thing".

Further capacity is mentioned regarding local networking, regarding involvement of local people in projects and regarding further work building on the project:

"I'm very grateful that we got to know all the local people that have to deal with the local people who deal with air quality issues".

"professionally I think we have improved our network and so improved our knowledge and have a more realistic view".

"I think we have more ideas on what is needed to involve people, what is needed to inspire them. And in that way I think we have opportunities to keep working, to keep improving air quality, and creating communities and also through research projects".

"this whole topic of co-creation, and the importance of participation, this I think will open up new opportunities regarding new calls and proposals and future work. Because this is what we've been working on now, and I think we quite liked it. And I think we will further work toward this direction, to engage participants more, or citizens more in science".

"I feel much more comfortable and more competent in working together with schools and pupils/students as potential citizen scientists. And that's something I would like to persuade after the project and see how we can build upon what we have learned and make new strong, or even stronger research projects that both adds more to the scientific knowledge on air pollution and health and to be empowerment and improvement for new generations".

"we need one more (project as follow up of this one). Now we will know from lesson learned, much more better how to perform number of things".

"We would hope that the collaborations that we have had within the CITI-SENSE project that we would have the opportunity the collaborate once again on some air quality projects, in the longer term (…) We've build up a good network there and so you know, we're aware of possible initiatives and we hope that that will then allow us to be involved in projects which are focused on air quality".

Some interviewees mention barriers to their own empowerment, such as lack of alternatives in daily life, lack of resources from the project such as lack of relevant data, lack of tool quality, or a general lack of funding:

"On a personal level, I suppose, I don't think there is any changes I would take in air quality improvement actions as a response to the city sense project. I live the life that I live because it's most convenient for me. I wouldn't change driving to work because I live 17 miles away and cycling at work is not an option. So, on a personal level I don't think I would be making any changes as a consequence to the project".

"we can't really support action against the industry, because we don't provide that data".

"some of the products aren't super attractive or user friendly that I think the amount of people that will actually use these tools as they are will be very limited".

"You know that's what the barrier is actually, having funds available for to do some research in the area".

One interviewee expresses clear disappointment in the project's functioning, having a bad effect on young experts in science at large, on citizens' expectations:

"I really expected much better work within this project, so I think that for the young scientists who want to do a good work, good science, effective… it's not good when the projects are not going in a good enough effective way. And I can see it also in the science here in (name country). I'm very sad from the fact that good young very good people, going out from science because of this (…)

I can see much better feedback from the private companies (…)

even the citizens they were also asking this. You should do a good work, effective enough to have some results after a long time project (…)

I think this is about coordinating and management. Because you are leading the project, and you know where you are going, and if you see that something is not working you should solve it, and you should not wait. And we waited so long, we waited the whole project for something that is not working. And from my point, this is not possible to do. I would not do it in this way".

Empowerment of participants of the Empowerment Initiatives

How do the interviewees assess empowerment of participants of their Empowerment Initiatives?

Empowerment opportunities are mentioned regarding capacity building, e.g. regarding air quality information, be it with limitations on the quality of the data:

"the high school kids, this was a great opportunity for them. (…) I can see them where they are in ten years from now, they have their own company probably".

"They really received very bad information and false information. About the air pollution in Europe. Or in the world. So I think that this is very important, a project like this. (…) Because policy, or politics really have a lot of money, and (…) they really have a lot of impact, and if they are not correct, they are not saying the truth. It's important that also other people say the facts. So this is very important".

"(…) the authorities that were in charge of kindergartens (…) I think they also learned about new opportunities to improve air quality in kindergartens".

"But for some more serious action, on a city level, to be honest I don't think we contributed much. Like one of the initial ideas was that we would be able to provide some relatively good and reliable air quality model. And based on which we could then estimate what is the actual contribution of the traffic, of different sources in different parts of the city. Based on that we could then really discuss some measures and actions. Without something really valid and more serious data, I don't think we are able to do so".

Also mentioned are opportunities regarding perception information, further local collaboration be it perhaps with different methods, as the tools that were developed were not liked by all participants:

"The NGO they already said that they would be considering the results from the long air quality perception questionnaire, and consider whether or not that would perhaps weigh any sort of engagement campaigns that they have with the communities about air pollution in the area".

"one of the volunteers in (the project), are now volunteers in other projects that we are involved in".

"But they don't like see the point of the app in fact in general. And when it comes to the results of the questionnaire, it's a general issue that everybody seems to hate questionnaires. (…) we tried to come up with this new idea, so getting people's feedback like directly, interacting with them. Like on the streets we have these street events for example. So it's… to create new methods of gaining this feedback, I think is an opportunity".

6. Discussion, conclusions and recommendations

6.1 Lessons learned from the participants' interviews & literature

The way in which empowerment would be defined seemed to be very important in relation to the RRI-goals (Responsible Research and Innovation) of the European Union. Especially if empowerment would be defined in terms of "power-to-choose", a high risk of developing counterproductive tools can exist (as was shown in various examples). But even with better definitions of empowerment, problematic situations might still arise. This means that – no matter how empowerment is defined exactly – the newly available AQ-data (e.g. coming from mobile sensor technology) often can be both empowering and disempowering, depending on how the information will be used exactly by various stakeholders and depending on how this information can lead to solutions for AQ-problems. First of all, the good intentions of a COs-coordinator (who can help to interpret the data in an appropriate and nuanced way) is no guarantee that others will not misuse some of the data. Secondly, making the invisible AQ-problems visible without making it equally clear how to address them, can also lead to situations of frustration and learned helplessness. This means that unintended negative outcomes might be expected and have to be acknowledged by all scientists involved, e.g. according to their roles in the goals regarding Responsible Research and Innovation (RRI) as part of EU-funded research.

On the other hand, these risk should not be a reason for inactivity, because doing nothing at all will also not contribute to the empowerment of citizens (and instead help to remain the status quo). But the process, the activities and the ways in which project goals, results and outcomes (or impacts) are evaluated and communicated should be selected very carefully, and these kinds of tools – which aim to support empowerment – should also be developed very carefully and together with the target-groups (e.g. co-design). Also the ethical debates about the tools or the topics in general should not be avoided. Both positive and potentially negative outcomes should be discussed with citizens right from the start of these kinds of projects. If not, there is a real danger that these new technologies might become contested. It is important to emphasize the opinion of the European Commission again:

> *"[…] There are many examples in which the outcomes of research have been contested in society, because societal impacts and ethical aspects have not adequately been taken into consideration in the development of innovation. In many cases, the related research funding was wasted. On the other hand, there are many cases in which the successful and early consideration of societal needs has brought up innovation which were particular successful, also in economic terms" (European Commission, 2013a).*

Besides the challenges mentioned above, the idea that empowerment would follow automatically from the collection of copious environmental surveillance data was also challenged. Instead, the degree and the kind of empowerment that will be supported by environmental surveillance is determined by the manner in which these data are made meaningful.

Other relevant lessons that were learned have been briefly summarized below:

- One of the most important lessons is that the project would have been probably easier if there had been a better balance between social scientists and more technical experts in a project such as CITI-SENSE. The involvement of more social scientists for the practical case study work might have been beneficial, because a large part of the work on the ground now had to be done by non-social scientists;
- Without enough implementation of the concepts and tools in real practice, it is difficult to draw robust conclusions about the (potential) empowerment: much more process on the ground was really needed.

- It is important to involve end-user and decision-makers right from the start, as it:
  - takes some time before the project and its aims and products will be clear to participants;
  - takes some time for the researchers too;
  - helps to avoid a lot of miscommunication;
  - helps to avoid the creation of unrealistic expectations;
  - helps to better tune-in to the practice and the needs of users.
- Being informed does not necessarily equal to empowerment, it can be even the contrary.
- The interpretation of the data is not purely a technical and neutral activity, but it deserves an open debate with all stakeholders.
- It is important to take into account the privacy of participants (during these kinds of data collection efforts).
- The process of knowledge co-production is as important as the data and knowledge itself.
- In order to maximize success, all process elements should not be underestimated in their (contextualized) complexity which plays an important role in such processes (e.g. the issue of representativeness, decision-making process parts both in science and governance); some were clearly underestimated during this project by the technical experts in general and the location officers in the EIs.
- It is important to accept the fact that different perceptions and preferences among participants is a fact of real life.
- The project was a story of great learning, but also of many missed opportunities regarding the co-design of the tools.

Finally, for project coordinators or researchers it is important to acknowledge the importance of creating the appropriate opportunities for participants, not only to disseminate the results at the end of the project (e.g. one-way-communication), but also to enable participants to ask questions (two-way-communication) and to enable them to network or even give them the chance to talk with politicians (at least if politicians are willing to do so). These kind of activities have been found by the participants to be very relevant. Also the willingness of researchers (or research institutes) to stay open to people's questions about air quality in the future can make a difference and is an aspect of (social) networking.

6.2 Lessons learned from the experts' interviews

Also the interviews with the location officers (air quality experts) were very meaningful in order to get a better grasp on the achievements and remaining challenges. The most relevant lessons learned are briefly summarized below:

- Although agreeing on a social scientific ambition in a project such as CITI-SENSE is relatively easy, it appeared to be far from straightforward or easy to make it joint work. It really takes time to do so, and this time investment will also compete with the core expertise (or the usual work or areas of interest) of the non-social scientific experts. During the project, it has taken much more time and efforts than expected in the beginning of such project (even to get just beyond the first steps of awareness-raising regarding the relevance and the challenges of such work (amongst the other experts involved);
- In a project where social scientists are outnumbered by other types of experts, it is really difficult to have the social science being implemented in the main stream of the project's work (which is often also competing for limited time and resources available);
- The social scientific work is often very uncommon for the technical experts and they tend to underestimate the complexity related to it. This was reflecten in the way how they still seemed to be taken by surprise when they were asked quite straightforward questions about

it, and also in how they struggle with relating to these questions and with understanding and answering them. This still happened even after the project has been going on for quite some time already and the most essential issues related to social science have been addressed in multiple presentations and discussions;

- Environmental/technical experts can find it difficult with reflecting on their own role in science (and in citizen science in particular), and with reflecting on the role of science in society. Sometimes they also struggle with dialogue with others, tend to think mainly in one-directional communication like educating the public and policy-makers (e.g. speaking truth to power), instead of acknowledging them as potential collaborative partners with valuable complementary roles and inputs;
- Environmental/technical experts struggle with their role in environmental issues: should they stay neutral, or take position? This is for instance difficult when discussing quality of research: choosing a method is not necessarily objective or neutral and can lead to different outcomes, which is also used by societal groups to support their stakes in the social debate on the issues.
- Coordination of these kinds of projects is a huge challenge. Due to the stretch of complexity it covers and the complex constellation of the project's composition, which in this project was perhaps underestimated;
- Late lessons from early warnings: many of the collaborative, co-design, participative lessons learned by several – if not most – of the experts, are in fact late when considering the early and over and over again repeated advice and support of social scientists related to that work;
- The idea to complement technical data collection with collection of perceptions was a big step in this project for the technical experts. It took them quite some time to open up this type of data being relevant;
- Acknowledging that the scientific process is also a kind of decision-making process in which others may also have a say, is rather difficult for technical experts to appreciate, even when supporting citizen science. In that sense, it is mainly traditional science in a new jacket.
- The belief in technical and big data promises is very strong in this community of experts, so strong that it blinds them from a lot of collaborative and co-design potential which could be part of the core of citizen science; this still is a long way from current understanding and attitude within that expert community.
- Lessons on responsibilities of different actors in citizen science (partly covered above):
- Tensions between being objective/neutral and quality checks. Are the methods (or is the quality of those methods) in relation to the issue? And are the ways in which the methods are used always objective/neutral, or can they be assessed objectively/neutrally?
- Tension between being objective/neutral and awareness-raising: is raising awareness not taking sides in the social debate about which issues are important for society to consider?
- Tension between ambitions and ideal type notions of scientific responsibility and real practice, as in this project.

6.3 Recommendations for similar projects in the future

For **(research) organizations who are planning to start a similar project in the (nearby) future**, the following recommendations can be made (based on our experiences and on the evaluation of the project and the tools by participants involved):

1. **Put the principles of "co-design" and "co-development" at the core of these projects**
   User-involvement is seen as the most important success-factor for the development of Environmental Decision Support Systems (EDSS). It will help to make tools "fit-for-purpose" and it will also increase their final uptake. Acknowledge that the needs of different end-users, stakeholders and scientists might differ (for example also in terms of required/needed

accuracy and reliability of the tools, the specific functionalities that are asked for, etc.). Therefore, start with a thorough need-analysis (but be careful to remain flexible enough for changing needs and try not to raise unrealistic expectations: see also recommendation no.4). The involvement of potential end-users will also contribute to most of the other recommendations below...

2. **Make sure right from the start that all consortium-partners are aware of the best-practices that need to be shared in order to maximize success**
   Try to valorize as much as possible the best-practices and (practical) lessons that have been learned from similar projects in the past. Try not to reinvent the wheel again and also avoid to make the same mistakes that have been made. Often there are many (good and bad) examples available to learn from (in order to avoid bottle-necks that could have been avoided despite all the good intentions of all consortium-partners). Disciplines that can be thought of are:
   - communication in general
   - science communication and science-policy-interfaces (incl. risk communication)
   - inclusive participation and empowerment (incl. decision-making, policy-making, etc.)
   - citizens science
   - development of Information Systems (IS), ICT and human-technology-interactions
   - development of Environmental Decision Support Systems (EDSS)
   - etc…
3. **Set up your project in such a way that it can become a real "learning organization"**
   True interdisciplinary and transdisciplinary work needs to be enabled actively. This also means that sometimes project partners might need to be pushed a little bit out of their comfort zone and/or out of their major domains of interest (and expertise) in order to maximize the outcomes and impact of the project. Crucial partners in the development process need to be open to learn from best-practices on other research disciplines they are not familiar with. They may not ignore relevant feedback from involved citizens or stakeholders, as the product-development might easily become a bottle-neck then (despite all the good intentions of other consortium-partners).
4. **Make sure that every project-partner takes care of "expectation management"**
   In order to avoid unnecessary disappointment and all the extra challenges that this might bring (for example in early drop-out of participants), expectations should be managed carefully. Most of the times, projects don't fail in an absolute sense, but they rather fail to meet individual expectations. Of course, it is not always possible to avoid disappointments, but when expectations are too high then disappointments will occur more easily. Therefore, it is important to discuss what can be expected (for instance when setting out the specific goals and actions for the project) and to be careful about what is promised (on the project website, during public meetings, in more informal conversations with stakeholders and/or in project-proposals). Furthermore, it is also important to discuss openly the uncertainties that are still remaining (for instance regarding the accuracy, reliability, etc.) during the development of the tools. Also recognize the difference between perception and reality, but use these discrepancies (which often have a signaling function) to improve the outputs of the project (e.g. developed tools) or the outcomes and impact. Expectation management is not only about avoiding failure. A good insight in the expectations of stakeholders will also bring opportunities.
5. **Take into account possible barriers for implementation which can reduce the outcomes and final impact of the project**
   There are many facilitating factors which stimulate, provide or promote a fertile environment for the type of participatory research that CITI-SENSE has been doing:
   - interest from the intended target groups and authorities (or lack of interest)

- good overall communication and collaboration with the participants
- appropriate user-involvement in tool-development (e.g. co-design and co-development
- user-expectations (and expectation management)
- user-attitude towards the COs (or towards a particular CITI-SENSE-tool or the project)
- the involvement of a "champion" (e.g. individuals who can make a difference)
- internal organizational support and organizational structure (user-organization)
- attitude of top management (towards the tools or citizen science in general)
- external organizational support (from the tool developer and/or provider)
- etc.

Some of these facilitating factors (or also potential barriers) are mainly seen as external influences that can go beyond the control of the project management (often referred to as threats in a SWOT-analysis), while some of the others facilitating factors can be – at least partially – anticipated upon.

6. **Make sure that the EU-goals for "Responsible Research & Innovation" (RRI) are taken seriously by all project-partners involved**
   All project partners involved are co-responsible of meeting these goals. Be open for the societal debates regarding the issues you're involved in and don't ignore the possible negative consequences. Be aware that the ways in which problems are defined – or "framed" can have an important role on the outcomes. For example, the way in which empowerment would be defined within this project seemed to be very important in relation to the RRI-goals of the European Union, because various forms of disempowerment might become an unexpected side-effect. Interdisciplinary research should address the still often overlooked dimensions of sustainability that are related with inequitable development and environmental injustice.
7. **Double-check also during the research process if all project goals are still really shared**
   At first sight, project goals seem to be shared and to be interpreted in the same way. Nonetheless, the same task descriptions in a project proposal can be read in multiple ways (e.g. from different perspectives), and different aspects of the task description might be emphasized (also depending on the specific interests/expertise of the project partners).
8. **Double-check regularly if the consortium is really balanced enough to deliver on all the necessary aspects of this research (including the social aspects):**
   When citizens or other stakeholders are involved in the product-development, or when a project is faced with unforeseen challenges, the project needs might change a little bit. Check if the consortium is flexible and balanced enough to adapt to these new needs.

Recommendations for the **European Union** in particular are:

1. **Put the principles of "co-design" and "co-development" at the core of these projects**
   The importance of active user-involvement in product-development has been addressed by many authors in the field of the development of Information Systems (IS) in general and for the development of Environmental Decision Support Systems (EDSS) or Integrated Spatial Decision Support Systems (ISDSSs) in particular (Mahmood et al, 2000; McIntosh et al, 2011; van Delden, 2009; van Delden et al, 2011). Nontheless, *"Information Systems (IS) are often designed and implemented based only on technical merits, and perhaps this is why many IS are substantially less successful than originally intended"* (Mahmood et al, 2000). Similar lessons can be drawn for the development of the COs. User-involvement can for instance help to increase the usability and the meaningfulness of the CITI-SENSE-tools. Also for the RRI-goals, co-design and co-development are crucial.

2. **Make sure that every project-proposal takes care of "expectation management"**
   In order to avoid possible disappointments that might lead to an early drop out of some of the involved stakeholders, expectations need to be managed to some degree. Most of the times, projects don't fail in an absolute sense, but they rather fail to meet individual expectations. Unfortunately, some of the requirements that are asked for in project-calls (and the sometimes over-enthusiastic promises that will be made then in the proposals) might become counterproductive if Responsible Research & Innovation requires active stakeholder- involvement and if not all promises can be met. Besides that, bottlenecks can easily be created if subtasks are strongly intertwined.

A project can become very successful when it exceeds expectations, sometimes in unexpected ways. Especially when "normal" is the standard that is expected by the participants and the project delivers results that are much better than normal, it will definitely be called a success. This should lead to the conclusion that it might be a good strategy to "under-promise and over-achieve". Aiming too low is not a good idea either, because in that case people will not be very interested in the project then (and it will be very hard to find volunteers). But the recommendation to start "simple and small" (e.g. with technologies that have already proven to be reliable) is very relevant when different goals – including social goals – have been set. As often, finding the right balance is important (Verheyden et al, 2013). Overly optimistic promises at the start of a project can only become a major barrier when participents would get disappointed along the way.

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