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The (re-)turn to sensing: exploring the Sensing Contract in time

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The (re-)turn to sensing: exploring the Sensing Contract in time

Abstract

The article posits that, with the emergence of modern states, a *sensing contract* was formed between citizens and the ones that rule them, in which governments assume responsibility for monitoring the environment. Governments in turn *delegated* this responsibility to appointed authorities, such as environmental protection agencies. In response to specific instances of governments' inaction or insufficient action to ensure a safe living environment, people reverse this delegation trend, claiming back the ability and entitlement to monitor their environment through forms of citizen science (what we frame as *taking back the sense*). Doing so, ordinary people produce environmental data that can address institutional enforcement gaps. This article explores the evolution of the sensing contract, with a focus on the legal and policy implications of a (re-)turn to *civic sensing*. We offer a theoretical lens to understand citizen science as a re-appropriation of sensing, review illustrative cases and reflect on the implications of an increased reliance on civic environmental monitoring.

Keywords: citizen science – sensing – environmental law – monitoring – enforcement.

Introduction

Across the globe, ordinary people are demonstrating the ability and entitlement to monitor their environment through forms of citizen science¹. For instance,

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¹ Berti Suman *et al.* 2023.

in the Netherlands, a group of citizens, organized under the name *Behoud de Parel* (preserve the pearl), is carrying out their own monitoring of air quality to map the environmental impact of intensive livestock farming business in their local area. With this data, they aim to convince the local municipality to exercise precaution in the granting of new agricultural permits². Various similar examples are emerging in very diverse fields, such as the civic monitoring initiatives in Basilicata, Southern Italy, aimed at investigating pollution resulting from oil extraction³. In the United States, such civic environmental monitoring initiatives have even been able to demonstrate corporate harm and ground requests for damage, as occurred in the case of the ground-breaking 2019 ruling against petrochemical company Formosa, Texas. Remarkably, the case was built in large part on citizen-collected evidence of plastic pollution⁴.

Civic environmental monitoring can be considered a manifestation of the broader practice of *citizen science*. In the existing literature, citizen science has been approached through multifaceted definitions. The practice has been broadly defined back in the '90s as the active and voluntary engagement of ordinary people in scientific research⁵. Haklay frames it as «the generation of scientific data», engaging volunteers, and addressing «a politically relevant issue»⁶, suggesting the importance of a public engagement not only with scientific data but also with political matters. Skarlatidou and Haklay discuss a distinctive type of citizen science, *geographic citizen science*, as a set of practices involving «the utilisation of geographic information technology to collect, analyse and disseminate data collected by non-professional participants in a systematic and objective way»⁷.

Drawing on Kullenberg et al., we embrace the definition of the practice as «a research method, aiming for scientific output, [...] as public engagement, aiming to establish legitimacy for science and science policy in society, and, as civic mobilization, aiming for legal or political influence in relation to specific issues»⁸. In addition, this definition can be complemented arguing that citizen science can and has been regarded as contributing to science for policy⁹ and even to the shaping of environmental law and policy *from below*, as we will discuss in this article. Furthermore, we will build on recent literature that has shown how citizen science can be seen as a manifestation of a civic «right to contribute environmental information»¹⁰.

² Waarlo 2020.

³ Berti Suman 2022.

⁴ Berti Suman, Schade 2021.

⁵ Irwin 1995.

⁶ Haklay et al. 2021: 13, 15.

⁷ Skarlatidou, Haklay 2021: 4.

⁸ Kullenberg et al. 2017: 1.

⁹ Bio Innovation Service 2018.

¹⁰ Berti Suman et al. 2023.

The dimension of citizen science as mobilization and struggle for claiming entitlements shows an evolution from an understanding of citizen science as subordinate of official science (where the citizen scientists just ‘help’ professional scientists) to a form of cross-validating and also contesting institutional science, as the examples above illustrate. With increased technological capabilities and rampant environmental pressures, people stand up to ensure a safe living environment, at times filling institutional enforcement gaps.

Our article focuses on those forms of environmental citizen science that aim to challenge official and industry-reported data, and therefore can contribute to detecting non-compliance with environmental laws and, potentially, demonstrate violations of human environmental rights. We label this manifestation of the practice as *reactive environmental citizen science* (in short, RECS)¹¹. We juxtapose RECS practices with the evolution of a *sensing contract* that was formed between citizens and governors, when modern states organized themselves at a political and administrative level.

The present study follows the subsequent structure. We start from describing the relation that has been forming over time between governments (in particular through environmental protection agencies) and citizens. We discuss how the first actors started acting on behalf of ordinary people who agreed to entrust them with these tasks. At that time, the people were largely convinced that governments would be bound to act solely in their best interests, similarly to what occurs in a fiduciary model. We thus qualify the foundation of the sensing contract through a fiduciary model, while leaving open the possibility of other qualifications. We could indeed focus our analysis only on one of the possible qualifications of this relationship. We then demonstrate how this *fiduciary sensing contract* can be seen as a component of the broader social contract, also in legal terms, where delegating environmental monitoring tasks is just a small part of a trust relationship between citizens and governments. In a second stage, we argue that the idea of entrusting the government with the responsibility to protect the environment and people’s health through a fiduciary model (what we qualify as a *delegation scheme*) largely depends on the attitude of citizens towards governments. We show through examples how in specific critical junctures (associated with particular situations of perceived or actual governmental shortcomings in performing the sensing contract) people’s attitude towards their governors moved from trust (or at least acceptance) to distrust and reaction based on the production of civic data as a form of contestation of the official discourse. In a third stage, we discuss how people, moved by distrust and concern, in these specific scenarios decided to *take back the sense* informally through performing

¹¹ We build on our earlier framing of reactive environmental citizen science as developed over time. See Berti Suman and Alblas 2023, where we studied constants and turning points of the practice.

spontaneous civic environmental monitoring initiatives as a way to contest or at least compare official data resulting from governmental monitoring.

We address the topic based on scientific literature, review of relevant policy and legislative frameworks, and on selected real-world examples. We could also discuss the topic in an expert interview conducted with Alan Irwin, Professor in the Department of Organization at Copenhagen Business School, and author of a milestone book on citizen science back in 1995, titled «Citizen Science. A Study of People, Expertise and Sustainable Development»¹². The book introduced in academic and practitioners' debates the term «citizen science», at the time a rather novel term, and was highly influential in the further development of scholarship in this field.

The interview was conducted by the first author, lasted approximately an hour, it was semi-structured and based on guiding questions focusing on the very notion of citizen science through a temporal lens (past, present and future, taking inspiration from Abe's conceptualization of «temporal pluralism»¹³ in citizen science) and the argument of a sensing contract/breach thereof. The interview was accompanied by follow-up communications with the expert who could review the authors' interpretation of his talk. Results from the interview and of these communications, with selected quotes, are integrated in the text.¹⁴

In the conclusion of the article, we draw legal and policy implications of a (re)turn to civic sensing and develop reflections on how to ensure that even reactive forms of citizen science can still contribute in a meaningful way to environmental protection. While we build on literature that is not exclusively European, we focus mostly on citizen science in Europe and on European Union (EU) environmental law and regulation. Our conclusion also highlights limitations of our study and outlines areas of further research.

Delegating environmental monitoring from citizens to governments, and back again?

EU environmental law and policy as manifestation of the sensing contract

In the literature, the history of EU environmental law and policy has been widely discussed. A particular question that has sparked interest among scholars is how it was possible for EU environmental law to evolve, in relatively short time-span,

¹² Irwin 1995.

¹³ Abe 2023: 1753.

¹⁴ The interview was not recorded but transcripts can be shared with the interested reader upon request to the corresponding author.

from «silence to salience»¹⁵, despite its challenging legal and institutional outset¹⁶. In fact, from 1970s onwards, the EU has extended its reach in environmental law and policy-making exponentially. Examples span from the regulation of air pollution caused by motor vehicles as one of the earliest examples of EU environmental law making – at the time still legally based on EU’s internal market provisions – to now spanning over 200 legal acts on *inter alia* water protection, waste, nature conservation, chemicals and more¹⁷. Environmental considerations have further spread across policy domains, most prominently through the integration principle that requires the incorporation of environmental objectives into the EU’s other policy-making domains¹⁸, as well as «the polluter pays principle» that mandates that the cost of preventing, reducing or repairing environmental impairment should be borne by the polluter, and thus not the general public¹⁹.

Whilst there is no conclusive answer as to how environmental policy came to proliferate within the EU, it is clear that a growing awareness of environmental concerns among EU citizens has played an important role²⁰. Similar tendencies can be perceived at the country level (thus, EU member states). Taking Ireland as an example: while environmental issues had historically not played much of a central role in Irish politics, a number of incidents of serious pollution in the agricultural and chemical sectors in the 1980s helped to raise greater awareness for the need for strong environmental policies²¹. This eventually led to the establishment of the Irish Environmental Protection Agency (EPA) in 1993, tasked *inter alia* with the responsibility of monitoring environmental impacts by industries²².

While varying in roles and mandates, each EU member state presently has its own environmental protection agency involved in investigating and documenting environmental, ecological and spatial parameters²³. Although these actors do not always have a strong role in environmental enforcement

¹⁵ Weale 1999: 40.

¹⁶ See, for instance: Jordan 1999.

¹⁷ Knill, Liefferink 2013: 1-2.

¹⁸ As laid down in article 11 TFEU, the integration principle requires that environmental protection requirements must be integrated into the definition and implementation of the Union’s policies and activities, in particular with a view to promoting sustainable development.

¹⁹ See: Ibid (n. 1) Ch. 2. This principle, as laid down in article 191 TFEU, stipulates that the cost of preventing, reducing or repairing environmental impairment should be borne by the polluter, and thus not the general public. See: Lindhout, van den Broek 2014.

²⁰ Jordan 1999.

²¹ Flynn 2007.

²² National Economic & Social Council of Ireland 2011.

²³ Increasingly, these organizations are seeking to coordinate their individual efforts in a network called the “European Environment Information and Observation Network (Eionet)”, which is also joined by the European Environment Agency as well as by representative organizations of a range of non-EU countries. See: “About Eionet” (*Eionet Portal*) <https://www.eionet.europa.eu/about> (Accessed: 23 November 2022); “About PBL” (*PBL Netherlands*

as such, the monitoring data they collect can effectively feed into enforcement decisions by other public actors and provide core evidence on possible cases of non-compliance with environmental laws.

Drawing a parallel with the social contract model as we discuss below, we argue that this turn towards environmental law and policy effectively embodies the conclusion of a *sensing contract* between governments and citizens. Responding to concerns by citizens (and associated voting behaviour), governments set environmental rules regarding, for instance, acceptable dispositions of polluting materials by industries. Observing compliance with these rules is complex, time-consuming and costly. The average citizen is not able to take on such tasks but does rely on the observance of these rules for their health and well-being. In this context, the sensing contract means that, as industries become larger and environmental impacts more severe, it is agreed that the government will bear the burden of setting rules and overseeing compliance through environmental monitoring on behalf of its citizens, thus ensuring that violations of the applicable rules can be addressed if necessary.

The sensing contract, therefore, marks the essential obligation²⁴ of the state to ensure compliance with environmental rules to guarantee the health and well-being of its citizens. The creation of supervisory authorities follows these objectives. Under this scheme, citizens entrust the state with the management of their interests concerning the conservation of a healthy environment, thereby bringing this situation closer to a fiduciary relationship. A characteristic feature of the fiduciary relationship is the duty of loyalty on the part of the fiduciary to act in the beneficiary's best interests, requiring the fiduciary to place the beneficiary's interests above their own²⁵.

In other words, the state is placed as a fiduciary. Consequently, it is bound by a duty of loyalty²⁶, which requires effective control of compliance with the environmental rules set up and an effective remedy for any non-compliance observed. The sensing contract can therefore be compared to the fiduciary model. The enforcement of the sensing contract requires that the supervisory authority consistently uses its discretionary power to protect the interests of citizens, for example, by refusing operating permits that could harm the environment and the health of citizens²⁷. However, the very nature of discretion lies in the fact

Environmental Assessment Agency, 29 November 2010) <https://www.pbl.nl/en/about-pbl> (Accessed: 23 November 2022).

²⁴ In contract law, the essential obligation refers to the obligation that constitutes the main element of the performance agreed upon.

²⁵ Easterbrook, Fischel 1993.

²⁶ Lee 2007.

²⁷ Wood 2007

that it enables its holder to decide freely, albeit within the limits of established procedures. The exercise of such power implies the prioritization of interests²⁸.

This is why, in practice, the implementation of the sensing contract may come up against the realization of interests other than those guaranteed by this contract. The described dynamic marks the presence of various actors with divergent interests in society: ordinary citizens but also companies (some of which claim to represent a corporate citizenship²⁹) lobbies, NGOs, environmental associations, etc., which could lead to the hierarchization of interests and consequently to the struggle of forces. Citizens ensure the implementation of the sensing contract, intensifying their awareness and civic oversight whenever there is a lack of control by appointed authorities over practices that fail to comply with the regulations and a lack of information on environmental damage. In this regard, it should be noted that the sensing contract is part of a broader *social contract*, the performance of which depends on a whole series of actions, which can themselves be understood through the contractual lens³⁰.

Following Campbell, the social contract can be understood as the legitimizing force of citizens' consent to authorities that limit their freedoms, and as the reciprocal duty of social institutions to promote equal rights for all³¹. With a long history in political philosophy, social contract theory has been vigorously debated regarding the balance of power between the state and civil society. Moreover, this theory explains how governments and responsibilities evolve over time as emerging risks challenge the consensus on the state's role³². However, drawing on Blackburn and Pelling, we argue that a plural view of social contracts is required in an increasingly complex governance landscape, which includes other asymmetric power relations (e.g., multinationals, lobbies, epistemic communities, etc.)³³.

Blackburn and Pelling's proposal is based on a distinction between three intersecting but differentiated types of social contracts: *legal-institutional social contract* (LSC); *imagined social contract* (ISC); and *practised social contract* (PSC). The three types represent distinct domains in which rights and responsibilities are held in tension, which exist alongside one another and may or may not overlap. The LSC exists in the formal and legally sanctioned distribution of rights and obligations among actors in society, which is defined by and through

²⁸ *Ibid.*

²⁹ For a historical approach to the notion see: Crane, Matten, Moon 2008: 25-49.

³⁰ In this scheme, the social contract appears as a framework contract, the implementation of which presupposes application contracts. For example, the preservation of health implies the corresponding regulations and the establishment of control authorities, in various sectors: water, air, health products, food, etc.

³¹ Campbell 2010

³² Blackburn, Pelling 2018

³³ *Ibid.*: 3

legal and constitutional frameworks, whether or not this distribution is considered fair by the individuals it governs. The ISC refers to the subjective vision of a fair social order, which may or may not be reflected in policy or practice. The PSC relates to the real balance of rights and responsibilities exercised and claimed by individuals and state actors that are observable in the everyday relations between, on the one hand, the state and citizens and, on the other hand, the citizens themselves.

The threefold understanding of the social contract just described results from a negotiation between multiple conflicting imagined social contracts (which coexist in the actual world, reflecting the different interest groups that form each society) and the existing legal-institutional social contracts³⁴. This alternative approach provides a response to the constraints of a classical contractualist approach, which conceives the social contract as intrinsically reciprocal between a ruling sovereign and the ruled, with the latter legitimizing by their consent the power exercised by the former over them in terms of limiting their freedom. It emphasizes the crucial need, as society and risks evolve, to redefine responsibilities and powers to offer citizens the protections they expect³⁵.

In the case of the sensing contract, this threefold distinction describes the transfer of power from the citizens to their governments for the implementation of appropriate rules and the sanctioning of their breaches (legal-institutional social contract, which we have apprehended through the prism of the fiduciary relationship). We witness the practised social contract in the taking over of the sensing duties in the case of a failure at the institutional level, whether this failure is materialized by the lack of responsiveness of the state or by the limited effects of its action in practice. Often, citizens judge failures according to their subjective vision of a fair social order, i.e., the imagined social contract described.

Between ambition and reality: the issue of monitoring and enforcement gaps

As the European Commission (EC) emphasizes: «our environment can only be well protected if member states properly implement the legislation they have signed up to»³⁶. While the EU has some of the world's most ambitious environmental laws on paper, their effectiveness can be compromised by non-compliance³⁷. An illustrative case of non-compliance was the notorious *Dieselgate* scandal³⁸ that unfolded in 2015, which also stimulated the emersion of a number

³⁴ Blackburn, Pelling 2018: 4-5.

³⁵ *Ibid.*: 3

³⁶ See: "Implementation – Legislation – Environment – European Commission" https://ec.europa.eu/environment/legal/implementation_en.htm (Accessed: 15 September 2022).

³⁷ Kingston *et al.* 2021.

³⁸ For a detailed overview, see: Barigazzi 2021.

of citizen science initiatives responding to widespread air quality concerns. The Dieselgate case revolved around the issue that Volkswagen – and, as later found, several other major European car manufacturers – did not properly fulfil their duties to accurately report in official emission tests, with the aim to not disclose the fact that the emissions of these cars did not meet the EU requirements³⁹. In the meantime, civic and institutional concern was mounting on air pollution as a major cause of premature death and disease in Europe, and as the single largest environmental health risk on the continent today⁴⁰.

The EU responded vigorously to this concern, in particular after the Dieselgate case, enacting several Directives on the maximum amounts of exhaust emissions of new vehicles, and requiring EU member states to have an effective penalty system in place to deter car manufacturers from non-compliance with these rules⁴¹. Specifically after the Dieselgate scandal, in 2017, the European Parliament set up a committee of inquiry into emissions measurements in the automotive sector to investigate alleged contraventions and maladministration in the application of EU law to the field⁴². The EU legislative process on the matter accelerated considerably and several new pieces of legislation were approved⁴³, such as Regulation 2018/858⁴⁴, providing enforcement powers to the EC, as well as mandating compulsory vehicle testing to measure emissions on the road (the Real-Driving Emissions method of testing)⁴⁵ and refining new testing procedures, also based on studies of the EC's JRC⁴⁶. Furthermore, the EC increased its market surveillance powers and those of EU member states, pursuant to art. 8 of Regulation 2018/858. In 2022, the Commission launched the new Euro 7 standards for cleaner vehicles and improved air quality to meet the European Green Deal's zero-pollution ambition⁴⁷.

As Zhelyazkova and Thomann emphasize, the Dieselgate scandal is not just a case of companies breaching EU rules, but also of member states failing to enforce EU rules, particularly when this means going against the interests of major car producers with significant political power⁴⁸. The cited 2017 committee convened by the European Parliament found that many member states had not actually adopted an «effective, proportionate and dissuasive penalty system» to

³⁹ See: Zhelyazkova, Thomann 2021.

⁴⁰ European Environment Agency 2020.

⁴¹ See, respectively: Directive 2007/46, art 46 and Regulation 715/2008, art 13.

⁴² European Parliament 2017; European Court of Auditors 2019, 45.

⁴³ *Ibid.*, Annex I.

⁴⁴ Which came into force on 1st September 2020, amending Regulations 715/2007 and 595/2009, and repealing Directive 2007/46/EC.

⁴⁵ *Ibid.*, Annex II.

⁴⁶ For example, Pavlovic *et al.* 2018; Weiss *et al.* 2013.

⁴⁷ See official press release at https://ec.europa.eu/commission/presscorner/detail/en/ip_22_6495.

⁴⁸ Zhelyazkova, Thomann 2021: 226.

prevent fraud by car manufacturers⁴⁹. It also emerged that the EC had «lacked the political will and decisiveness to act upon the seriousness of the high NO_x emissions and to give priority to the protection of public health that was at stake»⁵⁰. The authors of the report further add that, due to political priorities, lobby influence and a «constant pressure from the industry», the attention of both the EC and the member states had been focused on «avoiding burdens on industry in the aftermath of the 2008 financial crisis»⁵¹.

The Dieselgate scandal showed how economic pressures from the global integration of markets caused reluctance by EU member states to adopt stricter environmental regulations. The economic crisis further caused a strong shift in political priorities, towards «economic rather than ecological aspects of sustainability»⁵². Gravey and Jordan also point to the long-lasting effects of austerity policies implemented during the economic crisis in various EU member states such as Greece, which undermined their capacity to implement and apply environmental laws and policies⁵³. Ambitious laws and policies have thus not necessarily lead to the changes intended, in particular if the regulated parties are powerful actors that can pressure governments. Indeed, the Dieselgate scandal showed that official data can be subject to capture by the interests of industries, posing a strong threat to the reliability of such data. Beyond such issues, budget cuts and shifted political priorities more broadly can also negatively affect the capacity of public actors to engage in monitoring and enforcement activities⁵⁴.

The Dieselgate scandal has further had spillover effects for spreading awareness on the importance of clean air in cities, which has increasingly become a matter widely discussed among the public⁵⁵. The growing concern for air pollution stimulated the flourishing of several civic initiatives aimed at monitoring the quality of the air that people were breathing, especially in urban areas. In the German city of Stuttgart, for example, in January 2017, air pollution in the city was 25 times above the EU limits. In the same year, local citizens sued the city mayor for bodily harm caused by air pollution⁵⁶. In Stuttgart, an initiative was launched with the aim to enable citizens to monitor air pollution⁵⁷. The

⁴⁹ European Parliament 2017: 34.

⁵⁰ *Ibid.*

⁵¹ *Ibid.*: 5.

⁵² Knill *et al.* 2016: 1057. For a comprehensive overview on the implications of the economic crisis on EU environmental policy, see: Burns *et al.* 2018.

⁵³ Gravey, Jordan 2021: 347.

⁵⁴ Outside of the EU context, the United States is of course a prime example here. See, for more detail: Reardon 2017: 471.

⁵⁵ Vonberg, Schmidt 2018.

⁵⁶ The Guardian 2017.

⁵⁷ Flagner 2022.

initiative was called *Luftdaten.org*, which subsequently evolved into the larger citizen science project *SensorCommunity*, and soon spread internationally⁵⁸.

SensorCommunity offers everyone interested a manual and list of equipment to build an air quality sensor and deploy it. The sensor measures fine particulate matters, temperature, relative humidity, pressure, and noise. It also gives an evaluation of the air quality, ranging from good to dangerous. The initiative had a considerable social uptake and, until now almost 13,000 sensors (operated by ordinary people) in 80 countries were activated (figures reported on the initiative's web page consulted in October 2023), mainly, but not only, in Europe.

SensorCommunity is a particularly illustrative example of the civic *taking back of the sense*, from two points of view. First, it provides a large open-source database for researchers, but also for decision-makers to orient their actions about air quality in cities. Second, it gives citizens that are using the sensors the awareness of the level of air pollution in their cities, stimulating behavioural changes and enabling them to gather the evidence needed to urge policy makers' actions for a cleaner air. Sensors such as those used by the people that joined the SensorCommunity initiative are often being tested by scientific institutions, such as by the cited EC's JRC. Such tests are run to ensure the scientific accuracy and credibility of the monitoring devices, offering a quality assurance to authorities wishing to rely on the results of citizen science initiatives of this kind for monitoring and enforcement actions.

What just described for the EU has manifested also in other countries where occurrences that concerned the public opinion, causing loss in trust towards official environmental monitoring. A good example is discussed in the work of Abe⁵⁹, a Japanese scholar who specialized in post-Fukushima citizen science initiatives. Abe discusses how, after the nuclear accident, the state «failed to use the information it had obtained through its System for Prediction of Environmental Emergency Dose Information (SPEEDI) during the initial evacuations, although the state later apologized for not promptly releasing the information»⁶⁰. Other authors, cited by Abe, associate the lack of information with the need for people to monitor environmental radiation, as they were concerned for their health and safety⁶¹. What we define as the act of *taking back the sense* (citizens start monitoring themselves the environment) was boosted by the fact that this nuclear disaster occurred in an era when digital media had become embedded in people's daily life⁶², differently from past disasters such as Chernobyl which occurred in a pre-digital era.

⁵⁸ See: "SensorCommunity" <https://sensor.community/en/> (Accessed: 28 November 2022).

⁵⁹ Abe 2023.

⁶⁰ *Ibid.*: 1573.

⁶¹ Tateno, Yokoyama 2013.

⁶² Abe 2014.

Abe citing Feldhoff points to the remarkable role of technology in the case, which recalls the discussion on the German SensorCommunity initiative. Thanks to technology, people could «not only measured environmental radiation using dosimeters but also processed and circulated the resulting data via the Internet and social media»⁶³. Digital technologies thus enabled ordinary people and civil society organizations to complement or at times substitute state's responsibility in measuring radiation and offered spaces to share such information widely⁶⁴.

In the interview with Irwin, the expert explained that, at the time of his milestone book on «Citizen Science»⁶⁵, which was before the wide public use of the Internet, it was very difficult to find citizen science cases and connections among cases. The advent of large Internet usage and of big data platforms where citizen science projects could recruit volunteers from all of the world, store and share data widely changed citizen science and its scale. All this made citizen science less focused on nature exploration, and more on collecting large quantities of data and analysing them (so called *citizen data science*).

In the opinion of Irwin, also citizen data science can play an important role in «re-visualizing and, at times, challenging official data sources». This development (i.e., the advent of the internet and big data transforming the potentiality of citizen science) was not expected by Irwin at the time of writing the book. On the one hand, this «has enabled new forms of network-building and data sharing – and so boosted the possibilities for citizen science substantially». On the other, Irwin also shared the concern that all this could «lead to citizen science being seen only as remote data collection: useful in scientific terms, but not necessarily responsive to the needs and curiosities of citizens themselves». In other words, «the 'citizen' dimension of 'citizen science' should not be forgotten», concluded Irwin.

From monitoring and enforcement gaps to civic action

Our central argument is that institutional monitoring and enforcement gaps such as what occurred in the Dieselgate scandal give rise to a *breach of the sensing contract*, in that citizens no longer rely on governments to monitor the environment in their interests. In these instances, citizens discover cracks in the system.

Another example is that of the Tata Steel factory plant in the Netherlands. For more than a century, a small Dutch port city called IJmuiden

⁶³ Abe 2023: 1574; citing Feldhoff 2018.

⁶⁴ Abe 2023; citing Morita, Blok, Kimura 2013.

⁶⁵ Irwin 1995.

has been one of the main European hubs for steel production⁶⁶. In recent years, steelmaking company Tata Steel's production activities in this area increasingly gave rise to environmental and health concerns. In a monitoring report of the Dutch Municipal Health Service (GGD) of June 2020, for instance, it was found that the incidence of lung cancer among local residents was 25% higher than the national average, while suggesting a potential link with air pollution in the area⁶⁷. A year later, a freedom of information request advanced by local newspaper *Noord-Hollands Dagblad* revealed, however, that the local GGD director had ensured that the name Tata Steel was removed from this report, even though draft versions *did* mention as plausible that pollution from the factory plant contributed to the high amount of cancer occurrences in the region⁶⁸. Similarly, a report by the National Institute for Public Health and the Environment (RIVM) of April 2021 listed that acute health complaints such as headaches and nausea were more common in areas close to the plant than elsewhere, again without making an explicit link with Tata Steel⁶⁹.

Having increasingly lost faith in the monitoring by public actors, residents in and around IJmuiden decided to reclaim those sensing responsibilities originally delegated to public actors through the conclusion of a sensing contract. Doing so, local citizens started producing their own scientific data on their environmental surroundings. Although in this case the citizens played a role mostly in generating funds to commission data collection by external research bodies, and not in performing the actual monitoring itself, citizens took action as they felt that the authorities competent to intervene to protect their safety were not acting upon their concerns. It is in such *critical junctures* that people overturn official monitoring schemes and join efforts to take back the sense.

The Dutch and German cases are illustrative of the phenomenon of ordinary people distrusting official environmental reporting and responding to this distrust through civic monitoring. Distrust indeed seems a key component that can trigger the initiation of a civic environmental monitoring initiative⁷⁰. Through forms of RECS, these people contest the status quo⁷¹ and enact strategies to legitimize their data⁷². Performing civic monitoring can also be seen as a *manifestation of rights*⁷³, both substantive rights, such as for instance the right

⁶⁶ See: "A Century Of Steel | Tata Group" <https://www.tata.com/newsroom/ijmuiden-a-century-of-steel0> (Accessed: 30 May 2023).

⁶⁷ Schildkamp 2021.

⁶⁸ NL Times 2021.

⁶⁹ Kreling, Schoorl 2021.

⁷⁰ Berti Suman 2021b.

⁷¹ Berti Suman and Alblas 2023.

⁷² Berti Suman *et al.* 2020.

⁷³ Berti Suman 2021a.

to life, and procedural environmental rights, such as the right to scrutinize the evidence on which the contested environmental decisions are taken⁷⁴.

When asked about the very essence of citizen science, the interviewed expert, Irwin, noted that citizen science is more than «just about monitoring», being not only factual but also about collectively asking questions, adding nuances to a certain environmental issue and promoting the achievement of a shared understanding of the problem. Part of the value of the term *citizen science* – according to Irwin – is «its fluidity », which can embrace different manifestations of the practice, from the more tamed forms of participation to uninvited and spontaneous forms, which we frame here as RECS. At the time when the term originated, civic environmental evidence was overall being considered irrelevant and dismissed by both public and private authorities. This is quite different from the present-day context, where citizen science is generally recognized by institutions at least within the EU and can even offer evidence for official enforcement, which can arguably boost the motivation of participants⁷⁵.

Civic-gathered evidence can also escalate to courts (e.g., the Formosa case discussed earlier and a more recent case on civic monitoring of gas flaring in the Amazon rainforest, Ecuador⁷⁶). Customary laws in several jurisdictions accept civic evidence in court for law enforcement, although legal professionals and judges may not be prepared or willing to embrace such evidence, and rather discard it defending that environmental problems require technical handling. Other authors explored the potential of civic-gathered evidence for advancing climate and broader environmental justice claims⁷⁷, bringing in people's experiences of environmental distress and ultimately achieving those environmental participation rights enshrined, for example, in the Aarhus Convention for Europe⁷⁸ and the Escazú Agreement for Latin America and the Caribbean⁷⁹.

Focusing on specific cases, Breen et al. discuss the experience of Public Lab, a civic science organization founded in response to the Deepwater Horizon oil disaster (Gulf of Mexico) in order to «critique existing data collection regimes»⁸⁰. Wylie et al.⁸¹ illustrate the case of the Bucket Brigades (Louisiana, U.S.), a civic data collection motivated by the «practical need for lawyers working on an en-

⁷⁴ Enshrined in the European context most prominently by the Aarhus Convention. See: The United Nations Economic Commission for Europe (UNECE) Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters adopted on 25 June 1998 in Aarhus, Denmark, also referred to shortly as the Aarhus Convention.

⁷⁵ Berti Suman 2023.

⁷⁶ Facchinelli *et al.* 2022.

⁷⁷ Haklay, Francis 2017.

⁷⁸ Berti Suman *et al.* 2023.

⁷⁹ Berti Suman 2021b.

⁸⁰ Breen *et al.* 2015: 850.

⁸¹ Wylie *et al.* 2014.

vironmental justice case to get air quality data» as institutional environmental standards disregarded the needs of exposed communities⁸². Other studies discuss the strategic use of civic science by environmental and climate justice movements in Durban, South Africa, to counteract the lack of official acknowledgement of people's perception of environmental issues⁸³. All these manifestations of RECS are situated in different local and institutional contexts but, arguably, can be traced back to breaches of the sensing contract.

The breach of the sensing contract, viewed through the prism of the fiduciary relationship, can actually justify the mobilization of the beneficiary of the fiduciary (the citizens) against the trustee (the state) in order to recover the power of control over the compliant application of the rules aimed at preserving their health, transferred to the state and carried out by its delegates. In the same way that the mere failure of the fiduciary to comply with their duty of loyalty gives the beneficiary the right to compensation⁸⁴, the state's failure arguably gives the citizens the right to take back the sense to restore the disrupted equilibrium.

For example, after the Fukushima nuclear disaster, citizens, concerned for the lack of communication by the state of the available information on the level of radiation to preserve their health, mobilized⁸⁵ to measure the radioactivity using dosimeters and relayed the data obtained in real time via the Internet and social media⁸⁶. The mobilization of Japanese citizens to collect data that until then was mostly the state's responsibility was justified by the gravity of the disaster and its adverse effects on their health and safety⁸⁷. This example shows the «essentially temporal or transitory role [of citizen science] in environmental disaster recovery»⁸⁸. This taking back the sense lasts as long as people become convinced that their health and safety are assured again by their governors⁸⁹. This also suggests that RECS initiatives essentially respond to an ancient, human tendency to *sense* for ensuring own survival. By collecting data that attest to environmental and health damage, citizens can compel the state to act by renegotiating the balance of power and rebalancing it.

Taking back the sense through performing civic environmental monitoring can also be theoretically regarded as a way to advance «civic epistemology and alternative knowledge [...] in the digital age»⁹⁰. Jasanoff defines civic epistemology as «the institutionalized practices by which members of a given

⁸² Ottinger 2010.

⁸³ Scott, Barnett 2009.

⁸⁴ Miller 2013.

⁸⁵ Tateno, Yokoyama 2013.

⁸⁶ Abe 2023:1574.

⁸⁷ Abe 2014; Feldhoff, 2018.

⁸⁸ Abe 2023:1584.

⁸⁹ *Ibid.*

⁹⁰ Jasanoff 2005: 255.

society test and deploy knowledge claims used as a basis for making collective choices. These collective knowledge-ways (..) are distinctive, systematic (..) and articulated through practice rather than in formal rules»⁹¹. Such alternative ways of knowing can prove to be «a resource for assessing the rationality of the state's knowledge claim»⁹² and to advance «science-based knowledge claims (..) collectively»⁹³. This is essentially *alternative knowledge making* in the digital age, and is game changer because it overturns the traditional paradigm according to which the ordinary citizen «does not possess the means to make the invisible threat to their life visible, [and thus] all the power to define global risks lies in the “hands” of the institutions», citing Beck⁹⁴.

We also discussed our theory on the breach of the sensing contract with the interviewed expert. Irwin pointed to the risk of authorities losing their monitoring capabilities and his concern that the evidence could be lost when people no longer have interest in the monitored environmental issue. However, in Irwin's eyes, citizen science has the merit to «push the boundaries of what is admitted evidence and knowledge», which can be very valuable to authorities tasked with law enforcement. Citizen science «should not be regarded only as an extended science but can do things that professional scientists cannot do», he argued. Thus, the message that Irwin wanted to convey is that, as citizen science becomes more mature, also more spaces are opened for it, which should not substitute but rather *complement* appointed institutions' efforts to protect the environment.

Today: citizen science interfaces EU law and policy

We now look at a study published in 2018 by the EC, which illustrates how citizen science is actually playing an increasingly important role in the EU's environmental law and policy landscape. The study lists and describes more than 500 different citizen science initiatives that are impacting or aiming to impact on environmental policies, decision-making and enforcement⁹⁵. Such impact was sought by the citizen scientists through different avenues, spanning from social to policy (and even judicial) uptake⁹⁶. The trends emerging from the study are summarized in Figure 1 below.

⁹¹ *Ibid.*

⁹² Abe 2023: 1582.

⁹³ *Ibid.*: 1584.

⁹⁴ Beck 2016: 100.

⁹⁵ “An Inventory of Citizen Science Activities for Environmental Policies” by the European Commission Joint Research Centre. Available at <https://data.europa.eu/euodp/data/dataset/jrc-citsci-10004> (Accessed: 30 May 2022); see also: Bio Innovation Service 2018.

⁹⁶ Bio Innovation Service 2018.

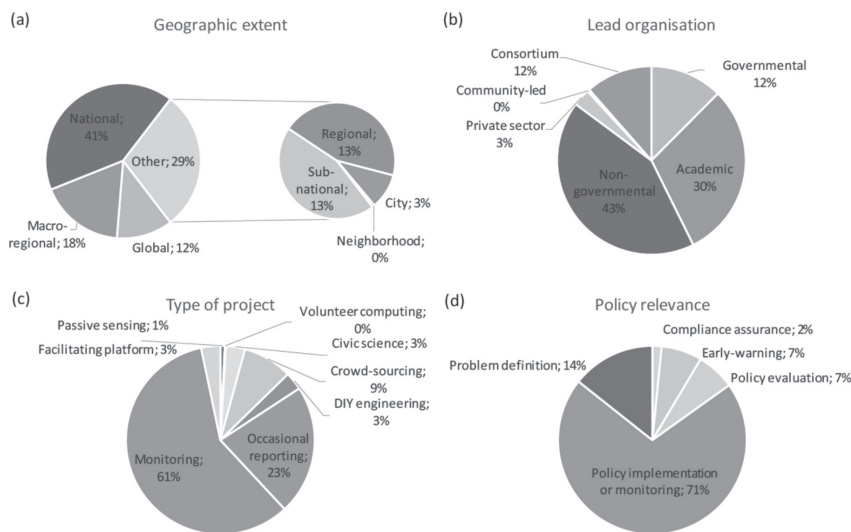


FIG. 1. Characterisation of citizen science projects: geographic extent, lead organisation, project category and policy relevance⁹⁷.

For our purposes, particularly the policy relevance aspects including citizen science contribution to environmental monitoring (*early-warning*), policy-monitoring and enforcement (*compliance assurance*) are significant. It is important to note here, however, that the EC's analysis mostly reports about institutionalized or, at least, structured and formalized forms of citizen science. As the figure above shows, most of the projects included in the 500+ cases of citizen science inventory are led by non-governmental organisations (41%) or by academics (29%). The most underrepresented initiatives are bottom-up community-led projects (<1%). As already flagged in previous research⁹⁸, the EC's estimation may not necessarily reflect the breadth of citizen science initiatives out there, as it did not capture forms of more spontaneous, less institutionalized types of civic environmental monitoring. As such, it is difficult to judge what the effect is of these types of citizen science activities in terms of policy relevance.

In its report, the EC holds that citizen science can contribute to policy, but can also erode the support and trust of citizens in the environmental policy process⁹⁹. In fact, the study argues, citizens' expectations to a prompt and effective

⁹⁷ From the study by the European Commission, "Figure 4 - Characterisation of the citizen science projects in the inventory: geographic extent, lead organisation, project category, policy relevance for policy", Bio Innovation Service 2018: 43.

⁹⁸ Berti Suman 2021b: 160, 161, 165, 167.

⁹⁹ Bio Innovation Service 2018: 11, 86.

government intervention based on their data may be deluded, especially when decision-making processes on environmental issues are long and complex¹⁰⁰.

Other examples of official endorsement by the EC of the contribution that citizen science can bring to inform law and policy interventions can be found in a Staff Working Document – SWD from 2020 on «Best Practices in Citizen Science for Environmental Monitoring» (European Commission 2020). The SWD offers guidance on how to systemise and sustain the support of citizen science approaches for environmental monitoring. The network of Environmental Protection Agencies (EPAs) in Europe endorsed this SWD in a targeted response (Rubio-Iglesias et al. 2020). Earlier, the European Environment Agency published a report on how citizen science could contribute to monitor air quality in the EU (EEA 2019). It is also worth highlighting that the EPAs Network established an Interest Group on Citizen Science¹⁰¹. All the mentioned initiatives suggest a growing convergence between environmental citizen science and institutional governance.

Discussion: from contract to contestation

Through what we framed as a sensing contract, the responsibility for monitoring the quality of our environment and for inspecting compliance with set rules was moved from citizens to their governments over history. Responding to specific shortcomings by governments to ensure a safe environment, people took back the sense, engaging in civic environmental monitoring. These people were no longer satisfied with delegating tasks to institutions that were perceived to be unable to protect their interests¹⁰², and thus turned to citizen science as a reaction (this is why we called it *reactive* environmental citizen science - RECS). To do so, citizens have increasingly access to technological devices, such as smartphones, and to the interactive, user-generated Web 2.0, which can provide key resources in terms of engaging in citizen science activities – also independently from governments and traditional scientific institutions.

Interestingly, citizens can build on legal frameworks that have been established by governments, and on the substantive as well as procedural environmental rights conferred upon citizens, in order to support their cases. This adds a degree of credibility to citizen science, which can now be used as a tool to assess whether pollution in the environment is within legally defined parameters. Such data, in turn, has the potential to feed into enforcement decisions, particularly where public monitoring agencies lack the capacity or willingness to inspect compliance

¹⁰⁰ *Ibid.*

¹⁰¹ “EPA Network Interest group on Citizen Science”, <https://epanet.eea.europa.eu/reports-letters/epa-network-interest-group-on-citizen-science/epa-network-interest-group-on-citizen-science> (Accessed: 30 May 2023).

¹⁰² Berti Suman *et al.* 2020.

with environmental laws¹⁰³. Although, existing environmental laws may not always be entirely optimized for protecting the rights of citizens, and may be perceived as exposed to economic influences¹⁰⁴, such laws still provide an important recourse for citizens seeking to ensure that their findings are fed into policy decisions.

Leveraging technological developments and resources such as funding that have come available in recent times, citizen science can provide a key support to enforce environmental laws and rights. Particularly when joining forces with other civic actors, non-governmental organizations and scientists, citizen science can potentially influence political and corporate actions. In this panorama, a new push within the legal domain is emerging to recognize the civic right to contribute environmental information¹⁰⁵, which could mirror this new trend of RECS – implying a change of power relationships within public governance approaches. Framed through a plural understanding of the social contracts (i.e., between a plurality of social actors with different values and interests), the sensing contract illustrates the urgency to renegotiate responsibilities and duties/obligations between actors, and to reconsider the scope of and the way actors' accountability is ensured¹⁰⁶.

Figure 2 below summarizes the analysis developed throughout our study, highlighting the key phases that led to breach of the sensing contract and the emergence of RECS. The arrows are bidirectional in the middle of the flow because laws and policies that shape reactive environmental citizen science are influenced by technological evolution but have also shaped the evolution of technology through history.

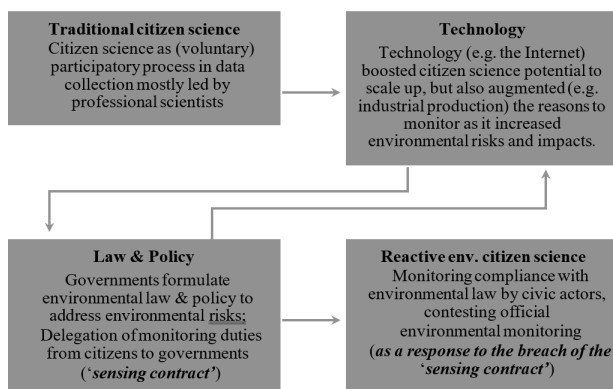


FIG. 2. From traditional to reactive citizen science, interplaying with law, policy and technology.

¹⁰³ See, in this context, the chapters on beryllium and tobacco in the European Environmental Agency's 2013 report: European Environment Agency 2013. See also: Saltelli *et al.* 2021.

¹⁰⁴ See, in this context: Mahoney 2007: 35, 46.

¹⁰⁵ Berti Suman, A. *et al.* 2023; Dutch Research Council - NWO 2021; Berti Suman 2021a.

¹⁰⁶ Blackburn, Pelling, 2018: 5. The authors ultimately question the emergence of multiparty social contracts.

Conclusion, limitations and future research avenues

Our study presented both theoretical and empirical evidence of ordinary people responding to enforcement gaps of existing environmental laws and regulations. These people increasingly employ technological resources such as smartphones as monitoring devices and big data platforms as communication means. They can leverage on existing laws to identify what is legal or illegal in terms of environmental pollution. Data from citizen science initiatives, in their current level of maturity, can be valuable for enforcement decisions, at times addressing institutional shortcomings. This suggests, in line with what argued by interviewed expert Irwin, that citizen science is not simply an *extension* to current knowledge practices but rather a practice raising an variety of new epistemological and governance possibilities (and also challenges).

Studying RECS initiatives, we can reflect on the implications of this taking back the sense by ordinary people. On the one hand, citizen science may be complementary to institutionalized monitoring activities, being a cost-effective way of addressing enforcement gaps. On the other hand, if governments would overly rely on citizens to carry out complex, time-intensive and costly monitoring tasks for which they are not sufficiently equipped, this may threaten the degree to which effective monitoring takes place.

In this context, it is important to emphasize again how citizen science has come to the fore in reaction to specific government shortcomings. The question of where should be the balance between putting too much pressure on citizens, and leaving the monopoly for monitoring and law enforcement to governments, is still up for debate. For this reason, future research should examine how a move towards an increased reliance on civic environmental monitoring can be used both as a tool that empowers both citizens and governments, and as a means to re-define their roles in public governance. Enforcement agencies should particularly look at RECS initiatives as a resource to rely upon for ensuring the respect of environmental law. Unfortunately, these forms of citizen science are often overlooked in the institutional debate, as the study of 2018 by the EC demonstrates¹⁰⁷.

Another open question is to what extent civic environmental monitoring is shaping and can shape law-making and regulatory processes. Interviewed expert Irwin too asked the question on «the value accorded to citizen science within regulatory processes». Is citizen science allowed to shape monitoring standards? Is it given the same status as official forms of scientific knowledge «when it comes to areas of regulatory dispute or controversy?», citing the provocative questions raised by Irwin after reading the final version of this article. On a related note, we know from previous studies¹⁰⁸ that citi-

¹⁰⁷ Bio Innovation Service 2018.

¹⁰⁸ Minna-no Data Site 2018; Ottinger 2010; Berti Suman 2019; Abe 2023.

zen science actors (and in particular citizen science associations) *self-regulated* over time, developing standardized data collection and validation methods so that initiatives could be scaled up and the data could be used effectively.

The article is limited in the sense of being focused primarily on EU legal and policy discourses, but we also tried to acknowledge citizen science scholarship from other parts of the world. Our analysis is also limited as it is mostly theoretical, whereas future studies could be enriched with empirical evidence on the civic perception of the sensing contract. For example, it could be interesting to perform surveys in different EU member states, asking citizens directly whose responsibility it is in their view for setting up and enforcing environmental protection and whether they had performed any of these tasks themselves. Performing such a study in different geographical regions of the EU would be key as the citizen perspective may well vary a lot between member states.

We also had to limit our lens to understanding the sensing contract under a private and contract law scheme, i.e., the fiduciary model. The partnership agreement under corporate law, for example, may have offered an alternative inspiration. This model grants the right to alert to all partners of a company, including minority partners, to raise the attention of executives on any facts noticed in corporative operations that may affect the company¹⁰⁹. Further areas of investigation (e.g., from public contract law) could be explored in future studies on the matter.

Lastly, here we discussed citizen science as participatory and inclusive civic initiative, but a deeper exploration could have offered the opportunity to also look at the inequality effects of citizen science, often appealing to people with more agency, knowledge and education. It would be worth to empirically explore if, in more affluent areas, for example, the incidence of RECS is greater, whereas people in areas that are less affluent (which are often those areas more exposed to environmental stressors) may lack the opportunities to engage in citizen science and therefore suffer even more from unsatisfactory environmental law enforcement.

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¹⁰⁹ For instance, see article 225-232 of the French Commercial code: «One or more shareholders representing at least 5 % of the share capital may, twice a year, ask questions in written form to the CEO or the Broad of Directors on any fact likely to compromise the continuity of operations. The replat is communicated to the Auditor, if any».

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Declaration of interest statement

The authors declare no conflict of interests to be reported for the present study.

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