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Anna Berti Suman

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Challenging risk governance patterns through citizen sensing: the Schiphol Airport case

Anna Berti Suman

Tilburg Institute for Law, Technology and Society, Tilburg University, Tilburg, The Netherlands

ABSTRACT

This contribution analyses how citizen sensing initiatives can contribute to or, contrarily, hinder the governance of certain or uncertain public health risks. It draws on the example of the Schiphol Airport case, where citizens developed a bottom-up system for tracking and reporting noise after the Dutch Minister of Transport, Public Works and Water Management responded to their complaints about expanding the airport with the statement that 'Noise cannot be measured'. Despite the State's position of no adverse effects on the inhabitants' well-being, local residents started reporting ailments ostensibly linked to the increase in noise pollution. The central questions this contribution addresses are: how did lay people living near Schiphol use citizen sensing to respond to the risk represented by the increase in noise? How did this bottom-up initiated monitoring intertwine with the traditional top-down governance of the risk? The interplay between four theoretical concepts related to the case (citizen sensing, risk governance, lay people and social accountability) serves as a lens of observation for analysing the case. The ultimate goal is to assess whether 'pure' citizen sensing, only recognized by the institutional system at a later stage, can succeed in fostering social accountability of institutional actors to citizens exposed to a specific public health risk.

1. Introduction: the increasingly 'sensing' citizens

The presence of technology in everyday life not only affects interpersonal communications, but also the human capacity to monitor the surrounding environment (Suman 2017, 298). This article focuses on the progress of bottom-up monitoring technologies and their possible uses in the hands of lay people. The interaction between individuals and natural phenomena is investigated, zooming in on the application of technology to monitor environmental factors that affect public health.

The adoption rates of bottom-up monitoring technologies are increasing due to their growing affordability and availability (Boulos et al. 2011b). Furthermore, an individual using a smartphone can perform monitoring activities similar to what a sensor does. For

CONTACT Anna Berti Suman ✉ a.bertisuman@uvt.nl

example, an app for tracking air quality and an easy add-on device on one's smartphone can potentially make the individual carry out the task once belonging to public air monitoring stations. In the Schiphol case presented here, citizens in the neighbouring areas used microphones placed on their roofs to demonstrate a substantial increase in noise pollution impacting on their health and well-being, contradicting arguments made by the Dutch government.[1]

These data generated by people using bottom-up monitoring technologies are often geo-located and registered in real time, and therefore linkable to a specific spatial context and temporal dimension and to a certain individual or community (Kitchin 2013). This flow of data can provide valuable information on the risks to which people are exposed (Allwinkle and Cruickshank 2011) and may result in being crucial for orienting public policies related to risk governance.

This paper analyses the use of bottom-up monitoring technologies to influence the political decision-making process related to environmental health risks. A case study analysis provides insight into how this technological development is reshaping how citizens track environmental health risks surrounding them. The focus is on how non-professional and non-institutional users of monitoring technologies can challenge or complement institutional patterns of risk governance by creating alternative ways of tracking and reporting risks. The ultimate aim is to investigate whether these bottom-up solutions can foster accountability of institutional actors to citizens exposed to a specific public health risk, complementing top-down governance patterns.

2. Conceptualization

2.1. Citizen sensing and lay people – some definitions

Before approaching citizen sensing 'in context', it is necessary to conceptualize the underlying theoretical notions exemplified in the Schiphol case. The concepts outlined in this section are those of 'citizen sensing' and 'lay people'. Because the first concept is a dynamic notion, it is difficult to crystallize the number of heterogeneous citizen sensing practices into a rigid definition. The second concept, 'lay people',[2] is relatively easy to define, given its everyday use.

One could plainly affirm that a layperson is someone who is not a professional in a particular subject, because s/he is not qualified and/or recognized as holding a particular degree, training or role in which an expertise is implicit. The concept is indeed often presented in opposition to 'expert' people. For example, Callon (1999) presents 'lay people' in contrast to 'specialists', 'scientists' and as patients to 'doctors and biologists'. The criterion for identifying the reference group of lay people could therefore be the mastery (or not) of expert knowledge deriving from a specific professional role. However, among 'lay people' there may also be experts (as for example, the ICT trained initiator of the Schiphol noise monitoring system described below). Indeed, especially in healthcare, the concept of 'experiential experts' is well known. Consequently, the here so-called lay people refer to ordinary people, that *can be* expert in a certain subject, but *are not assumed* to be expert in relation to a certain role or situation. Furthermore, among the ordinary people, it is noted that the experts but non-professionals often play a key role in the launch of the monitoring, making this expertise at the service of their community.

In this article, only a sub-set of the broad lay people group is analysed, namely composed by the sensing citizens as non-professional users of monitoring technologies, which are experiencing new ways of information generation and new forms of participation in risk governance. The expert group is composed of professionals and policy-makers that rely on professional knowledge to inform their decisions, and that are being confronted with these alternative forms of monitoring and responding to risks.

The notion of lay people in this section is studied as juxtaposed to the notion of citizen sensing in order to reflect on their intertwined relationship. The definitions of citizen sensing hereby considered contain the notion of lay people, more or less explicitly. The role played by lay knowledge will emerge by observing how the two concepts are described in combination. An important disclaimer must be made to start, i.e. that not *all* lay people practice or keep practising citizen sensing. Contrarily, non-professional individuals using citizen sensing technologies represent a *sub-set of the society* that decides, for their needs or ethical, social or political beliefs, to embrace a non-standard system of tracking and reporting certain phenomena.

Citizen sensing is conceived as a dynamic and evolving concept. Among the numerous definitions, the phrasing of the 'Citizen Sense'[3] project suggests that citizen sensing is a practice of monitoring environmental (health) factors using smartphones and networked devices, which may foster citizen participation in tracking environmental (health) factors, including risks.

Other researchers underline that citizen sensing would not exist without certain technology and focus more on the technical side of citizen sensing, whereas lay people knowledge seems less crucial to the definition. According to Sheth (2009), citizen sensing would indeed result from the interaction between the citizens and the Web 2.0, which would augment these citizens into citizen sensors. Sheth (2009, 87) defines citizen sensing accordingly: 'humans as citizens on the ubiquitous Web, acting as sensors and sharing their observations and views using mobile devices and Web 2.0 services'. Technology, under this perspective, would increase the sensing potential of the already sensing citizens. Boulos et al. (2011a, 6) follow this line drawing attention to the 'sensing' component as 'the detection of a physical presence and the conversion of that data into a signal that can be read by an observer or an instrument'. However, the human component emerges in the acknowledgement that, in citizen sensing, the sensing is not performed by a hardware sensor but by a human interpreting sensory data and combining these data with his/her *situational awareness*. This situational awareness would relate to lay knowledge because it is contextual and does not entail any educational process or specific expertise. Through citizen sensing, lay people would generate quasi-expert knowledge on the basis of the above-mentioned situational awareness.

Srivastava, Abdelzaher, and Szymanski (2012) stress this idea, adding that humans in citizen sensing are not only information sources, but also engage in information sharing, information fusion and analysis. The additional value of ordinary people's knowledge, though non-professional, is that it reflects an 'in-the-loop' understanding which often is missing to institutional actors intervening in the context (for this reason citizen sensing has also been denominated as 'human-in-the-loop' sensing). This view can be complemented with Burke's et al. (2006, 2) assertion that 'participatory [read "citizen"] sensing tasks deployed mobile devices to form interactive, participatory sensor networks

that enable public (..) users to gather, analyse and share *local knowledge*'. Again, the connection between citizen sensing and lay knowledge (here characterized as 'local knowledge') is made explicit. Moreover, an additional element, of sensor networks, through which networks of sensing citizens act and interact, is presented. The potential of citizen sensing and the added value of local knowledge are stressed by Goodchild (2007, 218) who states that sensing citizens are 'intelligent synthesizer[s] and interpreter of local information'. Ganti, Fan, and Hui (2011) add an element which will result particularly important in the Schiphol case analysis. Namely, they stress the importance of the possession of the sensors through which the measuring and analysis are performed. Non-institutional actors' ownership of the tracking technology and the data would – in the view of the sensing citizens – grant a system of 'external' validation, absent when the institutional players control both the action and its assessment.

Boulos et al. (2011a, 4) underline the transition from passively tracked and profiled individuals to active trackers. A trend showing a push from a 'quantified self' to a 'quantified surrounding' of the self may be hypothesized. The discourse of 'empowering' the people, of 'consulting' or 'including' them in scientific/decisional processes seems replaced by a self-empowerment and auto-inclusion. Traditional patterns as the domination of expert knowledge and the restrictions on access to information by third parties are challenged. In purely bottom-up citizen sensing initiatives, lay people are in fact those who decide what to track and how. There seems to be a connection to what Harrison and Mort (1998, 60) describe as 'technologies of *legitimation*'. The authors use this term to characterize public consultation and user involvement that would not truly represent the general public but only a *certain sample* of it. Furthermore, the authors identify a risk of performativity in general public consultation, which would often be more about showing that (a) public was consulted, rather than actually using the public's input on an issue. The sensing citizens seem to refuse the described technologies of legitimizations as top-down imposed means for 'engaging' the people. On the contrary, they feel *legitimized* (though they also represent only a fraction of the citizens) to decide which technology and how to use it in order to play a certain role in the debate – in the case of this article – with regard to risk governance. This transition is highlighted by Campbell et al. (2006, 2), according to which the citizens would be 'no longer just consumers of sensed data about some natural phenomenon or ecological process'. Instead, 'the sets of producers and consumers of sensed data now overlap; people are *in the loop* and may participate in both roles (producers and consumers of sensed data)'.

Combining and unpacking these definitions one could sum up the discussion affirming that citizen sensing entails lay people acting as intelligent interpreters through pre-existing networks, or networks created more spontaneously by events (e.g. a public health crisis), on which they actively observe, report, collect, analyse and disseminate information via certain technologies. Following Boulos et al. (2011a, 6), citizen sensing would complement machines' sensing because it relies on finer perception; on humans' capacity to 'contextualize, discriminate and filter'; and to accompany the sensing with 'common sense, background knowledge and experience'. The case study analysed in this article will be presented with the purpose of showing the complementing potential of citizen sensing, and the extent to which situational awareness and local knowledge may contribute to risk governance.

2.2. Risk governance and social accountability

This section further develops two additional key concepts: 'risk governance' and of 'social accountability'. Although the two concepts are not evidently related, a link can be drawn between them. The first term is composed of two already complex concepts, 'governance' and 'risk'. Governance is a concept primarily belonging to political science which aims to describe the multitude of actors and processes that lead to collective binding decisions. Particular attention is devoted to the interplay between governmental institutions, economic forces and – particularly relevant for this article – civil society actors. The term 'risk' is a very broad concept which refers to the possibility of damage, whether in health, environmental, economic or other terms (Van Asselt and Ortwin 2011). Van Asselt and Ortwin (2011, 431) combine these two notions to define risk governance as 'the translation of the substance and core principles of governance to the context of risk-related decision-making'. They argue (2011, 432) that risk governance provides both a conceptual and a normative basis for orienting decision-making in dealing responsibly with uncertain, complex and ambiguous risks.

The importance of combining governance and risk arises mainly in dealing with complex and uncertain risks which cannot be calculated as a linear function of probability and effects as for example, the risk presented in the Schiphol case (an increase in noise *possibly* undermining people's health and well-being). Furthermore, from the acknowledgement that complex risks are often ambiguous, derives the need for a joint action of the numerous stakeholders interplaying in the risk arena, which introduces governance issues. This because ambiguous risks are perceived and addressed differently from the various perspectives represented by each stakeholder. For example, in the Schiphol case, the same notion of risk is under discussion: the risk was perceived as such by the airport dwellers but it was denied by State actors. Risk is a social and cultural construction (Johnson and Covello 1987) and consequently, it may appear differently depending on the standpoint from which one looks at it. From this acknowledgement rises the ambiguity that makes governance of risk a complex practice.

Fisher (2017, 125) recently addressed the contrast between risk regulation conceived as a linear pattern in which the top-down ways of addressing the risk prevail (the author exemplifies it as linear diagrams) and more participatory approaches to risk regulation (exemplified as 'looping arrows going all over the place representing risk regulation as an iterative process that constantly involved many scientific, socio-political and other inputs' as the civil society input). She advocates for the second approach to regulating the risk, despite acknowledging that risk regulation is now framed primarily as a linear process. Considering that for certain aspects risk regulation (though narrower and more law-oriented than risk governance) may be considered synonymous with risk governance (Ortwin 2008), Fisher's reflections seem particularly fitting in the argument of this article that the engagement of non-institutional actors in risk governance may enhance the effectiveness in how society faces risk. The 'linear' way(s) of governing environmental risks to public health here corresponds to the approach adopted by the institutional actors responsible for those risks (in the case study, the Dutch Ministry of Transport). Generally, the institutional approach would be based on high-quality monitoring equipment, that require a considerable expense and continuous labour, which often leads to low spatial and temporal resolution (Mead et al. 2013).

Moving now to the concept of 'social accountability' and its intersection with risk governance, it can be said that actors able and expected to govern a risk are *accountable* to the society because their conduct affects citizens' rights and therefore needs justification. Moreover, in a democratic society, citizens confer the power to govern specific risks to their representatives. From this mandate derives the expectation that the risk is governed for the public good and the underlying accountability claim.

Risk, as stated before, is a social construction, therefore it is constantly shaped by society and always subjected to the 'eyes' of society in a form of 'sousveillance', using the term coined by Mann, Nolan, and Wellman (2003). In particular, those societal groups exposed to a certain risk will likely be the stakeholders claiming for an accountable risk governance, probably more so than society at large. In this article, the focus is on the social accountability of institutional actors to citizens exposed to a specific risk. Surrounding the 'affected' people there is a consistent number of other actors, for example, relevant NGOs acting on behalf of the exposed group. However, the reflection will be centred on the narrower relationship of accountability between the citizens (considered the accountability claimers) and the government (considered the object of the accountability claim). Those actors external to this narrow relationship but supporting the citizens will be labelled as 'extreme publics' following the definition of Georgiadou, Lungo, and Richter (2014, 516), namely 'existing organizations and professional users who populate the space between the state and citizen sensors'.

Accountability is often discussed together with democracy and, talking about *social* accountability, it seems even more appropriate to bring the two concepts together. Bovens (2005) affirms that democracy remains a paper procedure if those in power cannot be held accountable in public for their acts and omissions, for their decisions, their policies and their expenditures. Accountability would then be a prerequisite for democracy and the accountability claims, which citizens may make, would be rooted in the very core values of democracy. Often accountability is also approached jointly with the concept of transparency. The right of the citizens to make their governors accountable for the governance of a certain risk can go together with people's 'right to know' (Fenster 2012) to which kind of risk they are exposed. This right to be informed can be considered as encompassing also the proper and understandable communication of a risk by the authorities responsible for managing such risk to the affected people. In the Schiphol case illustrated here, the airport dwellers considered that the threat to their quiet and well-being represented by the increase in noise was not disclosed to them in a transparent way, thus possibly leading to a breach of their right to be informed.

Georgiadou, Lungo, and Richter (2014) present this connection between transparency and accountability (T&A) by documenting a series of T&A interventions that entailed crowdsourcing citizens' reports in middle and low-income countries. The interesting point they make is that there is an increasing push towards a 'horizontal transparency', understood as a form of access to sectoral information where the citizens can 'see' the information of service providers, for example, providers of water and health services, or produce it themselves if the information is not available (Georgiadou, Lungo, and Richter 2014, 520). This horizontal transparency would be in a sense a 'short route' to social accountability (McGee and Gaventa 2010), preferred to the 'long route' of traditional accountability (via elected politicians and public officials). Social accountability would,

therefore, imply horizontal transparency and this combination would be indispensable to create an equal playing field between citizens and government. Horizontal transparency, on the other hand, goes together with the idea underlying the concept of citizen sensing, which entails even access to information and bottom-up produced knowledge. Citizen sensing will be a way of producing a 'technology-mediated' accountability (Georgiadou, Lungo, and Richter 2014, 521).

2.3. Bringing these concepts together

Four concepts have been analysed in the previous sections, on the basis of the literature regarding lay people, citizen sensing, risk governance and social accountability. Now, these concepts need to be put together to frame the case inspected in this article. First, it must be said that there are cross relationships between the two sets of concepts. Lay people, for example, as non-institutional actors, are those from which can arise the claim of accountability directed towards governmental actors (diagonal arrow in Figure 1), conceived as the experts and institutional players. Furthermore, the group exposed to a risk can be formed by lay people which will interact with experts in observing or, in case of participatory approaches, co-designing how the risk is governed (vertical arrow in the figure below). Conversely, citizen sensing may be considered a tool for co-governing a risk. Moreover, it can be regarded as a technology mediating accountability claims in contexts where there are information monopolies, real or perceived (horizontal arrow in the figure below). Social accountability, as mainly tending towards horizontal transparency, may arise from initiatives aimed to create and make wise use of local knowledge and situational awareness. These initiatives could be characterized as citizen sensing initiatives that are contextual to specific situations of risks.

Developing these reflections further, the following components of the picture emerge: (1) in the case X, a group of *lay people* is exposed to a risk; (2) they are dissatisfied with how the risk is communicated and distrust how the risk is governed; (3) institutional actors
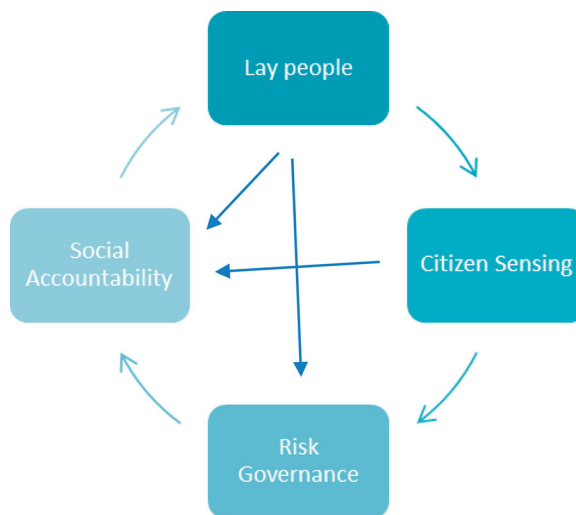
Figure 1. The interplay between lay people, citizen sensing, risk governance and social accountability.

proceed with their way of *governing the risk* (which may also mean denying/ignoring the risk because considered as not subsisting); (4) the group demands *social accountability* and transparency on how the risk is addressed; (5) the group decides to complement/substitute the institutional patterns of governance with *citizen sensing* initiatives; (6) a parallel system of information generation and analysis is created; (7) the parallel system gains attention from societal actors beyond the exposed group of citizens; (8) eventually the system is understood as potentially effective by institutional actors and included in the top-down governing strategies; *or* – most likely – the two systems clash and one prevails, through legal, political and social avenues. With regard to the outlined picture, it must be said that what appears as, and often is, a sequence may instead consist of overlapping stages, which do not follow the presented order.

3. In practice: the Schiphol Airport case of citizen sensing

3.1. Methodology for the case analysis

The aim of analysing the Schiphol Airport noise monitoring case is understanding the response of the people living around Schiphol to the uncertain risk represented by a supposed increase in noise disturbance, and the socio-political consequences that this response produced in the status-quo. The two questions through which the case has been inspected are:

(1) How did lay people living near Schiphol use citizen sensing to respond to the risk represented by the increase in noise?
(2) How did this bottom-up initiated monitoring intertwine with the traditional top-down governance of the risk?

A methodological disclaimer must be made, namely that this article is part of ongoing research, and until now it has been built mainly on the secondary literature relative to the Schiphol noise case that is available in English. Numerous official reports and relevant articles available only Dutch[4] could not be digested into this article because of language barriers but will be considered and analysed in the future.

In addition to secondary sources, the information has been complemented with three semi-structured, face-to-face interviews conducted at the Dutch National Institute for Public Health and the Environment – RIVM (Rijksinstituut voor Volksgezondheid en Milieu), and at Delft University of Technology. At RIVM, an expert of Risk Governance and an expert of Citizen Science have been interviewed. At the Delft University of Technology, an expert of Responsible Innovation and of Urban Innovation theories has been interviewed. The interviews lasted approximately 1.5 hours each, and the two conducted at RIVM were recorded with permission. For all the three interviews, summaries were made for the purposes of this paper and are available upon request. The agreements made with the interviewees entail the disclosure of the function but not of the name of the experts interviewed. The interviewees were granted access to the article as incorporating their statements. Though their number is limited, the interviews conducted play a key role in the article due to the significant positions held by the experts.

3.2. The theoretical notions enter the case

There are many, but primarily two, ways of viewing the Schiphol Airport case. One lens of observation is to consider the technology that lay people used to measure noise as 'neutral', and the residents' engagement in reporting noise disturbance as an effective contribution to the governance of the risk represented by the increase in noise (following, for example, Carton and Ache 2014). Another approach is based on the argument that technology is never neutral, and the fact that the dwellers started to measure noise with a non-institutionally established system already discloses political ideals embedded in the technology used. This second view can also be coupled on the argument that the engagement of alternative ways of monitoring and reporting a risk increases the complexity of risk governance (following, for example, De Jong and Boelens 2014). While there may be positive examples of including bottom-up initiatives in the institutional system of decision-making, the authors affirm that in general participatory processes are not desirable.[5] Arguably, risk governance would need expert intervention and detachment from the situation of risk, rather than situational awareness of in-the-loop actors.

This section develops the clash between these two perspectives using the four concepts from the previous section to frame the case study analysis. The scheme going from point (1) to point (8) presented in the conceptualization section here is verified in the case. In this instance, lay people, in the sense described above, are the inhabitants of the surroundings of Schiphol Airport. Schiphol residents represent the non-institutional and non-professional stakeholders, which experience the increase in noise. On the other side stand the institutional players (policy-makers and the experts to which they refer) that have a professional role in governing the risk and the consequent knowledge necessary. This latter knowledge is contrasted with the 'situational awareness' of the people living 'in the loop', which is represented by the information generated by people measuring the risk through their own means. Their self-organized use of microphones to track noise can be viewed as a way for the citizens to claim their right to live in a healthy environment and act to preserve it, but also as a means to democratize how data about risk are collected. The right serves as a sort of legitimization of the alternative measuring and as a legal basis to seek horizontal transparency in environmental health risk governance.

The way this bottom-up initiated monitoring is intertwined with the traditional top-down governance of the project's consequences is illustrated. A form of 'sousveillance' is identified in this movement from the grassroots to the top, represented by on the ground eyes from which the claim of accountability arises towards governmental actors. The notion of social accountability 'in practice' as resulting by the people's action is investigated. The object analysed through the accountability parameters is the governance of the risk posed to public health and well-being by noise pollution. The case serves also as a scenario to investigate whether *certain* citizen sensing initiatives can be integrated in the state's action through an 'institutionalization' process.

3.3. The case

The case regards Schiphol Airport, the main airport of the Netherlands, situated near Amsterdam. The controversy originated from a political decision to extend the airport, creating the so-called fifth runway (the 'Polderbaan') in 2003. The time line of the initiative

is relevant because it falls before the 'boom' of the phenomenon of citizen sensing, which can be situated around the year 2010 (Boulos et al. 2011a).[6] This consideration shows that, regardless of the advancement of technology, the concept of citizen sensing and the desire of non-professional people to 'track' (not only the self, but also the surrounding) are not new. As a matter of fact, the need for accurate and real-time information about a risk and its use for policy-making have always existed, and the introduction of constantly evolving technologies is just answering in different ways to an already existing demand.

The mentioned expansion of the Airport would have caused airplanes to make manoeuvres over densely populated areas. Environmental activists and parties filed numerous complaints against the project, largely in relation to the risk of an increase in noise burden for the residents. It is identifiable here stage (1) of the aforementioned picture (a group of lay people is exposed to a risk). The Dutch Minister of Transport, Public Works and Water Management (Minister van Verkeer en Waterstaat, now part of the new Ministry of Infrastructure and the Environment), at the time Ms Tineke Netelenbos, responsible for the expansion of the Airport, on public media reassured those groups that there were no risks of adverse effects on the inhabitants' quiet (Carton and Ache 2014). Ultimately, the new runway was built despite the societal opposition, and it became operational at the end of February 2003. It is noteworthy that the opening of the new runway coincided with the revised Aviation Act (Wijzigingswet Wet luchtvaart)[7] effective from February 2003, which provided for new environmental and safety standards. The enactment of the mentioned legal instrument could be regarded as sort of top-down response to the people's claims. It may be argued that, in the view of the Dutch government enacting the revised Aviation Act, the controversy – if any – was solved by the issue of new, more stringent standards. However, the study conducted on the affected community by Carton and Ache (2014) does not show any change in the adversity of the people towards the project after this legal intervention. This suggests that actions at the macro and abstract level are often insufficient to answer the claims of those citizens which are facing a very specific risk.

In the meanwhile, the inhabitants started reporting intrusive noise levels that allegedly were the cause of disturbance to their sleep, headache and other ailments. The Ministry of Transport, Public Works and Water Management's response broadcasted on public media was that noise could not be measured due to interferences like wind direction and disturbances from the environment, but it could just be calculated using mathematical models.[8] The Schiphol Group Annual Report for 2003 (2004)[9] has been consulted but no mention of this controversy involving the dwellers and their initiative was found. However, a reference to a possible related issue is present on page 28 of the report. The aforementioned set of standards is cited, and it is made explicit that, for the first time, the new measuring system (Environmental Impact Assessment (EIA) procedure) according to the new standards will take into account not only noise levels but will also cover air quality and third-party risks. It could be assumed that the controversy about the impact of the runway expansion on the residents' health has been reflected in this reform. It is also explicitly mentioned that this reform has been triggered by an error made in the calculation of the environmental standards regarding the 2003 EIA input data for Schiphol Airport. The report informs that the error leads to the incorrect distribution of flights taking off to the north from the new runway, due to an overestimation of the possible use of the new Polderbaan. The report states that more information on the environmental, safety and airport

accessibility policy can be found in Schiphol Group's 'Sustainable Development Report' for 2004.

The information about noise burden under the perspective of the Schiphol Group Report would, therefore, be available and easily accessible. However, Carton and Ache (2014) present a shared feeling among residents of the area of a lack of transparency in how the public was informed about the noise burden. Stage (2) of the picture is here represented by citizens' dissatisfaction with how the risk of an increase in noise was communicated and their distrust in how it was governed. The authors describe an 'informational monopoly' arising from the denied possibility to measure noise, and from the fact that the measuring stations were owned by the Schiphol Group (the controller and the controlled coincides). They also present the 'emotional trigger' (a sense of anger and frustration spreading among the citizens) as the initiator of the bottom-up initiative. The interviewed expert of risk governance at RIVM confirmed the institutional pattern of noise governance as based on: (a) a vertical control over the monitoring system; (b) a denial of discussion over the appropriateness of this monitoring and (c) an uncertainty on whether the expansion could have caused disturbances to public health. These three points reflect stage (3) of the picture, where institutional actors proceed with their way of governing the risk.

The interviewee from Delft University of Technology stressed the importance of the question 'who owns and governs the measuring sensors and the results?' which sheds light on the reasons for the perceived lack of transparency. The interviewee adds that the status quo (top-down governance of a risk where institutional actors control the measuring points and the relative data, and set the parameters to be measured) may not change until a break occurs. The 'break' in this case can be exemplified by the rise of an unexpected and alternative measurement system.

The second interesting element of the case regards the 'purely' bottom-up citizen sensing initiative. The idea of the alternative monitoring came to a citizen named Rene Post, trained in ICT, and living in the city of Leiden, which is close to Schiphol. The fact that an individual citizen launched the monitoring project distinguishes this initiative from other forms of citizen sensing that cannot be considered 'purely' bottom-up because they are either consigned from institutions to the people as ready-to-use tools for monitoring (e.g. RIVM providing sensors to a community in order to monitor air quality), or yet they are controlled by pre-existing civil society organizations (e.g. Greenpeace controlling the actions of victims of environmental crimes in tracking companies' wrongdoings). These latter are also identifiable as 'extreme publics' following the terminology used by Georgiadou, Lungo, and Richter (2014) already discussed above. The fact that there was no pre-organized civil society entity (or extreme publics) orienting lay people shows that the initiative is completely citizen-led, and therefore that it is a case of a clearly bottom-up *vs.* top-down interaction. However, the Citizen Science expert from RIVM stated that the distinction between completely citizen-led initiatives and extreme publics-mediated initiatives does not subsist when the citizens identify themselves with the pre-existing civil society organization. In this sense, the civil society organization would not control people's action but just voice the interests of the citizens that remain the key players of the initiative.

In any case, Rene Post was not acting in representation of any pre-existing organization. He decided to challenge the State's argument that noise could not be measured as an

ordinary citizen enforcing his right to live in a healthy environment. In order to achieve his purposes, he committed himself to the creation of an ICT tool to get meaningful evidence of noise impacts on the dwellers' quiet. Stages (4), (5) and (6) of the picture come true: the group demands social accountability, by substituting the institutional system with a citizen sensing initiative. Consequently, a parallel system of information generation and analysis is created.

The key idea was that the tool should have been used by on the ground actors, relying on people's ability to track what they were experiencing every day (the above discussed 'situational awareness'). In the system ideated by Rene Post, the information about noise levels was sent to local personal computers (the 'network of sensing citizens') that in turn communicated these data to a central server through the Internet. The noise was measured through microphones, which locations and data were registered on a website (now converged into 'Sensornet').[10] The open access website allowed users to visualize via graphics the data in its entirety or specifically for each microphone.

The two possible lenses of analysis presented above now enter the case. One, as claimed by the residents engaged in the measurement, and reported by Carton and Ache (2014), is that the microphones can be regarded as a *neutral* measuring instrument. The neutrality of the tool would stem from the fact that it was not aimed to demonstrate that there was a noise impact, but simply that noise could be measured. In this sense, Carton and Ache (2014, 7) highlight that the objective of the initiative was to provide an 'independent, factual, open noise measurement' on various locations in populated areas surrounding the airport. One could argue that the facts that the website collecting the information was designed in an open access format, and that the measurements were performed by various independent actors on the ground show the transparency and neutrality of the technology used. However, relevant bodies of literature from science and technology studies (e.g. ANT scholars Law [1992]; Callon [1999]; Latour [2005]) argue that neutral technology does not exist. The decision of measuring already embeds in itself socio-political values and opinions. If there was no controversy on the appropriateness of the measuring, the residents would not have started an alternative measuring. This shows that the attempt to demonstrate that noise could be measured may be regarded as a political response to the government's position. This point was also made by the expert from the Delft University of Technology, who underlined that the citizens' decision to measure a risk by themselves derives from a distrust in the system. Measuring would then be in itself a demonstration of public scepticism about the government's way of facing the issue. Moreover, with regard to the argument that transparency and neutrality stem from open access, one could debate that open access diffusion of the information collected through the alternative measuring does not automatically ensure transparency and neutrality.

Another element of the case worth examining is the fact that Rene Post engaged a group of 25 volunteers (sub-set of the group 'lay people' inhabiting the interested area) among the residents to become performers of the measurement. Therefore, not *all* the residents affected by the noise engaged in the measurement, but only a part. This indicates possible bias hidden in the assumption that the bottom-up measuring reflects the interests of the *whole* community of residents, and a risk of a legitimacy deficit deriving from the fact that the active people may not represent the community at large.

Rene Post, after grouping the volunteers, found a small subsidy to finance a pilot project. A relevant element of the implementation of the idea is the high usability of the technology, and the capability of the participants to rely on the limited resources available. As a matter of fact, the participating citizens started to measure the noise by connecting their own personal computer to a microphone placed on their roofs. The participants also found creative ways to overcome the difficulties of conducting the measurements (the non-linear way of responding to the risk, exemplified above by Fisher [2017] as 'looping arrows going all over the place'). For example, the issue of the interference of other noises was solved by arranging the sensors in triangles for each measuring station. On the basis of triangulation and resulting information on noise speed, the participants were able to detect airplane noise, among other noises. Being an initiative based on cheap technology, there was an additional problem related to the accuracy of the data gathered. Specifically, the low-cost microphones sometimes did not work properly under rainy conditions and at times their calibration was not stable causing unprecise measurement. Nevertheless, the overall result was a visualization of noise loads recorded continuously at 25 observation points made available on a public platform (now converged into 'Sensornet').

Stage (7) of the picture described in the previous section can be identified: the parallel system of information generation and analysis gains attention from societal actors beyond the exposed group of citizens. The project indeed attracted the interest of a broader public, not only activists and local inhabitants, but also influential non-governmental organizations, policy-makers and the media. Two years after its launch, a professional foundation, Geluidsnet,[11] proposed to create a venture between the noise measurement infrastructure and 10 municipalities in the interested areas. The platform was improved and the shortcomings in accuracy addressed. Several other partners joined the initiative. The system, from a small-scale idea, became a widely used system for assessing noise impacts over the country.

Apart from the two possible lenses of analysis, this case can be considered particularly remarkable because – in contrast to other citizen sensing initiatives – it was not 'offered' to the citizens as a given project. Rather, it was the result of the citizens' self-organization, counting on low resources but feeling a sense of lack of transparency in how the noise issue was managed by the government. All the matters here revolved around the challenge to the informational monopoly (possibly just perceived by the citizens) discussed above and the claim that the institutional way of governing (or ignoring) a risk was not necessarily the best and the only way. In the case presented, the citizens did not trust official sources, consequently resorting to their own capability to obtain the information.

The notion of social accountability 'in practice' stems from the acknowledgement that the affected people wanted to make visible a physically and *politically* 'invisible' risk, and to generate awareness not only within their own community, but also in the outside world (namely media and institutional attention). The same existence of a risk was under discussion and the participants wanted to overcome this ambiguity by making it evident on a publicly accessible source, an online map of noise (the above-mentioned 'Sensornet'). The visualization of the risk through a map which is a relatively conventional and old way of visualizing information (despite here it is a matter of digital maps) shows the

need for the participants to rely on usual and easily understandable communication channels, beyond the ever-evolving and sophisticated sensors.

Furthermore, the monitoring citizens challenged the national government's information on what they perceived as a legitimate basis, namely their right to live in a healthy environment and their 'right to know' about a potential risk (see above Fenster [2012]). This alternative monitoring project warned the institutional actors that they were 'watched by the citizens', who no longer trusted their governors. This aforementioned 'sousveillance' may be considered as a catalyst for 'technology-mediated' (Georgiadou, Lungo, and Richter 2014) social accountability, without the perceived need to move into a judicial setting to challenge the institutional governance of the risk under a legal accountability point of view (as discussed above by McGee and Gaventa [2010]). Following this argument, Carton and Ache (2014) suggest that citizen sensing would be a 'method for hypothesis falsification'. The Schiphol noise initiative would be an instrument for challenging a hypothesis such as, 'noise cannot be measured', as a façade aimed at subtracting government's action to social accountability. The expert on Citizen Science from RIVM corroborated this view. The expert affirmed that the fact that people started their own alternative measuring makes itself an impact and tests the assumption that the institutional and traditional approach is valid. According to the expert's opinion, the clash of methods for risk measurement and governance (in the case, the bottom-up up and top-down methods) would be constructive and necessary to extrapolate the truth from each argument, and to improve the functioning of the system.

Moreover, Schiphol's dwellers could 'offer' their system to institutional stakeholders. An influential organization (the professional foundation, Geluidsnet) and 10 municipalities embraced the initiative. From an alternative and conflicting action, the bottom-up noise monitoring converged in a more institutionalized system, according to stage (8) of the picture where eventually the system is included in the top-down strategy (though only at the municipal level). This may suggest that 'purely' citizen-led citizen sensing initiatives may converge into the institutional frameworks of risk governance. When this convergence occurs, this is not necessarily a failure of the initiative. Contrarily, the integration of the bottom-up into a top-down system of governance shows that the two approaches can converge, strengthening and complementing each other.

Nonetheless, as demonstrated by the possibility of analysing this case through two lenses, other authors strongly disagree with the value of participatory approaches in addressing complex issues affecting public health and well-being. Specifically, De Jong and Boelens (2014) question the self-organizing capacity of lay people and the fact that their engagement can improve problem solving. They argue that these alternatives paths of governance may even worsen the scenario, and lead to misguiding conclusions. Under this point of view, the alternative measuring system would not contribute to solve the problem but be *part of the problem* itself. The expert on risk governance partially supported this opinion. First, the interviewee argued that bottom-up risk measuring and reporting often comes only from a small fraction of the grassroots, and therefore is not representative of the affected community at large. Second, 'targeted' or unintentional inaccuracy in the measurement might generate false fears and badly interfere with risk governance, hindering the whole process. The expert identified a worrying trend of rising complaints based on misleading information due to the technology-enabled

tracking capacity of lay people. Non-professional monitoring would carry, in this sense, bias related to conspiracy theories and risk perceived, which is often different from the actual risk, and would mostly lacks a proper methodology. Nevertheless, the expert recognizes that these initiatives create awareness in both the top and the bottom levels of the society and traditional risk governance patterns are already changing in view of these technological and mainly social transformations.

In this case study, the two lenses of analysis made it possible to show some of the promises and challenges of grassroots engagement through citizen sensing in risk governance. In the conclusions, a way forward will be outlined.

4. Conclusions

The theoretical concepts discussed and the case study showed that there is no straightforward answer to the questions raised in this paper. Numerous, but primarily two, lenses of judging citizen sensing in its interplay with risk governance have been outlined. Namely, citizen sensing has been inspected as a technology mediating or enabling accountability claims in order to overcome informational monopolies or, conversely, a way for 'fabricating' false claims. Moreover, citizen sensing has been regarded as an instrument to enhance horizontal transparency, and make wise use of local knowledge and situational awareness, or instead of a practice likely to increase complexity and intricateness in the allocation of important information about risks. Furthermore, it has been shown that citizen sensing can be a tool for co-governing a risk or, on the contrary, an obstacle to a proper risk governance. Despite the clash of these opposite views, a point that must be made is that the engagement of lay people in risk governance creates a dialogue between conflicting interests and often critical and constructive confrontation contributes to the resiliency and the progress of society. It can be affirmed that bottom-up monitoring initiatives arising from public dissatisfaction and distrust bring the promise to improve T&A in decision-making, besides creating awareness among the participants. Nonetheless, the risk of misleading information creating false fears, monitoring bias, conspiracy theories, mis-perception of risks and lack of proper methodology are all barriers that considerably hinder the potential of citizen sensing.

The lessons learned from the case study analysis make possible to outline a way forward with regard to how citizen sensing initiatives should be built in order to succeed in complementing the institutional patterns of risk governance. The following components seem crucial:

- *An issue driven initiative;* the sensing citizens must be able to show that they are addressing an issue which is relevant to them, urgent and which poses a real threat to public health (or, depending on the matter, public safety); the initiative must be clearly aimed to foster social accountability and transparency on how the issue is addressed.
- *An initiative as representative as possible*; though involving the whole affected community in a citizen sensing initiative is often unfeasible, the participants have to ground their arguments in analysis and researches that are the most representative of the interests of the community at large. This means for the sensing citizens to share the results of the measurements with the non-participants and to incorporate their feedback in the initiative.

- An 'honest' initiative; the participants must ensure that they do not depict themselves as the whole community if they represent just a part of them, they must acknowledge the intents that push them to challenge the institutional system, and be open to possible criticism of bias in the measuring.
- An accurate and reliable initiative; the citizens engaged in the sensing have to validate their alternative/possibly complementary system through the support of experts (both within the same group of participants and, most importantly, outside), in order to secure the credibility, accuracy and reliability of the data gathered, when showing neutrality is not possible; this is particularly crucial for drawing the attention of societal actors beyond the exposed group of citizens.
- An open and flexible networked initiative; the participants must be aware that they do not represent a self-sufficient network, but that their value is instead in their capacity to connect and cooperate with the institutional system with a view to improving the status quo; in this sense, the sensing citizens must be open to compromise with the top actors to find together better ways for governing a certain risk, complementing each other's approaches.

Lastly, it must be acknowledged that general conclusions cannot be drawn due to the fact that empirical evidence on the potential of citizen sensing is still limited, and researchable examples of large-scale citizen sensing initiatives are scarce. As Georgiadou, Lungo, and Richter (2014) claim, empirically and theoretically grounded research on citizen sensing, especially in middle and low-income countries, is missing. This article contributed to this still under-researched field, rising more questions than those answered. Future research is needed on the potential benefits and drawbacks of citizen sensing and its interaction with traditional patterns of risk governance, investigating, for example, how local and nationals governments react on citizen sensing, and how non-professional citizens and professionals can work together to optimize risk governance.

Notes

1. In this article, the term 'government' is used as representing the executive branch of the Dutch State. Within the article, the term is often used interchangeably with the term 'State', however, the two concepts do not exactly correspond. The Netherlands are a parliamentary representative democracy, a constitutional monarchy and a decentralized unitary state, in which the executive constitutionally consists of the King and the cabinet ministers. The King's role is limited to the formation of the government and he does not actively interfere in daily decision-making. The ministers together form the Council of Ministers, which holds the executive power to initiate laws and policy. The Dutch regional government is formed by 12 provinces. The local government in the Netherlands comprises 418 municipalities.
2. In this article, the notion of 'lay people' is often interchanged with that of 'citizens' (e.g. the sensing citizens involved in the analysed noise monitoring). However, it must be noted that the two notions do not coincide. Policy-makers, professionals and experts are, of course, also citizens, but I use the terms interchangeably for ease of reading, as well as to reflect a specific role of individuals in exercising their rights and responsibilities in the political arena.
3. "Citizen Sense"; accessed 23 June 2017. http://citizensense.net/about/.
4. For example, see Boelens and De Jong (2006) and Schiphol (2012).
5. De Jong and Boelens (2014) argue that participatory decision-making in major infrastructural projects like airport hubs focus on techniques (for instance, measurements), whereas these

techniques are part of the problem themselves. They criticize participatory arrangements because, in their opinion, the engagement of lay people in the process is likely to increase the complexity of the problem.

6. The authors' state at page 69: 'The unprecedented 96% growth in smartphone sales (in 2010) displays the availability and prevalence of these relatively cheap mobile sensing devices that enable Internet users to become sensing devices'.

7. 'Wijzigingswet Wet luchtvaart'; accessed 3 July 2017; available only in Dutch. http://wetten.overheid.nl/BWBR0013815/2005-12-07.

8. The information available in English on this communication is limited. Thorough researches on how this information was produced and communicated are missing.

9. 'Schiphol Group Annual report for 2003' (2004); accessed 5 July 2017; available in English. https://www.schiphol.nl/en/download/b2b/ … /2LZy4TTrYAAiwMA8WuGOy2.pdf.

10. 'Sensornet'; accessed 20 June 2017; available in English. http://www.sensornet.nl.

11. 'Geluidsnet'; accessed 20 July 2017; available only in Dutch; http://www.sensornet.nl/sensornet/geluidsnet.

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Disclosure statement

ORCID

Anna Berti Suman 🄳 http://orcid.org/0000-0002-8973-8436

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