Experimenting with Novel Forms of Computing

The case of the Swedish Citizen Observatory for Water Quality Conservation

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ABSTRACT

In the Anthropocene, we are looking at an impending future that is characterized by resource scarcity. In this paper we ask how socio-technical arrangements can facilitate a transition from the course we are on today to one of adaptation and conservation. Taking the case of citizen observatories (COs) for water quality conservation as an illustrative lens, this paper analyses the potential of COs to form Publics for management and stewardship of natural resources from a Computing within Limits perspective. Based on interviews, participant observations and co-design workshops with a wide range of stakeholders, we draw attention to 1) the complexities of water quality management in Sweden, 2) the differing views of policymakers and citizens about citizen participation in water governance and 3) designers' efforts in co-developing a sustainable socio-technical system for bringing about change in water quality management. Our work contributes to research on Computing within Limits by identifying opportunities and challenges that arise when designers seek to form Publics and through them transform institutional arrangements.

CCS CONCEPTS

• Human-centered computing → Computer supported cooperative work; • Applied computing → E-government.

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KEYWORDS

Citizen observatories, Publics, Water Quality Conservation, Design, Governance, Data-gathering practices, Mobile computing.

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1 Background

Research about involving citizens in science, i.e. as part of "*citizen science*", has gained significant momentum in the last couple of years. It is often presented as having an important role to play in monitoring climate change and biodiversity [35]. Particularly the use of information and communication technologies (ICT) has facilitated the possibility of volunteers to participate in data-gathering activities in their local environment. In doing so, such participatory approaches seek to engage citizens in scientific issues, educate them about said issues and collect data that otherwise would be difficult or impossible to obtain [18,12, 43]. While several prominent citizen science projects have been successful in engaging the public and gathering environmental data [26], these projects have produced few, if any, applied scientific results [18]. This disconnect between contributing data about the environment and using such data to take action for the environment has recently been addressed by citizen observatories which have received much attention in Europe [8,41]. Citizen observatories (COs) can be viewed as socio-technical arrangements that use various technologies, for example web portals, mobile devices and sensors, in order to bring together citizens, scientists, data aggregators and policymakers in the task of monitoring the environment [24]. Aimed at enabling citizens "*to take on a new, crucial role in environmental monitoring,*

decision making, cooperative planning, and environmental stewardship" [17,p.1], the goal of COs is to strengthen the role of citizens in local environmental management, potentially resulting in profound societal changes.

Our interest in COs stems from the idea that "*in order to deal with the environmental challenges that humanity is facing and find more sustainable pathways, new management and governance systems are acutely needed. More specifically, there is a need for radical shifts to new approaches that can enhance the fit between human and biophysical systems and improve the capacity of ecosystems to generate services for human well-being*" [28,p.223]. More in particular, our work is motivated by the belief that "*computing has an enormous role to play in responding to global limits and in shaping a society that meaningfully adapts to them*" [25,p.86]. It is within this context that we argue that COs are of interest to the Limits community due to their potential for transitioning to novel forms of "*governing the commons*"[29].

This paper revisits the design work we were engaged in during the last 16 months when we developed and co-designed a citizen observatory for water quality conservation in Sweden. Our results highlight, on the one hand, that the integration of mobile apps and computer systems for data-gathering purposes provides a concrete way to involve actors that are concerned about their local environment (i.e. citizens, public officers, policymakers, scientists, data aggregators). On the other hand, bringing citizens and policymakers together is easier said than done, particularly when the ambition is to provide them with a dialogic space not only for consultation but also for deliberation.

Designing for new types of relationships between citizens and policymakers via COs runs into various limits. These limits are delineated in terms of 1) the complexities of water quality management in Sweden, 2) the differing views of policymakers and citizens about citizen participation in water governance and 3) designers' efforts in co-developing a sustainable socio-technical system for bringing about change in water quality management. This work contributes to the Limits-aware computing strategy suggested by [9,10] and previously developed by [25,44,37,30,33,34,31,6] by discussing the role of COs in forming Publics and mobilize action upon a future of scarcity.

2 Related work

Experimenting with the design of COs for water quality conservation connects particularly with Chen's [9] proposition that limits-aware computing research should focus on future challenges by trying to make a difference today while preparing for collapse. We ascribe to the idea that "*the collapse future is already here*"[9,p.2]. Water accessibility and quality conservation is a problem that affects millions today. According to [16], "*currently, water scarcity affects more than 40% of the global population and 80% of wastewater from human activities is discharged into waterways without any pollution removal. Unfortunately, these figures are projected to increase with the rise of global temperatures due to climate change and an increasing global population*" [p.1]. *"At the current time, more than 2 billion people are living with the risk of reduced access to freshwater resources and by 2050, at least one in four people is likely to live in a country affected by chronic or recurring shortages of fresh water*" [45 p.1]. In order to start acting upon this situation, we will need to pay closer attention to the management of freshwater ecosystems and sanitation facilities on a local level [45]. Furthermore, we will also need to cast light on how water is managed in the Global North and how such practices impact the Global South.

It is from an interest in the sustainability of our present aquatic environment that we approach the design of COs as an opportunity for computing to make a difference in the face of a present and future social-ecological collapse. More in particular, we engage with the design of COs as a way "*to support other limits-aware activities - especially those that seek to transform existing social arrangements [and] as a way to help other people trying to respond effectively to global change*" [9,p.1]. Furthermore, our attempts in co-designing COs with various stakeholders is linked to our ambition to "*focus on the social and ecological benefits, risks, and consequences of real socio-technical ecological practices, not on novel technologies per se*" [42 p.4].

From here, we turn to works that in the field of HCI are exploring how the design of socio-technical systems can help people to come together and act collectively by voicing environmental issues and contending with them. The work conducted by [20,21,22,23,14] provides us with an analytic lens to study how design can contribute to the enactment of Publics to further sustainability in the local environment and make a better use of our finite natural capital. By Publics, [22,14] build upon Dewey's [4] interpretation of an "*entity brought into being through issues for the purpose of contending with these issues in the current state and the anticipation of the future consequences of these issues*" [11,p.45]. Such an understanding of Publics is instrumental in exploring the relationship between design and collective action and more in particular, in engaging with the question of how Publics can be constituted by design [14]. In light of this, designing Publics [22] via COs connects with the ambition to develop new relationships, and new capacities to act rather than just using design to manufacture products. It also relates to the belief that we, as members of society, have the capacity to self-organize to overcome challenges by identifying common causes and by engaging with each other [cf. 22]. Ostrom [29], in her investigation of how to govern the commons, also stressed self-organization and self-governance as central to ensure the survival of present and future generations. In view of these insights, our exploratory work with designing Publics via COs aims to understand the potential of socio-technical systems to help stakeholders to develop self-organization capacity.

2.1 Toward relational models in HCI

Most recently, the field of HCI has experienced a growing interest in investigating alternative narratives of technology use

that is not driven by corporate profits [46,3,7]. Attention has particularly been paid to the role that digital technologies can play in supporting communities and citizen empowerment [2,22,46,49]. In this research domain, the scrutiny of issues related to the design of data-driven services and the development of socio-technical systems aimed at broadening participation in local governance and local public institutions has helped us become familiar with a new design space namely "*Digital Civics*" [46]. This design space is of interest here as it explores "*how digital technologies can scaffold a move from transactional to relational service models, and the potential of such models to reconfigure power relations between citizens, communities and the state*" [46, p. 1096]. More specifically, we build upon Cipolla and Mancini's work [7], where they define relational services as those based on interpersonal interactions, that challenge "*the standard way of conceiving and offering services*" [p. 46]. By focusing on the interpersonal relations between participants or stakeholders these models are presented as able to "*generate a particular form of efficiency in achieving desired results. These services propose an approach that focuses more on "actions" or "relations" than on "things" [...] which leads to environmental benefit*s" [7,p.48]". These works on relational services have caught our attention due to their potential to help build social capital and trust via relationships. We find examples of relational models in for instance the work conducted by [3] regarding the building of a mobile app for timebanking aimed at supporting on-the-fly service brokering and at increasing the scope and efficiency of acts of reciprocal altruism. This work is of particular interest as the authors underscore the idea of timebanks as offering "*a means to build a scaffolding of contrived relationships that over time solidify, becoming genuine, sincere and able to survive independently of the timebank*" [3,p.7]. Other examples can be found in works interested in "*the sharing economy*"; although these forms of computing have also been argued to have "*potential benefits for a future of scarcity— but only if the practice of sharing is approached with a dual focus on sharing and on limits at the same time*" [32, p.1].

Relational models and designing Publics are important standpoints for our work as they shape a particular understanding of the role that novel forms of computing can play in mobilizing collective action vis-à-vis the environment. Against this background, designing COs is clearly a matter of developing socio-technical infrastructure for gathering and sharing environmental data, but also for enabling relationships and trust between actors who rarely speak informally with each other. In particular we relate to the idea of the evolving community of actors here, with relationships that enable them to carry forward independently beyond the life-cycle.

3 The case of VattenFokus

This work is part of the ongoing research project Ground Truth 2.0. [17] which aims at co-designing, implementing and validating six citizen observatories in Africa (2) and Europe (4). Within the frame of the project, our design work focused on integrating tools (i.e., for data-gathering and visualization of data shared) as well as developing a web platform. The following guiding principles of the living lab methodology were adopted in the project by the six cases:

- Creating value for users by understanding their needs and motivations
- Giving future users influence on the decisions
- Aiming for sustainability in economic, environmental and social terms
- Involving multiple perspectives and collaborate widely for openness
- Carrying out activities is the real-life context

The socio-technical platform called VattenFokus constitutes the citizen observatory in Sweden. It congregates citizen groups, water authorities at the local level, to policy actors such as the county and regional government as well as scientists (water specialists). The technical platform (https://VattenFokus.se/) consists of the main communication tool, a website, a mobile app for monitoring, gathering and sharing environmental data (see figure 3) and citizen science data aggregator (see figure 2). The website has content and stories created by the CO's members and data collected by the citizen scientists visualized in maps and graphs. Analyzing water samples is performed with a test kit for water quality that targets chemical, ecological, hydrological and optical parameters of freshwater (see figure 4). The data gathered is uploaded in a global database [16].

Moreover, our design team consisted of water scientists and IT persons from a non-profit environmental organization (4 persons), data aggregator experts from a non-profit foundation focused on water (2 persons), computational linguists from a social media analytics company (2 persons), software experts from a 3D software company for urban planning (2 persons) and two researchers-designer (first and second author of the paper) who led the design team whilst been supported by two research project assistants. Our design team followed the general design guidelines and recommendations provided by the project research director (third author of this paper).

Figure 1: Representation of the data collection process with the mobile app integrated into the website

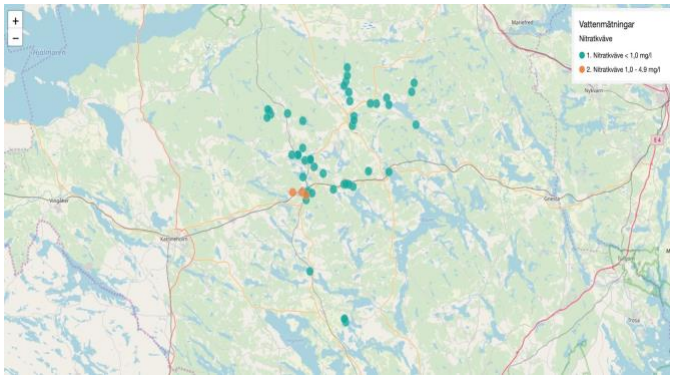

Figure 2: Representation of the citizen data collected

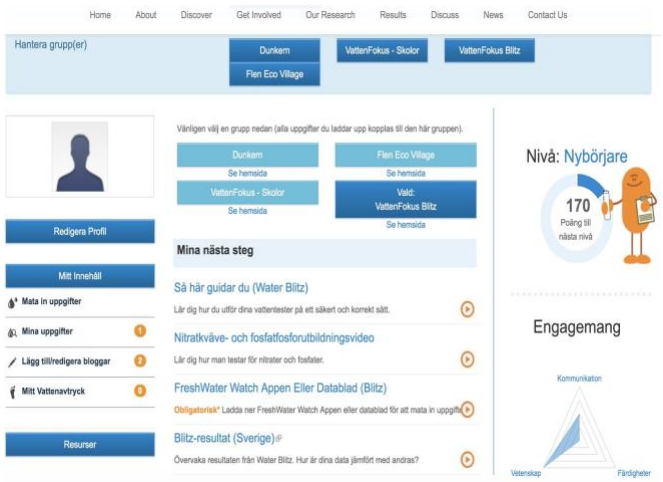

Figure 3: Interface of the mobile app for data collection and sharing

Figure 4:Test kits for water quality

3.1 Citizen science engagement around water measurements

We designed two main modes of citizen engagement around water measurements. The first aimed at engaging the general public two times a year in campaigns called water blitzes. The second mode was driven by the core communities of the citizen observatory and aimed at capturing data periodically on a regular basis. Water blitzes were organized to target a specific geographical region during a determined period of time (e.g., 48-72 hours). They served as very useful ways of getting an overview of water quality across the whole region and networking with potential future CO's members. In contrast, community groups have a more local focus and enable citizens to become more knowledgeable about their freshwater environments. VattenFokus consists of three community groups in the Flen Kommun (situated 100 km South from Stockholm), namely the ecovillage group and a group which has formed around the Dunkern Lake. A third group is constituted by a science teacher and a group of children aged between 8-10 years who after school regularly take water samples in a lake situated in the south of Stockholm. Of these three groups, the Dunkern group is the most committed in terms of time and consistency of water measurements taken. This group (see figure 5) has via VattenFokus driven dialogue between the Flen Kommun, Stockholm University, and policymakers from the regional county, creating a social framework around local water quality.

Figure 5: Citizens capturing data

3.2 Co-designing citizen observatories

Central to the co-design methodology is that it involves creative acts of making, wherein designers create probes, stakeholders then interpret the questions and answer them in the form of a shared vision, mission and objectives. This is followed by design researchers making generative toolkits (exercises and artefacts designed to inspire discussion, collaborative deliberation and visualization), which are then employed to make shared decisions. In iterative cycles these designs are evaluated and further prototypes developed. The act of making here is not just a performative act of requirement gathering, but a creative act which involves construction and transformation of meaning, by all the stakeholders impacted by the activity - in this case the co-designing of a public around water quality conservation.

In the traditional design process, designers usually engage in making after the design opportunity has already been identified. Over the last decade, we have seen the focus shift to more varied forms and formats of making where both designers and co-designers can engage in all phases of the process. Designers within this context are not only collectively monitoring and shaping the present, but also designing for futures, wherein certain novel opportunities can be created for participation [36]. In the co-design process that underpins our work within the remit of this paper, we look at how early conceptual designs and collective ideation evolves into more mature articulations via the use of generative toolkits. These toolkits were carefully crafted within the Ground Truth project to tease out the needs and concerns of the stakeholder groups within the CO. Here, the thing being made was not a forerunner of any given future product or computational tool, but a vehicle for observation, reflection, interpretation, discussion and expression. Here, our co-designing activities were used as vehicles for collectively (e.g. designers and stakeholders together) exploring, expressing and testing hypotheses about future ways of living - in this case resource scarcity within a future of limits.

4 Data collected and research methods

The analysis of the design work here presented is grounded in the collection of 23 semi-structured interviews with (4) policy officers, (3) non-governmental organizations (NGOs), (13) citizens and (3) expert advisers on mobile-based citizen science. The data collected also consists of 30 fieldnotes produced by the stakeholders during 6 co-design workshops organized. Researchers' fieldnotes from participant observations collected in the field during the running of water blitzes and meetings with local and regional authorities are also included in the data analysis. In particular, the interviews covered questions related to respondents' interest in water issues in Sweden, knowledge and/or experience with water management as well as with databases and data sets available in the country, views on citizen participation and scientific expertise required for capturing environmental data. The research data was collected both in Swedish and English, translated and transcribed. A thematic analysis of the data was performed by the first author. We collected the data between the end of October 2017 and beginnings of February 2019.

5 Findings

From the analysis of the data, it emerges that the process of co-designing VattenFokus brought together a Public that was prompted to come into being by communicating about water issues and data-capturing practices. We here unpack how this Public was formed and what role played the data produced by the citizens involved in the CO.

5.1 Emerging new relationships and data-gathering practices

The work toward the design of the CO brought together actors with different positions of authority and power that were key to overcome [22]. In order to destabilize such positions, we chose to focus our co-design workshops on articulating issues at the first stage. This connects to what [4] describe as practices of participation taking place in iterative cycles of making, telling and enacting. In the case of VattenFokus, these took place via co-design cycles of collective visioning, sketching and mapping. This resulted in the development of a discursive space to express multiple points of view in relation to data, the official action plans on eutrophication, technical infrastructure, education, lifestyle choices and consumption patterns. Our design work within this discursive space consisted in identifying how the issues manifested differently, how they overlapped and eventually how they became common issues [22]. One of such common issues

that emerged was: *how can we, as a collective, contribute to a healthier water ecosystem in Sweden?* The stakeholders' engagement with such an issue mobilized them to participate in different actions for the environment (i.e., raising awareness about how to protect water, participating in trainings to learn about how to test the water, in data-gathering activities, as well as social networking). These actions involved the mobilization of 100 volunteers who gathered 245 water samples in 60 bodies of water in the Sörmland Region where Flen municipality & the Dunkern lake is located.

Probes and generative toolkits are two prominent approaches in the practice of codesigning. They are both design-led approaches as described by the landscape of design research and practice [40]. While probes focused more on expert led interventions in design, the generative toolkits are of more interest to us within this paper, as they describe a participatory design language that can be used by future users in the front end of design so that they can imagine and express their own ideas about how they want to live, work and play in the future [39]. Generative toolkits are typically used in facilitated collaborative activities, such as the co-design workshops held within VattenFokus and their results (artefacts and descriptions or enactments of their use) can be analyzed to find underlying patterns.

During the process of Publics formation in VattenFokus, it wasn't the use of the technical platform that was central but rather the discussions about water issues, the data-gathering practices facilitated by the use of the mobile app and about the future design of the platform. In this sense, one of the citizens mentioned: "*In fact, all human activities are about emotions and relationships, so you can believe that if you make good web pages everything will work fine, but the reality is that if it works socially and in terms of information, you can disregard that the technology doesn't work perfectly*" (interview 17). This resonates with what [22] reminds us regarding "*the focus on issues is meant to express a network of actors, artifacts and institutions in a community setting rather than define product features*" [22 p. 61]. But only the presence of issues is not enough for the constitution of a public, there needs to be relationships and practices that weave the distinct actors, artifacts and institutions.

5.2 Understanding the institutional complexity of the design context

Our vision was, via the use of mobile apps, water tests kits, visualization tools and blogs to facilitate a relational space for a two-way communication between different stakeholders who although have common concerns about water quality, seldom speak informally to each other. However, aiming to engage with water authorities in Sweden requires a deep understanding of the regulated processes inherent in the management and stewardship practices as enshrined within the Water Framework Directive [15]. Such processes bring together many actors all they way from the government and the parliament via water authorities, county administrative boards and municipalities to several other authorities, companies, universities, water conservation organizations and private individuals that work in a decentralized way at different levels (i.e., European, national, regional, counties, municipalities). As such the responsibility for water quality conservation is shared by many actors making the process organizationally and geographically fragmented.

Within this context, to engage with government water policy-makers is a never ending process. Take for example the geographical water district for VattenFokus where there are 74 municipalities that are supposed to cooperate with 17 water organizations, 9 water councils and three reference water groups. The raw number of actors is just the tip of the iceberg of a complex techno-economic, socio-technical and political system. In that respect, it is therefore not surprising that communication between these implicated water actors often is unidirectional. "*It's a little bit uncoordinated in certain areas. It's not overlapping, but it's not optimized all the time. It's not crystal clear who is doing what sometimes […] We communicate and share the results of our water quality monitoring work through our website, the reports are open to download […] The norm is that you leave everything to the authority in charge and you rely on this authority to handle all issues related to water management.*" (policymaker, interview 1).

In this vein, our design intention to involve policymakers in the creation of a novel form of social arrangement might have sound exotic and even utopian to the water authorities invited to participate in this project. In this regard, [48] pointed to a mixed view about the role of digital technologies in transforming water governance. While digital technologies can enable new forms of stakeholder engagement, and participation in decision making and even governance structures, the multi-stakeholder setting characterizing many areas of water management and the paradigm of Integrated water resources management and water governance principles, make the water sector a challenging one for transformation via computing [48].

5.3 Engaging with the differing views of policymakers and citizens about citizen participation in water governance

During the co-design work we chose to engage with different stakeholders via a narrative on the promises of citizen participation regarding current water predicaments. Such a narrative was powerful as it connects with the EU's political strategy that since 2012 emphasizes the "*need to place the management of Europe's water resources into a wider perspective, addressing all users of water as well as water's interactions with other resources, such as land and energy*" [1,p.5]. It also links to the political discourse on "*an open and participatory process in which the Commission, Member States and stakeholders work together to improve the implementation of EU water policy*" [1, p.5]. In that regard, we are cognizant of our role in driving the formation of Publics in VattenFokus via rhetoric on citizen empowerment and participation. Such a rhetoric that served to mostly engage citizens and policymakers in the design work materialized different forms of participation. The citizens engaged with the illusion of gaining agency in decision

making processes and participated as "volunteers" capturing environmental data and advocating for water issues. The policymakers engaged because of curiosity and participated as "observers" of the whole co-design process.

These found differences correlate with insights gained by [47]. These authors were involved in the design of citizen observatories for flood risk management in the UK and the Netherlands. They found that *"[…] given the institutional structures identified in these cases and the obligation of authorities to be accountable for their decisions, citizen observatories have the potential, but do not automatically imply, that citizens will become more active players in flood risk management, gaining participation with higher impact on decision making, nor that communication between stakeholders will improve*" [47,p.9]. This resonates with observations we made during an exchange between citizens and policymakers with regard to citizens' involvement in the management of water locally. During that meeting, citizens presented data as evidence with the purpose of demonstrating the need to engage with other water parameters that required more expensive analysis of the water sampled. They mentioned that *"other parameters than nitrate and phosphate levels can be of interest. Methods like exploratory fishing can give additional useful information" (citizen)*. One of the policymakers then answered: "*we [this specific section of the county] don't have funding for such work but you could submit an application anyway*" […] the policymaker also invited the citizens to "*give a seminar about your data-capturing activities at our annual Water Week".*This exchange reflects that for citizens, citizen participation happens via data and for deliberating together with authorities, while for policymakers, citizen participation is a way to connect with citizens informally about water issues. One of the designers wrote in a field note*: "So, the main thing to keep in mind to convince local authorities to take part in VattenFokus is that no matter how much they like the initiative, they will only invest in it if it 'ticks one of their boxes': if it fits with plans they are already committed to or that are high on their agenda. […] Participation is often mentioned as an objective in annual plans, but many administrative officials do not know where to start or how to make that happen"*.

In that respect, it is valuable to note that the rhetoric we produced about citizen participation matters in how the socio-technical arrangement in question will be appropriated by different types of actors. This is evident in the power of our rhetoric in engaging stakeholders and forming a Public but also in its failure of helping the Publics to move on and take action on their water concerns and environmental issues.

6 Discussion

By looking at the results obtained so far, we reflect on the relational model that was enacted in the design of VattenFokus and we learn lessons about how participation of the various actors involved and the data contributed by the citizens were both configured by our design choices. These lessons are articulated in the following insights:

6.1. From Individual Citizens to Networks of Actors

From the beginning our efforts were primarily on engaging citizens to take on a more active role in water governance. This choice which is in line with the current political discourse driven by EU with regard to water governance in Europe [1] deflected us from developing a more comprehensive strategy for stakeholders engagement. Rather than individual citizens or small groups of citizens we should have put the emphasis on engaging networks of actors that were not directly connected themselves. As already underscored by [27] "*transformations in social-ecological systems require skills that go beyond the capabilities of individual actors. Networking strategies are needed for connecting nodes of expertise and developing networks of motivated actors*" [27,p.280] In this respect it is of particular interest to pay attention to brokering actors possessing bridging ties and having access to a diverse sets of actors [27]. Organizations such as water councils in Sweden are key bridging organization. Bridging organizations provide arenas for multisector and/or multilevel collaboration for conceiving visions, trust-building, collaboration, learning, value formation, conflict resolution and sense-making [27]. Many water councils in Sweden have been formed from existing water conservation organizations, where the knowledge of local conditions is great. Water councils that are successful in reaching consensus on water issues have great opportunities to influence development in their catchment area. Moreover, they have the ability to maneuver water networks which is an important part of the transformative capacity [27]. In the design of VattenFokus we should have prioritized discussions with the water councils rather than citizens and asked them first about their understanding of the water network dynamics and their needs for transformation of water governance.

6.2. From Top-Down Policy to more Dynamic and *Outside* Organizational Players

Another lesson learnt was realizing that the strategy deployed to engage policymakers wasn't the most relevant one as policy organizations are often locked-in what [27] call "*rigidity traps*" and "*path dependence*". These constructs refer to how adaptive behavior fails to respond to environmental feedback and more in particular to how people and institutions try to resist change and persist with their current management and governance system despite a clear recognition that change is essential. For example non-profit organizations such as the World Wildlife Fund (WWF) and The Swedish Society for Nature Conservation which are part of VattenFokus at the present could have received more attention from our side. These organizations are unlike policy authorities more prone to develop and use informal ties with various different actors on different scales [27]. On this note, [27] identifies the central role of informal social networks to bring change to social-

ecological governance. "*These networks emphasize political independence outside the fray of regulation and implementation in places in which formal networks and many planning processes fail*" [27,p.271]. However to engage such networks of non-formal actors, a certain critical mass of engagement needs to be built up in order to attract and sustain stakeholder participation. As designers of the COs, this is a crucial lesson learnt, where often the most impactful stakeholders who will go on to take ownership of the community platform are absent from the early stages of the design process, only to emerge later when intrinsic value in engagement has been demonstrated in more tangible ways.

6.3. From Citizen Science to Community Science

Participation in VattenFokus materialized via the environmental data-capturing practices the citizens developed. Such practices were strongly configured by the types of citizen science engagements we designed as well as the data-capturing tools, scientific data protocols and standards adopted in VattenFokus. In particular, the conflicting interpretations regarding the veracity and legitimacy of the data captured by the citizens was an eye-opener for our work. Following [23], "*while data-driven models of governance presume an empirical, objective and dispassionate basis upon which to make policy decisions, democratic participation by contrast is messy, subjective, and impassioned*" [23,p.1725]. These perspectives which were clearly reflected in the discussions observed about citizen data created tensions around how to relate to the CO's data. Data was interpreted differently if it was produced as part of professional practice or from personal contribution. In this sense, questions remains about the value, ownership and performativity of this citizen science data as well as "*how data based participation was presented, who was represented and by whom*" [23,p. 1724]. While prior work on civic data has pointed to the necessity to carefully integrate new forms of data-based civic labor into existing modes of governance [23] we believe that much attention needs still to be put on the participatory and democratic aspects of the data to be contributed by the Publics. Here, we point at the importance of defining together with the citizens and policymakers which data other than scientific data need to be collected to be able to have a good and broad understanding of the health of the watersheds in specific local communities. For example, we here refer to digital tools, questions, protocols and other resources able to capture the cultural, social and ecological knowledge that the locals have on their lakes, rivers, ditches, ponds, watersheds. This could also be a way to move on from citizen science engagements focused on "*matters of fact*" toward "*matters of concern*" [19] for local communities. On this note, [5] distinguishes citizen science from citizen(s') science and underscores that "*doing science with, in, and for the community fundamentally involves a reconstruction of citizen science in ways that account for [participants'] deep and critical connections to their community— in other words, in ways that account for their sense of place. Such a stance on citizen science positions participants [...] as community science experts, individuals with a collective expertise characterized by a deep connection to place, the capacity to use this connection to engage community members, and the knowledge of scientific processes to take action on local issues"* [5,p.3]. This observation relates to the main purpose of gathering data by and for the communities involved in COs. As stressed by [23] contributing civic data "*is not simply a problem of access to the tools for data production, but of considering and integrating alternate ways of experiencing* community [...]" [23,p.1725] in such practices. Specially, when focusing on data-gathering practices via citizen science in COs, it becomes important to differentiate the diverse data sets collected, their purpose and contextual value, so as not to undermine the validity of the effort by erroneously pitting citizen's data against professionally sampled lab data. Finally, designing COs from a perspective on Limits it is not only a matter of facilitating dialogues or of contributing data via the design of a platform, but rather a matter of understanding how trustworthy relationships between actors, data and tools can develop and ultimately infrastructure the basis for Publics to start delineating strategies for self-organization and self-governance.

6.4. Designing for Sustainable Citizen Observatories

When co-designing VattenFokus, it was clearly articulated the need to transition and make way from the initial group of stakeholders and co-designers to the future owners of the platform and CO. Here the underpinning rationale was to ensure sustainability of outcomes and a shared vision that could be realized independent of the original project's goals, methods and structure. A key design insight thus that emerged was to build into the CO an inherent flexibility wherein diverse technological tools, methods, constellations of actors could be adapted to changing needs and contexts of the CO. This links to and flies in the face of the institutional rigidity that we earlier spoke of with reference to political organizations. For sustainability of initiatives that have at their heart designing socio-technical systems for a future of limits and scarcity, it becomes that much more critical to not lock-into prescriptive language, methodologies, technical tools or decision making hierarchies, that would exclude segments of stakeholders, thereby allowing for a more fluid arrangement of adaptive governance of socio-ecological systems. In the case of VattenFokus for instance new CO stakeholders emerge as the community evolved and these actors who displayed agency and resourcefulness, came from the civic sector. Some emerged from local level water authorities, others from the nature conservation society with its broad membership across Sweden, while still others emerged from non-profit organizations such as the WWF. They were immediately impacted by the deterioration of the common pool resource of water, and hence took decisions and aligned themselves in formations to operationalize their shared goals and visions. This was an action of making, independent of the original design team of researchers and project coordinators, deploying its own local language and methodology that resonated with the immediate needs of that community. Here we find that VattenFokus operated by establishing new social relationships and new capacities to act rather than just using design to

manufacture specific artefacts and tools. In particular, their ability to self-organize to overcome small and large challenges by identifying common causes and by engaging with each other proved a critical factor for the sustainability of the CO.

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REFERENCES

[1] A Water Blueprint for Europe.(2013). Europe Union. https://publications.europa.eu/en/publication-detail/-/publication/4890db5a-ddc9-4181-9d39-8a277faef30b

[2] Asad, M. and Le Dantec, C. (2017). Tap the "Make This Public" Button: A DesignBased Inquiry into Issue Advocacy and Digital Civics. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, ACM (2017), 6304–6316.

[3] Bellotti, Victoria & Carroll, John & Han, Kyungsik. (2013). Random acts of kindness: The intelligent and context-aware future of reciprocal altruism and community collaboration. *Proceedings of the 2013 International Conference on Collaboration Technologies and Systems*, CTS 2013.

[4] Eva Brandt, Thomas Binder, and B.N. Sanders, (2012). Tools and techniques: ways to engage telling, making and enacting. In Routledge international *Handbook of Participatory Design*. Routledge,165-201.

[5] Angela Calabrese Barton (2012). Citizen(s') Science. A Response to "The Future of Citizen Science". *Democracy and Education*, 20 (2), Article 12.

[6] Teresa Cerratto-Pargman and Somya Joshi (2015). Understanding Limits from a Social Ecology Perspective. *First Monday* Volume 20, Number 8 – 3 August 2015.

[7] Carla Cipolla and Ezio Mancini (2009). Relational Services, In *Knowledge, Technology & Policy*, Vol. 22 (1). Springer. 45-50.

[8] Citizen Observatory Policy Brief (2017) http://gt20.eu/wp-content/uploads/2017/01/WSI-Citizen-Observatory-Policy-Brief.pdf

[9] Jay Chen (2015). Computing within limits and ICTD. In *Proceedings of the 1st Workshop on Computing within Limits*, 2015. ACM.

[10] Jay Chen (2016). A strategy for limits-aware computing. In *Proceedings of the 2nd Workshop on Computing within Limits*, 2016. ACM.

[11] Dewey, J. The Public and Its Problems. Swallow Press, Athens, OH, (1954-1927).

[12] Dickinson, J. L., & Bonney, R. (2012). *Citizen science: Public participation in environmental research*. Ithaca, NY: Cornell University Press.

[13] Directorate-General for Environment .http://ec.europa.eu/dgs/environment/index_en.htm

[14] Carl DiSalvo (2009).Design and the construction of publics. Design Issues 25, 1, 48--63.

[15] EU Water Framework Directive. http://ec.europa.eu/environment/water/water-framework/index_en.html

[16] Freshwater Watch. https://freshwaterwatch.thewaterhub.org/content/water-limited-resource

[17] Ground Truth 2.0. http://gt20.eu/

[18] Sunyoung Kim, Christine Robson, Thomas Zimmerman, Jeffrey Pierce and Eben Haber (2011). Creek Watch: Pairing usefulness and usability for successful citizen science. *In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2125-2134, New York, NY, USA, 2011. ACM.

[19] Bruno Latour (2004). Why has critique run out of steam? From matters of fact to matters of concern matters of concern. *Critical Inquiry* 2004 30:2, 225-248.

[20] Christopher Le Dantec, Robert Farrell, Jim Christensen, Mark Bailey, Jason Ellis, Wendy Kellogg and Keith Edwards (2011). Publics in Practice: Ubiquitous Computing at a Shelter for Homeless Mothers. *In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1687–1696, New York, NY, USA, 2011. ACM.

[21] Christopher Le Dantec, (2012). Participation and publics: supporting community engagement. *In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 1351-1360. New York, NY, USA, 2012. ACM.

[22] Christopher Le Dantec (2014). *Designing Publics*. MIT Press, London.

[23] Christopher Le Dantec, Mariam Asad, Aditi Misra and Kari E. Watkins (2015). Planning with Crowdsourced Data: Rhetoric and Representation in Transportation Planning. *In Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*, 1717-1727. New York, NY, USA, 2015. ACM.

[24] Hai-Ying Liu, Sonja Grossberndt and Mike Kobernus (2017). Citizen Science and Citizens' Observatories: Trends, Roles, Challenges and Development Needs for Science and Environmental Governance. In: Foody, G, See, L, Fritz, S, Mooney, P, Olteanu Raimond, A-M, Fonte, C C and Antoniou, V. (eds.) *Mapping and the Citizen Sensor*. 351–376. London: Ubiquity Press.

[25] Bonnie Nardi, Bill Tomlinson, Donald J. Patterson, Jay Chen, Daniel Pargman, Barath Raghavan, Birgit Penzenstadler (2018). Computing within Limits. *Communications of the ACM*, Vol. 61 No. 10, Pages 86-93.

[26] National Audubon Society. https://www.audubon.org/es

[27] Per Olsson, Örjan Bodin, and Carl Folke. (2010). Building transformative capacity for ecosystem stewardship in social–ecological systems. Pages 263-285 *in* D. Armitage and R. Plummer, editors. *Adaptive capacity and environmental governance*. Springer-Verlag, Berlin, Germany.

[28] Per Olsson and Victor Galaz. (2012). Social-ecological innovation and transformation. *in* A. Nicholls and A. Murdoch, editors. *Social innovation: blurring boundaries to reconfigure markets*. Palgrave MacMillan, Basingstoke, UK, Pages 223-243.

[29] Elinor Ostrom (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge Univ. Press, New York, 1990.

[30] Daniel Pargman and Barath Raghavan (2014). Rethinking sustainability in computing: From buzzword to non-negotiable limits. In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction*, (2014). 638–647. New York, NY, USA, ACM.

[31] Daniel Pargman. 2015. On the limits of limits. First Monday 20, 8 (2015).

[32] Daniel Pargman, Elina Eriksson and Adrian Friday (2016). Limits to the sharing economy. In *Proceedings of the 2nd Workshop on Computing Within Limits*. ACM.

[33] Patterson, D. 2015. Haitian resiliency: A case study in intermittent infrastructure. In *Proceedings of the 1stWorkshop on Computing Within Limits*. ACM, 111–117.

[34] Birgit Penzenstadler, A. Raturi,Deborah Richardson, Six Silberman, and Bill Tomlinson, b. (2015). Collapse (and other futures) software engineering. *First Monday 20*, 8.

[35] Jenny Preece (2016). Citizen science: New research challenges for human–computer interaction. *International Journal of Human-Computer Interaction, 32*(8), 585-612.

[36] Pilemalm, S., (2018), Participatory Design in Emerging Civic Engagement Initiatives in the New Public Sector: Applying PD Concepts in Resource-Scarce Organizations, ACM. *Transactions on Computer Human Interaction*, 25(1), 5:1–5:26.

[37] Raghavan, B. and Pargman, D. (2017).Means and ends in human-computer interaction: Sustainability through disintermediation. *In Proceedings of the 2017 SIGCHI Conference on Human Factors in Computing Systems*. ACM, 786–796. New York, NY, USA, 2017. ACM.

[38] Samar Sabie, Maha Salman and Steve Easterbrook (2016). Situating shelter design and provision in ICT discourse for scarce-resource contexts. In *Proceedings of the Second Workshop on Computing within limits*. ACM.

[39] Sanders, E., 1999. Post Design and Participatory Culture in Useful and Critical: The Position of Research in Design. Tuusula University, Helsinki, Finland.

[40] Sanders, E. and Jan Stappers, P. (2014) Probes, toolkits and prototypes: three approaches to making in codesigning, *CoDesign*, 10:1, 5-14.

[41] Ahmed Seffah (2018), Citizen observatories: Challenges informing an HCI Design Research Agenda. *Interactions of ACM*, 52-57.

[42] Six Silberman (2015). Information systems for the age of consequences. *First Monday 20*, 8.

[43] Jonathan Silverton, J. (2009). A new dawn for citizen science. *Trends in Ecology & Evolution*, 24(9), 467–471.

[44] Bill, Tomlinson, Six Silberman, M., Patterson, D., Pan, Y., and Blevis, E. (2012). Collapse informatics: augmenting the sustainability & ICT4D discourse in HCI. In *Proceedings of the 2012 SIGCHI Conference on Human Factors in Computing Systems*. ACM, 655–664. New York, NY, USA, 2012. ACM.

[45] UN Sustainable Development Goals https://www.un.org/sustainabledevelopment/sustainable-development-goals/

[46] Vasilis Vlachokyriakos, Clara Crivellaro, Peter Wright, Patrick Olivier (2016). Digital Civics: Citizen Empowerment With and Through Technology. In Proceedings of CHI'2016. 1096-1099. New York, NY, USA, 2016. ACM.

[47] Uta Wehn, U., Jaap Evers (2015).The social innovation potential of ICT-enabled citizen observatories to increase eParticipation in local flood risk management' in Technology in Society, Volume 42, Pages 187-198, ISSN 0160-791X, http://dx.doi.org/10.1016/j.techsoc.2015.05.002

[48] Uta When and Carlos Montalvo (2018) Exploring the dynamics of water innovation: Foundations for water innovation studies, Journal of Cleaner Production, 171(S), 1-19.

[49] Maruf Zaber, Bonnie Nardi and Jay Chen (2017). A Study of Hashtag Activism for Raising Awareness about Riverbank Erosion in Bangladesh. In *Proceedings of the 3rd Workshop on Computing within Limits*, 2017. ACM.