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The Right to the Sustainable Smart City

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ABSTRACT

Environmental concerns have driven an interest in sustainable smart cities, through the monitoring and optimisation of networked infrastructures. At the same time, there are concerns about who these interventions and services are for, and who benefits. HCI researchers and designers interested in civic life have started to call for the democratisation of urban space through resistance and political action to challenge state and corporate claims. This paper contributes to an emerging body of work that seeks to involve citizens in the design of sustainable smart cities, particularly in the context of marginalised and culturally diverse urban communities. We present a study involving co-designing Internet of Things with urban agricultural communities and discuss three ways in which design can participate in the right to the sustainable smart city through designing for the commons, care, and biocultural diversity.

Author Keywords

Smart cities; Internet of Things; sustainable HCI; right to the city; urban agriculture; hybrid cities; spatial autogestion; civic IoT; Anthropocene

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INTRODUCTION

As cities become fertile grounds for embedded IoT technologies and services, many in HCI have become increasingly interested in the projects, visions and narratives of their integration in what has become known as the smart city. In particular, environmental concerns have driven an interest in sustainable smart cities, through the optimisation of urban processes and resources, services and infrastructures, making them more efficient and

therefore, the argument goes, more sustainable [25]. The building of eco-cities is now at the “forefront of national and global agendas” [60]. Typical examples involve the use of networked sensing and tracking technologies, and mobile and cloud computing, for low-carbon infrastructure, including smart energy metering, reducing waste and emissions [44], water recycling, and automated collection systems [60] and increasing efficiency in food supply chains [27]. However, these visions are increasingly being critiqued, both for the ways in which they attempt to tackle the problem of urban sustainability, and also for their claimed benefits to the inhabitants of cities [23,25,41,60].

Critics argue that, like other modernist, top-down, efficiency-based, techno-solutions to the problem of environmental sustainability that have already been critiqued within HCI [8,71], eco-cities are subject to particular types of breakdown, because they are unable to deal with the complexities of real, messy cities [60], and sustainability gets performed in specific ways that leave little room for political participation or citizen agency [20,25,60]. There are also critiques over “green growth” approaches that merge economic growth with green objectives [46] that are inherent in smart cities narratives [25], with critics arguing that economic growth is the cause of environmental degradation [59], and that “prosperous descent” [1] or degrowth is the alternative we should be striving for.

At the same time, HCI researchers and designers interested in civic life have started to question whose ‘right to the smart city?’ recalling French philosopher Henri Lefebvre’s call for the democratisation of urban space through resistance and political action, amid growing concerns about who these interventions and networked infrastructures are for and who benefits [6,23]. Critics have voiced concerns over: who owns, controls, and has access to proprietary smart city infrastructure [2,23,25,53]; privacy, surveillance and censorship [2,17]; inequalities in terms of representation, participation, and access [2,74]; and the encroachment of algorithmic culture into government, civics and public life [17,25]. “More and more commentators these days critique the established hegemony of the engineering and technology-centric epistemology embedded in any one proprietary smart city vision” [23].

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We situate our work within citizen-centred smart cities, civic IoT, and sustainable HCI to make the following contributions: We begin by drawing on Lefebvre's 'right to the city' formulation, and introduce his term of spatial *autogestion* [49] to provide a critical lens through which to examine the smart city. We introduce perspectives from the Anthropocene literature as a way to broaden thinking about sustainable cities beyond efficiency. We then present a case study in this design space that involved co-designing networked environmental sensors, data visualisation, and an interactive seed library to support sustainable food practices with urban agricultural communities in London, UK. Finally, we reflect on this study in terms of the struggle for the right to the sustainable smart city through an articulation of: *Designing for Biocultural Diversity*, *Designing for Care*, and *Designing for the Commons*. We offer these conceptual repositionings of smart cities for diversity, care and commons as contributions to design research within sustainable HCI in order to begin to imagine, as Carl DiSalvo has asked us to do, what *else* a sustainable smart city might be [15].

RIGHT TO THE CITY

The 'right to the city' formulation that French philosopher Henri Lefebvre coined in 1968 [48], is a declaration of a collective intention to struggle against homogenising planetary urbanization. It is a commitment to become active and move towards the democratization of urban space, to reappropriate the production of space from the dominant hegemonic regimes, which in contemporary cities, is neoliberal capitalism. For Lefebvre, (according to Mark Purcell [65]), space is not just the objective material space of the city, it is also the mental constructions of space, the lived experience of space in everyday life, and it is a constituent element of social life, entailing "all aspects of urban life" [65]. Within neoliberalism, space is valued predominantly for its exchange value, and private property and profit is prioritised over all other rights and claims [34,47,66]. The 'right to the city' maintains that the use value aspect of urban space must take priority in decisions about how urban space is produced.

For Lefebvre, rights are not codified protections guaranteed by the state, achievements that come at the end of a struggle like the US Civil Rights Act of 1964 [66]. Rather they come at the beginning and are political declarations of an intention to struggle. Historically rooted in revolution and in Marxism, "Rights are people voicing their commitment to become active and to move together in a particular direction, towards a particular horizon" [66]. The horizon here is a society in which people manage all aspects of life for themselves without the intervention of the state or capital. Lefebvre uses the term *autogestion* which in French means self-management, and traditionally refers to factory workers taking over the means of production for themselves. For Lefebvre, *autogestion* is not limited to economic relations, but also to relations of governance,

such as between the state and citizens. "Each time a social group...refuses to accept passively its conditions of existence, of life, or of survival", he says, "each time such a group forces itself not only to understand but to master its own conditions of existence, *autogestion* is occurring" [49].

Within the dominant existing neoliberal capitalist system, the production of space in cities is alienated, or made strange, from the users – *citadins*, or urban dwellers – because it is not produced by them, but by others for them [65]. *Citadins* are also alienated from others who share the space. One of the ways that the right to the city can be articulated is in terms of the right to spatial *autogestion*, [49] which refers to the radical project of people self-managing the production of space for themselves and refusing to passively accept the existing system of spatial production [66], one of property rights on which the capitalist economy exists. Top-down decision-making processes turn urban locations into abstract spaces, where people are also alienated from each other. The practices of spatial *autogestion* return those spaces back into specific places. "Spatial *autogestion* reverses the separation and segregation of inhabitants; it draws them together into common spaces where they would encounter each other and engage in meaningful discussions about the city and its future" [66]. In this way, the applied practices of spatial *autogestion* are a way of realising the right to the city by reworking "control over urban space, resisting the current hegemony of property rights and stressing the primacy of the use-rights of inhabitants" [65].

The acts of spatial *autogestion* are happening continuously in our cities: there are examples of individuals and social movements everywhere engaged in active struggle to reshape the city and overcome isolations, resisting the efforts of developers and the state to create homogenising urban space for capitalist and state benefit [34]. Purcell provides the example of the cultivation of urban land as a concrete example to the abstract ideas of the right to the city. Viewing the struggles of urban agriculture through the lens of the right to the city helps us to understand their "radical political and ecological potential" [66]. According to Purcell [66] if we want to participate in the right to the city, then we must identify the sites of struggle, learn to see them, narrate them, and help them proliferate. Rather than focus on the structures of power, he argues, it is more productive to spend our energy cultivating the world we want to live in.

Right to the Smart City

With the proliferation of networked sensing and digital infrastructures in to urban life, the right to the smart city has become a subject of focus [2,6,17,23]. It speaks to the original declaration of a collective intention to struggle against homogenising planetary urbanization that turns us into passive consumers for the benefit of the few. There are concerns that the algorithms that drive these technologies, and the data produced will be steered towards increasing

profits of huge companies, rather than towards increasing civic participation. “Unlike the physical urban space that it overlays, this new and rapidly emerging “virtual” space has practically no capacity constraints. However, it is subject to inequalities in terms of access, representation, participation, and ownership” [2]. It is becoming increasingly clear that the control of global digital social interactions by large corporations such as Google, Facebook and Twitter, and “the complete lack of ownership and control of these platforms on the users’ behalf poses significant threats related to privacy, surveillance, censorship, and manipulation, which should not be underestimated” [2]. There are concerns over urban citizenship “reduced to a series of actions focused on monitoring and managing data, when that data is managed by corporate and state actors” [25], as well as the creep of “algorithmic culture into government, civics, and our public lives” [17]. As Lodato and DiSalvo argue, “smart cities have intensified the effects and reach of neoliberalisation” [53].

While for some, concerns about the right to the smart city remain firmly focused on digital networks, infrastructures, and services, and the data they produce, Antoniadis et al. [2] argue that the issue of citizens’ rights to the smart city must address the ways in which the digital and physical are emmeshed, producing the right to the hybrid city. “There is a gap today between those that fight for our rights to the city with those that fight for our rights to ICTs, despite the fact that in the times of the smart city, these two objectives are more and more interwoven” (ibid). This interweaving is exemplified in Apple’s ‘town squares’, where communities are encouraged to form around Apple’s products in hybrid physical and digital urban space [10]. In these new pseudo-public spaces [69], what would previously have been open democratic sites for people to encounter diversity and engage in meaningful discussions about the city [65] become homogenous spaces of consumption, where difference is viewed with suspicion [58] and the reach of corporate control is intensified through the digital layer.

As hybrid digital-physical space becomes increasingly important for the lives of city dwellers, their data, networks, location-based services, sensors and other devices have become increasingly valuable resources. Neoliberal smart cities seek to enclose such resources for the benefit of capital and the state. HCI designers have been actively working to reappropriate the production and management of these resources and bring them into the digital urban commons [2,6,24,68], where the *commons* refers to commonly held property, use, stewardship and management of the available and produced resources [4,61] by a community; and *commoning* refers to the social process that creates and reproduces the commons [ibid]. For example, Balestrini et al. [6] explored how citizens from disadvantaged backgrounds can “participate in the collection, sharing and use of data to tackle issues of their own concern”, where those concerns are emmeshed in the physical manifestations of urban planning and their resultant inequalities, for example through

participant sensing of pollution or damp [6,26]. Internet of things technologies are used for civic media and as a way to address “matters of concern and care” [17]. Wolff et al. [74] are helping citizens gain data literacy, thereby overcoming barriers of access and participation. And Calzada and Cobo [9] are working towards resisting technocratic determinism of the smart city through bottom-up, community-driven, low-cost, and local innovative efforts to “increase transparency, accountability, participation, and collaboration” [ibid]. By contributing to the creation and ongoing maintenance of an urban digital commons, designers are helping to empower citizens to claim their rights to privacy, freedom of expression, diversity, and self-determination [2]. These works participate in the right to the smart city by amplifying the acts of spatial autogestion in which citizens appropriate the means of production of the smart city for themselves. Rather than passively accepting or consuming the existing system of spatial production in the smart city, by creating a digital urban commons people are taking up the challenge of understanding and mastering the means of production of hybrid space for themselves.

Right to the City in the Anthropocene

Sustainable HCI has started to move beyond efficiency by drawing on discussions within Science and Technology Studies (STS), feminist technoscience, and the environmental humanities about the Anthropocene [50,52,70] – a term used to refer to a new geological era in which human activity is transforming earth systems [42], accelerating climate change and causing mass extinctions [59]. The Anthropocene is used as a way to rethink human exceptionalism and privilege in which the human is perceived as a separate, autonomous individual, superior to the non-human, living in a sovereign body whose actions do not have ecological consequences [62]. Exceptionalist thinking stems from traditions within Western knowledge to think in hyper-separated categories, or dualisms, such as human/non-human, nature/culture, and mind/body. Preferring the term Capitalocene to acknowledge the role of capital in the current age of environmental destruction, Jason Moore argues that exceptionalist thinking obscures “our vistas of power, production and profit.... It prevents us from seeing the accumulation of capital as a powerful web of interspecies dependencies; it prevents us from seeing how those interdependencies are not only shaped by capital, but also shape it.” Within the Capitalocene, the same system that causes social injustice results in environmental destruction, because people and natural resources are exploited for capital, made possible by exceptionalist thinking in which “Human relations are not only distinct from nature, but are effectively independent of the web of life” [59].

Neoliberal sustainable smart cities visions are based on exceptionalist and privileged ways of thinking, in which urban space is separate from nature, planned and built for (some) human inhabitants alone. As Houston et al. have argued, cities may have been built out of natural materials

but they are now “elevated to places of progressive human and technological mastery” [42] where nature is seen as a resource to be exploited, or as a nuisance to be eliminated, for the higher human needs. Within cities, human exceptionalism has resulted in “asymmetric ‘negotiations’ between human planners and nonhuman others”, which have contributed to environmental destruction [42].

HCI has started to pay attention to the entanglements of humans and non-humans in thinking about the production of hybrid space, with implications for the right to the smart city in terms of the complex biophysical urban worlds that we inhabit [14,52,70] and as a way to avoid ecocide [41]. Methods that merge speculative and participatory design have been identified as fruitful ways forward to conceive of humans and other species in a relational perspective, and to overcome problematic narratives of human privilege and exceptionalism [21,52,70,73]. Nonanthropocentric design [19,21,55] has the potential to “radically shift our experience of the world ... and prototype alternative possible futures” [21] in which humans and other species cohabit and coproduce urban worlds [70]. Theoretical perspectives from feminist technoscience, such as an ethics of care [63,64] have been used to rethink the role of technology in sustainable design [17,50] beyond designing for efficiency. Through a “speculative commitment to neglected things” [63] an ethics of care addresses power asymmetries and can help democratise our matters of concern, and therefore has a role to play in the right to the smart city. A perspective in which we understand the imbricated nature of humans and nature, humans and non-humans, and cities and nature, can have important implications for how we think about the right to the sustainable smart city. After all, “city dwellers are deeply entangled with natural elements, including plant life, animals, dirt, water” [70], and, as Houston et. al. have argued, “any presumed exclusive human ‘right to the city’ and the biosphere is increasingly untenable” [42].

Our work sits within this turn towards citizen participation and the Anthropocene, by involving urban agricultural communities in the design processes of Internet of Things technologies as a way to incorporate more voices into the debate about what sustainability means and how such alternative understandings can influence the design space of sustainable smart cities beyond efficiency. By situating this work within the discourse of the right to the smart city we aim to highlight how our case study of participatory design with urban agricultural communities surfaces new visions for what more socially just and environmentally sustainable smart cities could be [15] when we employ more democratic ways of doing design. We aim to demonstrate how design more generally can contribute to spatial autogestion in hybrid space and thereby stake a claim in the revolutionary struggle to regain control of the sustainable smart city.

CONTEXT: URBAN AGRICULTURE IN EAST LONDON

Our project took place with urban agricultural sites in east London. Our project partner was Spitalfields City Farm which, like many other community gardens in the UK and elsewhere, started in the 1970s by a group of local people who occupied vacant land to grow fresh food. Food is grown all-year round in rotation, with seeds being planted to replace the food that will soon be finished. The farm has a diverse base of volunteers and visitors in terms of age, ability, socio-economic and cultural background. Through its community gardens, volunteer opportunities, its various educational programmes and fresh produce sales, the farm encourages local communities to grow and consume healthy fresh food.

As discussed in [37,39,40], Spitalfields Farm places a high value on inclusivity, education, and health and well-being of people and the Earth. The farm supports Somalian, Zimbabwean, Bengali and Turkish community gardening groups, as well as school groups, people suffering from post-traumatic stress and mental health service users. Its environmental work includes food-growing and healthy eating activities, an integrative approach to the management of food production and waste cycles, and capacity building within nearby communities by strengthening knowledge and skills.

The farm is located in the inner east London borough of Tower Hamlets, which is one of the most economically deprived boroughs in the UK. It is characterised by high population density, large-scale immigration, ethnic diversity, poverty and huge divides between rich and poor. Tower Hamlets contains Canary Wharf, one of London’s two main financial centres and home to some of the world’s largest banks. It has proportionally more people earning above £90,000 and more earning below £15,000 than the London average, and the gap between the two extremes is growing [77]. There are high levels of racial segregation with around 50% of secondary schools being entirely non-white. It has the highest rate of child poverty across the UK [78] and suffers from a range of food-related illnesses, including high rates of diabetes and childhood obesity. Health inequalities are further compounded due to the availability of unhealthy eating options: 76% of households are within a 10-minute walk of a supermarket, while 97% are within a 10-minute walk of a fast food outlet [11].

As discussed in [38], it is against this background of ethnic diversity, economic disparity and deprivation, ill-health and marginalisation that we recognised an opportunity to leverage local understandings of sustainability, in order to strengthen existing practices of spatial autogestion through networked and digital technologies and begin to explore what sustainable smart cities could be when we employ more democratic and inclusive ways of doing design.

CASE STUDY: CONNECTED SEEDS AND SENSORS

Connected Seeds and Sensors was an 18-month participatory design research project that took place between October 2015 and March 2017. The project was developed collaboratively with Spitalfields City Farm and researchers at Queen Mary University of London. Through prior work [35] we identified opportunities for IoTs to support the practices of food-growing and seed-saving in east London. The project explored these opportunities through four design strategies described in this section: i) participatory workshops; ii) engagement with the community of practice; iii) technology driven design exploration through the design, development, and deployment of networked environmental sensors and visualizations of their data; and iv) the co-creation of a digitally-augmented interactive seed library.

We were interested in seeds as a vehicle to explore the role of IoT in sustainable cities in particular regarding the complexities of seed-sovereignty (the control of seed production and supply), biodiversity, community-based agriculture and the city. At the time of co-developing the funding proposal with the farm these concerns were pressing because proposed changes to EU law were going to make the registration of seed (at substantial cost) mandatory. Campaigners claimed this would be disastrous to biodiversity, farmers' rights, and play into the hands of big business such as Bayer-Monsanto [75]. A series of externally-run seed-saving training workshops took place at the farm before our project began, which focused on food not typically grown in the UK. These workshops served as inspiration and impetus for the co-created funding proposal.

Initial Workshops

The project started with a series of four workshops aimed at better understanding the needs, practices and values of urban growers and seed-savers. For example, we wanted to know what kinds of information would be useful and meaningful to include on seed packets (beyond the standard information that commercial seed companies provide), including exploring what data we usefully could collect from IoT sensors. Workshop activities included participatory mapping, a cultural probe pack [29], seed-saving trainings, and creative activities that explored the cultural, social, environmental, and political entanglements of saving seeds and growing food in the city. For example, participants were asked to choose a seed and tell its story as a way of foregrounding the role of seeds in community and culture which is typically lost when viewed from an industrial and commercial perspective. The probe pack contained a single-use 35mm film camera, a notebook and a series of open-ended instructions aimed at eliciting responses about growers' values and practices. The materials produced were used to collaboratively form what we called "data categories", which related to the information our growers would find interesting or useful to

know about seeds. These discussions highlighted the practical, and also the personal, cultural, social, economic and political aspects of growing food and saving seeds, and would inform our designs.

Engaging seed guardians

From February-December 2016 we recruited and engaged 15 seed guardians who committed to grow 1 to 2 crops for seed, and to donate some of those seeds to the library at the end of the season. Seed guardians were culturally diverse, with origins from Bangladesh, Trinidad, Egypt, Turkey, Zimbabwe, France, Belgium, Britain, Australia, Taiwan, and Ireland. They had differing levels of gardening and seed-saving experience ranging from those who knew nothing of growing food or saving seeds, to those who had horticultural qualifications and kept their seeds every year. Four guardians grew their crops at the farm, while others grew in community gardens, plots on common land in housing estates, and private gardens. Many of the crops grown for seed were "exotic", that is not typically grown in the UK, and included: kodu, lablab beans, Zimbabwean maize, calaloo, orach, summer purslane, chickpeas, pak choi, Thai basil, achocha, and black mustard. Seed guardians also took photos of their gardens, plants, harvests and meals cooked. We recorded audio interviews with them at the start of the season, and again at the end, structured around the different data categories that we had elicited in the workshop phase. These materials captured the considerable knowledge and skill required to grow such crops successfully in a UK climate.

We organised community events throughout the growing season including seed-swaps, garden visits and design sessions. We hired a growing expert to provide two technical workshops on seed-saving. The aim of these activities was to support a community of practice, encourage peer-to-peer knowledge and skill-sharing through structured activities and discussions, maintain motivation, and involve participants in design activities (e.g. requirements, iteration, and informal evaluation). Additional engagement was through a documentary film [51], a book [36], an exhibition [79], and a final celebration [76]. The project built on existing interests in the local communities but extended these through activities that brought diverse people together, many of whom had never been to the farm before, and creating a new network of committed seed savers.

Sensors and Data Visualisation

Networked environmental sensors are increasingly being used in precision agriculture to increase efficiency and productivity in mass crop production through resource management, pest control, and waste reduction [3,28]. In contrast, our project aimed to explore how IoTs could be used in the context of small-scale urban agriculture to support sustainable food practices, knowledge-sharing and community building. As there was no WIFI available in the gardens, we designed and custom-built IoT devices from

open-source systems and deployed them in eight of the seed guardians' gardens to explore both the kinds of data that could be collected and to act as a prompt to allow us to explore how people might respond to such devices. The sensors collected information about air temperature, air humidity, air pressure, soil moisture, soil temperature, and ambient light. A reading was taken from the sensors every hour, and, in order to save on battery life, sent once a day to a web server over a 3G network. We collected data for 2 months and overcame many technical and pragmatic hurdles in the deployment of our IoT sensors such as dealing with unreliable networks and theft of sensor units. Despite our original plans, due to technical obstacles, we were unable to test users' responses to live data (relying instead on historical data at the end of the season). This is something we would like to test in future work.

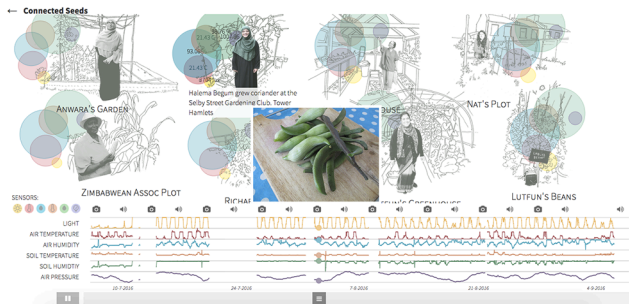


Figure 1. Screen grab of data visualization

At the end of the growing season we hired a data visualisation company to present the data in an interactive webpage. In addition to the data produced from the sensors – represented by a graphical animation across a timeline – photographic images pop up and audio clips from the Seed Guardians begin to play as the timeline progresses [80]. Viewers can compare the data from different sensors and in different gardens.

The Connected Seeds Library

The Connected Seeds Library concept was collaboratively envisaged as a way to collect and share the knowledge from guardians, connect people to their heritage through food, and to make available locally-grown seeds. Such seeds are highly valued as they have adapted to local climates and may be of unusual or heritage varieties not available in commercial catalogues. The library contains seeds that guardians donated, as well as their associated digital records (audio and photographs). Visitors to the library can select a jar of seeds and place it on a designated pad in order to start a slideshow of images from the gardens. They can turn a wheel to play 1-minute-long audio tracks of the guardian talking about their experiences of growing. There are ten different categories on the wheel to select, based on the data categories from the initial workshops: five relate to the grower (Who I am; Why I grow my own food; Why I save my own seeds; Connections to my heritage; How I feel when I'm working in the garden) and five relate to the

particular seed (Where these seeds came from; How I grow them; Tips and tricks; Recipes; How to save the seeds).



Figure 2. Connected Seeds Library

Figure 3. Engaging with the Connected Seeds Library



The interactive elements are built from a Raspberry Pi and screen, an RFID reader, a battery, and a speaker. The seed jars are tagged with RFID tags that link to their digital records. Visitors can join the library for free, take seeds home, and bring some back at the end of the season to maintain the living stock. The seeds also come in packets with QR codes that link to webpages with the digital content. The Connected Seeds Library is a new addition for the community from the project and continues to be used as a local resource at its permanent home at the farm.

DISCUSSION

In this section we discuss the ways in which our study surfaces possibilities for design to participate in the right to the sustainable smart city by contributing to the practices of spatial autogestion in hybrid space. We reflect with illustrations and perspectives from participants how the study works to conceptually reposition sustainable smart cities beyond the neoliberal focus of efficiency through an articulation of *Designing for Biocultural Diversity*, *Designing for Care*, and *Designing for the Commons*. We discuss how the right to the sustainable smart city is coproduced among the assemblage of human, non-human and technological actors, as a resistance to the hegemonic narratives of homogeneity and temporally bound efficiencies in hybrid digital-physical space. These themes encompass the various ways in which the study's artefacts, processes and participants enact the right to the sustainable city. The data we draw on includes materials produced in workshops, and

transcripts from audio interviews with seed guardians and others who interacted with the seed library.

Designing for Biocultural Diversity

The visions of neoliberal smart cities are alienated from nature, from the production of food, and from difference. If there are any people at all, they are typically “Resource Men”: white, middle-class technofetishists, “cast in the image of the male-dominated industries of engineering and economics that permeate energy management” [71] and who dream them into being. Such visions of homogeneity and abstraction are based on exceptionalist thinking and produce asymmetric relations between the planners of smart cities and human and non-human others. Thinking about the right to the smart city through the lens of the Anthropocene requires that we dismantle exceptionalist narratives and begin to consider the ways in which diverse beings coproduce hybrid space.

Our study demonstrates how designing with and for diversity is one way to resist homogenising planetary urbanization, expand the design space of sustainable smart cities beyond efficiency, and participate in spatial autogestion in hybrid space. Rather than creating homogenous urban space where people are alienated from each other and other species, urban community gardens such as those involved in our study are “sites of encounter” [66] with other people and other species. By supporting these encounters and drawing attention to growers’ entanglements with diverse others, our co-design process suggests ways for design to participate in the right to the smart city by breaking down privileged and exceptionalist ways of producing hybrid space and appropriating it for biocultural diversity [56].

The practices of community gardening foreground the interrelations and encounters within diverse multispecies worlds. As one seed guardian said, *“I keep the seeds and I keep plants living their whole life for the animal biodiversity so there’s insects coming in and the birds eat the seeds. So, there’s enough for everyone”* (Kate, seed guardian). Likewise, our participants spoke of encounters with diverse people, helping to break down social barriers and overcome racism, and contribute to social cohesion. *“We really love to come here and meet other people from our home. And other people from other places. We introduce them to our crops and we see their crops here”* (Basilia, seed guardian). The seed library, augmented with smart city technologies of IoT, networked sensing and data, recounts these stories of encounter. By amplifying and supporting the community gardening, it strengthens the practices of spatial autogestion in hybrid space and helps them to proliferate. By reversing the separation and segregation of human and non-human inhabitants [66] designing for biocultural diversity works towards restructuring power relations, providing the resources needed to bring diverse people and species together to support cohabitation [70], and in this way supports the practices of spatial autogestion.

Communities of colour, such as those in multi-ethnic neighbourhoods where our project took place, are often marginalised from the neoliberal visions of smart cities, so we would argue that the right to the sustainable smart city is enmeshed in the struggles against biocultural marginalisation [66]. As one seed guardian reflected on the project as a whole: *“I think one of the real strengths of this project is how it brought together lots of different people from different backgrounds and harnesses that expertise of the migrant communities”* (Richard, seed guardian). If we design for biocultural diversity then those who are usually marginalised from smart cities visions, in this case migrants, become experts. In this way design can help restructure power relations.

Designing for urban biocultural diversity requires consideration, and negotiation, of competing needs that arise from difference – which for some is a matter of life and death [32]. At the farm different groups negotiate the use of different plots for their growing activities. Non-human inhabitants in the form of weeds, slugs and snails are done away with, as are other “awkward creatures” [30]. Ladybirds are encouraged because they control aphids; bees and hoverflies are encouraged because they support pollination. The design artefacts including seed library and website acknowledge and narrate this complex negotiation which includes killing [7]: *“The biggest thing that’s going to impact on the slugs and snails is things like the blackbirds and the thrushes, so make sure you’ve got lots of shrubbery, and keep a pond for frogs. It’s not like an immediate cure, but it’s a sustainable long-term cure, and it makes life a lot easier to correct that imbalance in the biodiversity, rather than intervening too much”* (Richard, seed guardian). Rather than reverting to visions of technofixes embodied in top-down sustainable smart cities narratives (in which conflict and negotiation is erased), or succumbing to fatalism [32], community gardening and by extension the seed library, teaches us to ‘stay with the trouble’ as Donna Haraway urges us. As one seed guardian said: *“Gardening is... a process. It’s about life. It’s about growth and death and decay, which is all together”* (Ahmet, seed guardian). “Staying with the trouble requires making oddkin; that is, we require each other in unexpected collaborations and combinations, in hot compost piles. We become-with each other or not at all” [32]. If we want to take seriously the idea of the right to the smart city within multispecies worlds, as the Anthropocene asks of us, then we will need to consider designs that have little or no benefit to humans, or even adversely affect humans [e.g. 14].

In our study the deployment of networked environmental sensors worked as a type of speculative participatory design [12] probe, prompting one seed guardian to envisage an alternative sustainable smart city future in which a city-wide pollen-sensing network would allow growers to coordinate their plantings to ensure sufficient food for urban pollinating insects: *“If there’s a particular month when*

there's really low pollen, we'd need to think about things that flower at that time and try and fill in the gaps, for bees and other pollinators" (Nat, seed guardian). This idea could build on previous work in HCI on pollen sensing [18] but expand the focus beyond human benefit. Such more-than-human futures [12] of smart cities counter efficiency-based understandings of sustainability by taking into account our relationships with other species, suggesting opportunities for the more-than-human sustainable smart city [41]. As Houston et. al. have argued, "any presumed exclusive human 'right to the city' and the biosphere is increasingly untenable" [42].

Designing for Care

In the modernist neoliberal sustainable smart city data flows seamlessly through infallible IoTs, networks and other services, creating abstract spaces of homogeneity. Citizens are alienated from each other and reduced to obedient and passive responsive nodes within a cybernetic city [25]. The entanglements of labour and people required for the maintenance and care of hybrid physical-digital systems are invisible or erased from these visions. In reality we know that technologies break down, and cities are often messy, chaotic and agonistic places where the best intentions of planners are undermined by their inhabitants. Analysing our study through a feminist technoscience lens of care surfaces ways for design to help democratise smart cities, support practices of autogestion in hybrid space, and approach environmental concerns in line with Anthropocenic thinking.

STS scholar Maria Puig de la Bellacasa describes care as "an everyday labour of maintenance that is also an ethical obligation: we must take care of things in order to remain responsible for their becomings" [63]. A feminist notion of care asks "*who* will do the work of care, as well as *how* to do it and for *whom*" [ibid]. Focusing on care asks us to consider what practices, people and concerns have been excluded, taken for granted, marginalised, neglected, erased or devalued in our matters of concern. Care is an "ethically and politically charged practice, one that has been at the forefront of feminist concern with devalued labours" [ibid]. If our matter of concern is sustainable smart cities then designing for care participates in the right to the city by restructuring power relations through a "speculative commitment to neglected things" [ibid]. Bringing marginalised things to the fore generates "possibilities for other ways of relating and living" [ibid] in hybrid urban space beyond those dictated by the hegemonic powers of state and capital.

Urban agricultural communities are neglected sites within neoliberal cities but are sites in which groups of people show great care. Throughout our engagement process participants spoke of the slow practices of caring for soil, for other species, other people, and for the Earth, in time with the seasons and the weather, and with an awareness of a changing climate. These practices of care reveal

marginalised timescales, or "care-time" [64], and counter the efficiency-led timescales of both neoliberal sustainable smart cities and the global industrial food systems which, through technoscientific innovations, have intensified the rhythms of agricultural production, resulting in degraded soils, polluted waterways, and loss of biodiversity, ultimately threatening food security [57]. As one seed guardian said: "*Modern agriculture came in and slightly devastated all traditional farming methods. The concept of saving seed went out the window. I've gone back to more organic production and traditional farming and gardening methods*" (Kate, seed guardian). The care-full gardening practiced by our participants are acts of spatial autogestion because they prioritise the lived experiences of space in everyday life, and by demonstrating a commitment to the land and an ability to manage and care for it effectively [66] they appropriate space for its use value over its exchange value. The seed library, the IoT sensors and their data function as a proposition to challenge the "predominant timescales of technoscientific futurity and their reductive notion of innovation" [64] inherent in neoliberal sustainable smart city visions.

The visions of the global food industry are typically abstracted and alienated from the lives on which our food depends – typically a devalued migrant labour force, and other species – as well as the soil in which it is grown, and the contingencies of climate. Designing for care asks us to pay attention to marginalised labour practices and the bodies that perform them. For example, the seed library makes available the seeds of the kodu plant along with the expert knowledge required to grow it successfully in London (see Figure 4). Lutfun, a seed guardian, tells you how, in Bangladesh, the flower is pollinated by a moth at night. In London, the kodu plant must be hand-pollinated in the evening when the male flower is open. Without this knowledge or work the kodu won't produce any gourds nor seeds, so the presence of seeds in the library signifies that this labour has been performed successfully. By sharing the seeds along with the "*expertise of the migrant community*" (Richard, seed guardian) to ensure the proliferation of community growing practices, the seed library participates in spatial autogestion by restructuring power relations, and making evident the embodied, specific and situated practices of care and labour that are required for multispecies flourishing in hybrid digital-physical space.



Figure 4. The seed library provides the seeds, images, and advice on how to hand pollinate the kodu flower at night.

Designing for care in the sustainable smart city requires that we ask who benefits from our acts of care, resonating with other HCI design work concerned with questions over who benefits from the sustainable smart city [25,41,53]. Rather than putting a networked sensor in the soil to extract data for increased productivity and efficiency, as happens when motivated by a capitalogenic [59] perception of soil as a “receptacle for crops” [64], in our project the sensors engage with soil “as a living community” [ibid]. The soil sensor data taken together with the human stories tell of mutually beneficial human-soil relations [ibid] that progress over time. For example, one guardian reflected that the value of the sensor data was in its validation of his climate-adaptive gardening practices that involved nourishing the soil through mulching, without accessing mains water: *“It is nice to have those numbers there, to consolidate your feeling that it doesn’t need watering”* (Richard, seed guardian). The soil cares back in return, by supporting the growth of plants that we eat, but also through supporting our health [54]. As one guardian, a counsellor working with immigrant communities who have endured torture said: *“Working in the soil, with soil, these things can change moods easily”* (Ahmet, seed guardian). Designing for care participates in the right to the smart city by foregrounding the community users, over capitalist utilisers [47], where the community also includes non-human elements such as soil and other species.

If networked devices, infrastructures, and their data are matters of concern in the sustainable smart city, then turning them into matters of care has implications for design because designing for care is “an aesthetic and political move in the way of re-presenting things that problematises the neglect of caring relationalities in an assemblage” [63] and therefore suggests strategies for reappropriation from capitalism and the state. In the neoliberal visions these elements are presented as abstract homogenous things that get put out into the world, they function seamlessly, and never require our engagement. Lucy Suchman talks of the disappearance of ‘the human labour’ involved ‘in technological production, implementation [and] maintenance’ in her study of smart interfaces in software assistant technology [72]. Our study highlights the entangled labour, bodies, objects, spaces, and practices required to maintain the smart city. To illustrate, batteries failed, one sensor unit was stolen, 3G network was intermittent, and both researchers and growers found the sensor data to be limited because it was difficult to reduce the successful growth of plants to a few values such as temperature and moisture. We had to replace, monitor, safeguard, and repair units and their batteries, which sometimes required negotiating access with inhabitants or climbing over fences – all providing opportunities for further engagement and encounter. The data required “cleaning” (with its domestic connotation), visualization and interpretation – no trivial matter. Designing for care through a feminist technoscience lens demands that we pay

attention to and engage with marginalised practices and things from which we are alienated in the neoliberal smart city with their glossy images of seamless data and infallible tech. Yet these devalued labours are crucial for spatial autogestion in the smart city. In order to self-govern hybrid space citizens will need new technical skills, competencies and practices such as data management care [5] and literacy [74] in order for them to be able to care for and manage smart cities infrastructures and devices. Designers who want to participate in the right to the sustainable smart city must take these attentions to care seriously or they risk perpetuating or intensifying inequalities and exclusions.

Designing for the Commons

Our study contributes to efforts within HCI to build a digital urban commons [22,24,61] as a way of strengthening the acts of spatial autogestion and staking a claim in the right to the sustainable smart city.

Urban agriculture prioritises the collective needs of inhabitants (human and otherwise) over individual property rights. In the community growing sites involved in our project urban resources include land, seeds, soil, worms, water, compost and tools, as well as the expert knowledge and labour required to grow plants successfully. These resources tend to be collectively managed for the benefit of the “community users” [47], rather than for profit for the “capitalist utilisers” [ibid] which, in the neoliberal global industrial food system, are large multinationals. Rather than seeing seed as a commodity whose value is produced through exchange, the seed library gives each seed the ability to participate in the urban commons. It has a unique and important role entangled with stories of life, death, culture, migration, land, climate, power and politics. As one seed guardian said, *“Over the years lots of seed varieties and heirloom seeds have been lost in favour of commercially grown crops. So, for me seed sovereignty is about taking the control back and being able to collect our own seeds and being able to carry on doing practices that farmers have been doing for a long time all over the world”* (Nat, seed guardian). Our co-design activities and artefacts demonstrate that citymaking can be reappropriated from neoliberalism’s attempts to enclose the city’s resources by strengthening the acts of spatial autogestion through the sharing and planting of seeds and their stories and data in a process of commoning. As one guardian explained: *“You know, seeds, food, water, the air that we breath, they’re all basic human rights, and I think business needs to back off... Why do we get sucked into that whole commercialism, you get the glossy seed catalogue and January, February time you’re poring over it and planning, and we should just be sharing what we’ve grown...[The seed library] is just that nudge”* (Debbie, seed guardian). By making the physical seeds, their accompanying digital stories and environmental data, available to all, the library supports the collective cultivation and management of urban land, contributes to the hybrid commons and stakes a claim in the right to the

smart city. We envisage that this collective ownership of the commons could be strengthened further through a hybrid digital/physical network of seed libraries that serve different communities and locations, to address scale [20], while at the same time being sensitive to local socio-ecological contexts.

Indeed, if we want to extend and scale the urban commons, we would argue that celebratory and social interactions, and dissemination activities (e.g. website, book, documentary film, exhibition, and launch event in our project) are crucial for the proliferation of ideas. We urge design researchers to put such activities at the centre and not leave them as an afterthought. As one seed guardian explained: *"[the seed library and celebration] has created something that lasts beyond the project itself, to share with other people.... Although there was a fairly small group of us who took part, the impact of it is much wider and can continue to be shared... that shows the ongoing knock-on impact of bringing people together to celebrate something. It brought in other people who also wanted to be part of it without having to be directly participating in the main bit of the project itself. So I think that's really powerful"* (Nat). This knock-on effect is evidenced by the following: members from a different seed-saving group who were inspired by our project, went on to successfully apply for funding for a youth project around seeds and make their own interactive seed library.

The commons bears a collective responsibility for its ownership and management, or it risks suffering from "the tragedy of the commons", or depletion [33]. As one seed guardian said, *"You can't just have a seed library and then it be done. You've got to keep it running: so, who's going to grow this seed this year, so that we can have fresh seed next year, and it's from this location. All of that is really important"* (Kate, seed guardian). Designing for the commons entails a consideration of how it will be maintained, which will require *"expanding the network and making [the seed library] a place that everyone feels they can go to. And also, food security, you know it's getting hotter, [food is] more expensive already. We've all got to work harder in our communities, about making food growing and sharing of food more viable"* (Kate, seed guardian). This echoes perspectives from the Anthropocene literature by acknowledging the entanglements of the commons, care, and biocultural diversity in collectively managing the natural resources of our planet. Such acts of maintenance contribute to the never ending struggle for spatial autogestion [66]. As we look to a future commons, we can also reflect on how the construction of a particular site for commoning in the seed library is messy, involves work and maintenance of digital and social connections. We shouldn't accept only a romanticised version of what it means to belong together, just as we should not accept a monolithic vision of the optimised smart city. The reality of the commons is more nuanced, pragmatic, and emergent than these two idealised positions.

Our project also contributed to the digital urban commons by using open-source hardware and software, which is available for others to download and use [45]. The data too, both from the sensor data and the digital stories and images, are available from the project website. By using specific and locally owned, generated and maintained technical systems, the project strives for digital sovereignty and counters the abstract digital spaces and proprietary infrastructures of neoliberal smart cities [2]. Likewise, however, as discussed in the subsection on *Designing for Care*, citizens will need technical skills and data literacy [31,74] in order to own and self-govern the digital commons, for which the study raises issues of barriers to participation and access. There was limited engagement from guardians and other participants with the sensor data. Typically, it is designers and other "experts" who decide how the knowledge is generated and "who has the capacity to contribute towards addressing climate change" [70]. It is certainly not trivial to make ecological data accessible to the general public, but examples from art [43,67,70] suggest productive ways forward. In the right to the sustainable smart city citizens should make collective decisions on how to manage digital space, and the rights of all inhabitants to participate in managing the urban digital commons must be considered, not just a private elite [24].

CONCLUSION

Within HCI we are starting to see alternatives to the visions of top-down, managerial, efficiency-led sustainable smart cities. Design research that seeks to increase citizens' participation, access, governance and bottom-up understandings of sustainability in smart cities are working towards democratising hybrid space and reappropriating the production of space from neoliberalism. In this paper we contribute to these efforts by introducing the notion of spatial autogestion in hybrid digital-physical space and perspectives on the Anthropocene as ways to think about the 'right to the sustainable smart city' beyond efficiency. We contributed a discussion of a case study in this space that involved co-designing networked sensors and a Connected Seeds Library with urban agricultural communities. We contributed a conceptual repositioning of smart cities and the ways in which they participate in the right to the city through designing for biocultural diversity, care, and the commons, as illustrated with insights and perspectives from participants. We offer these contributions to sustainable HCI, civic IoT and citizen-centred smart cities research by expanding the design space beyond efficiency-led, modernist, and authoritarian approaches, in order to envision what else a sustainable smart city could be when inhabitants manage urban space for themselves in socially inclusive and environmentally just ways.

Most often design is understood as disconnected from the politics of consumption [20]. But as designers we make choices about where we put our time and energy. Design-

led HCI research cannot separate itself from politics even if it wishes to, because it doesn't exist in a political vacuum. It is informed by the cultural narratives we tell ourselves – of natural resources being unlimited, of human exceptionalism, of “Cheap Food” and “Cheap Nature” [59], of technological progress, of the unstoppable nature of neoliberal capitalism, and of the incompatibility of agriculture with urban space. The current global economic, humanitarian, and environmental crises demand a change in these cultural narratives [8,16]. As argued by Light et al. [50], it can no longer be business as usual in HCI. We must take the Anthropocene, and Capitalocene, seriously.

Rather than focus on the hegemonic structures of power, or retreat into one or other of the twin illusions of technoprogress or fatalism [32], the right to the city urges designers to participate in the struggle by identifying sites where spatial autogestion is already taking place, strengthening and amplifying it through design practice, and narrating and sharing the process through design research, thereby helping the resistance to grow and proliferate. By working with such sites, we can observe changes in cultural and political narratives in action. We recognise that grassroots urban agricultural communities, and other communities where the struggle for the right to the city is ongoing, are not separate from the neoliberal capitalist system within which they function and therefore they still participate in it. But because of their values, and the inclusive practices in care time and space, which help strengthen the links between collective action, participation and environmental citizenship, they present a site where such shifts can begin to occur.

The challenge for design is to dismantle exceptionalist ways of thinking of cities and raise provocative questions, dilemmas and possibilities for diverse human and nonhuman actors to cohabit, coproduce, and co-manage the urban commons, in ways that are respectful of difference and in timescales that are more nourishing of our relations and our Earth. Design has an important role to play in supporting and strengthening these shifts in the hybrid smart city.

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REFERENCES

- [1] Samuel Alexander. 2015. *Prosperous descent: Crisis as opportunity in an age of limits*. Simplicity Institute.
- [2] Panayotis Antoniadis, Ileana Apostol, Mark Gaved, Michael Smyth, and Andreas Unteidig. 2015. DIY networking as a facilitator for interdisciplinary re-search on the hybrid city. *Hybrid Cities 2015 Data to People* (2015), 65–72.
- [3] Aline Baggio. 2005. Wireless sensor networks in precision agriculture. In *ACM Workshop on Real-World Wireless Sensor Networks (REAL WSN 2005)*, Stockholm, Sweden, 1567–1576.
- [4] Corelia Baibarac and Doina Petrescu. 2017. Co-design and urban resilience: visioning tools for commoning resilience practices. *CoDesign* 0882, December (2017), 1–19. DOI:https://doi.org/10.1080/15710882.2017.1399145
- [5] Karen S Baker and Helena Karasti. 2018. Data Care and Its Politics: Designing for Local Collective Data Management As a Neglected Thing. *Proc. 15th Particip. Des. Conf. Full Pap. - Vol. 1* (2018), 10:1--10:12. DOI:https://doi.org/10.1145/3210586.3210587
- [6] Mara Balestrini, Yvonne Rogers, Carolyn Hassan, Javi Creus, Martha King, and Paul Marshall. 2017. A City in Common: A Framework to Orchestrate Large-scale Citizen Engagement Around Urban Issues. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*, 2282–2294. DOI:https://doi.org/10.1145/3025453.3025915
- [7] Jeremy Brice. 2014. Killing in More-than-human Spaces: Pasteurisation, Fungi, and the Metabolic Lives of Wine. 4, (2014), 171–194.
- [8] Hronn Brynjarsdottir, Maria Håkansson, James Pierce, Eric Baumer, Carl DiSalvo, and Phoebe Sengers. 2012. Sustainably Unpersuaded: How Persuasion Narrows Our Vision of Sustainability. *Proc. 2012 ACM Annu. Conf. Hum. Factors Comput. Syst. - CHI '12* (2012), 947. DOI:https://doi.org/10.1145/2207676.2208539
- [9] Igor Calzada, Cristobal Cobo, Igor Calzada, and Cristobal Cobo. 2016. Unplugging: Deconstructing the Smart City Unplugging: Deconstructing the Smart City. 0732, January (2016). DOI:https://doi.org/10.1080/10630732.2014.971535
- [10] Kelsey Campbell-Dollaghan. 2017. Stores Are Not Town Squares. Retrieved September 17, 2017 from https://www.fastcodesign.com/90139799/stores-are-not-town-squares
- [11] Martin Caraher, S Lloyd, and T Madelin. 2009. *Cheap as chicken: fast food outlets in Tower Hamlets (report no 2)*.
- [12] Rachel Clarke, Sara Heitlinger, Marcus Foth, Carl Disalvo, Ann Light, and Laura Forlano. 2018. More-than-Human Urban Futures: Speculative Participatory Design to Avoid Ecocidal Smart Cities. (2018), 18–21.
- [13] Tristan Cork. 2017. Street lights on Bristol to Bath cycle path switched off so glow worms can find love. Retrieved September 18, 2017 from http://www.bristolpost.co.uk/news/local-news/street-lights-bristol-bath-cycle-182389
- [14] Aidan Davison. 2015. Beyond the mirrored horizon: modern ontology and amodern possibilities in the Anthropocene. *Geogr. Res.* 53, 3 (2015), 298–305.
- [15] Carl DiSalvo. 2017. What Else Might a Smart City Be? In *Connected Seeds*, Sara Heitlinger (ed.). Queen Mary University of London, 24–25. Retrieved from http://www.connectedseeds.org/about/what-else-might-a-smart-city-be
- [16] Carl Disalvo, Kirsten Boehner, and Nicholas A Knouf. 2009. Nourishing the ground for sustainable HCI: Considerations from ecologically engaged art. *Proc. 27th Int. Conf. Hum. Factors Comput. Syst. (CHI '09)* (2009), 385–394. DOI:https://doi.org/http://doi.acm.org/10.1145/1518701.1518763
- [17] Carl Disalvo and Tom Jenkins. 2017. Fruit Are Heavy: A Prototype Public IoT System to Support Urban Foraging. (2017), 541–553.
- [18] Carl Disalvo, Thomas Lodato, Jonathan Lukens, and Tanyoung Kim. 2014. Making Public Things: How HCI Design Can Express Matters of Concern. (2014), 2397–2406.
- [19] Carl DiSalvo and Jonathan Lukens. 2011. Nonanthropocentrism and the nonhuman in design: possibilities for designing new forms of engagement with and through technology. In *From social butterfly to engaged citizen: urban informatics, social media, ubiquitous computing, and mobile technology to support citizen engagement*. 440–460.
- [20] Paul Dourish. 2010. HCI and environmental sustainability: the politics of design and the design of politics. *Proc. 8th ACM Conf. Des. Interact. Syst. - ACM.* (2010), 1–10. DOI:https://doi.org/10.1145/1858171.1858173
- [21] Laura Forlano. 2016. Decentering the Human in the Design of

- Collaborative Cities. 32, 3 (2016). DOI:https://doi.org/10.1162/DESI
- [22] Sheila Foster and Christian Iaione. 2017. Ostrom in the City: Design Principles for the Urban Commons. (2017), 1–24. Retrieved from <https://www.thenatureofcities.com/2017/08/20/ostrom-city-design-principles-urban-commons/>
- [23] Marcus Foth, Martin Brynskov, and Timo Ojala. 2015. *Citizen's right to the digital city: urban interfaces, activism, and placemaking*. Springer.
- [24] David Franquesa and Leandro Navarro. 2017. Sustainability and participation in the digital commons. *interactions* 24, 3 (2017), 66–69.
- [25] Jennifer Gabrys. 2014. Programming environments: environmentality and citizen sensing in the smart city. 32, (2014), 30–48. DOI:https://doi.org/10.1068/d16812
- [26] Jennifer Gabrys, Helen Pritchard, and Benjamin Barratt. 2016. Just good enough data: Figuring data citizenships through air pollution sensing and data stories. *Big Data Soc.* 3, 2 (2016), 205395171667967. DOI:https://doi.org/10.1177/2053951716679677
- [27] Filippo Gandino, Bartolomeo Montrucchio, Maurizio Rebaudengo, and Erwing R Sanchez. 2009. On improving automation by integrating RFID in the traceability management of the agri-food sector. *IEEE Trans. Ind. Electron.* 56, 7 (2009), 2357–2365.
- [28] Antonio-Javier Garcia-Sanchez, Felipe Garcia-Sanchez, and Joan Garcia-Haro. 2011. Wireless sensor network deployment for integrating video-surveillance and data-monitoring in precision agriculture over distributed crops. *Comput. Electron. Agric.* 75, 2 (2011), 288–303. DOI:https://doi.org/https://doi.org/10.1016/j.compag.2010.12.005
- [29] Bill Gaver, Tony Dunne, and Elena Pacenti. 1999. Design: Cultural probes. *Interactions* 6, 1 (1999), 21–29. DOI:https://doi.org/10.1145/291224.291235
- [30] Franklin Ginn, Uli Beisel, and Maan Barua. 2014. Flourishing with awkward creatures: Togetherness, vulnerability, killing. *Environ. Humanit.* 4, 1 (2014), 113–123.
- [31] Jonathan Gray, Carolin Gerlitz, and Liliana Bounegru. 2018. Data infrastructure literacy. *Big Data Soc.* 5, 2 (2018), 205395171878631. DOI:https://doi.org/10.1177/2053951718786316
- [32] Donna J Haraway. 2016. *Staying with the trouble: Making kin in the Chthulucene*. Duke University Press.
- [33] Garrett Hardin. 1968. The Tragedy of the Commons. *Science* (80-). 162, 3859 (1968), 1243–1248. DOI:https://doi.org/10.1126/science.162.3859.1243
- [34] David Harvey. 2003. The right to the city. *International Journal of Urban and Regional Research* 27, 2 ST-The right to the city.
- [35] Sara Heitlinger. 2016. Talking Plants and a Bug Hotel: Participatory Design of ludic encounters with an urban farming community. Queen Mary University of London. Retrieved from <https://qmro.qmul.ac.uk/xmlui/handle/123456789/18381>
- [36] Sara Heitlinger (Ed.). 2017. *Connected Seeds*. Queen Mary University of London. Retrieved from http://www.connectedseeds.org/wp-content/uploads/2017/02/Connected-Seeds-Book_Low-res.pdf
- [37] Sara Heitlinger and Nick Bryan-Kinns. 2013. Understanding performative behaviour within content-rich Digital Live Art. *Digit. Creat.* 24, 2 (June 2013), 111–118. DOI:https://doi.org/10.1080/14626268.2013.808962
- [38] Sara Heitlinger, Nick Bryan-Kinns, and Rob Comber. 2018. Connected Seeds and Sensors: Co-designing Internet of Things for Sustainable Smart Cities with urban food-growing communities. In *Participatory Design Conference (PDC'18)*.
- [39] Sara Heitlinger, Nick Bryan-Kinns, and Janis Jefferies. 2013. Sustainable HCI for grassroots urban food-growing communities. In *Proceedings of the 25th Australian Computer-Human Interaction Conference: Augmentation, Application, Innovation, Collaboration*, 255–264.
- [40] Sara Heitlinger, Nick Bryan-Kinns, and Janis Jefferies. 2014. The talking plants: an interactive system for grassroots urban food-growing communities. In *CHI'14 Extended Abstracts on Human Factors in Computing Systems*, 459–462.
- [41] Sara Heitlinger, Marcus Foth, Rachel Clarke, Carl DiSalvo, Ann Light, and Laura Forlano. 2018. Avoiding Ecocidal Smart Cities: Participatory Design for More-than-human Futures. In *Proceedings of the 15th Participatory Design Conference: Short Papers, Situated Actions, Workshops and Tutorial - Volume 2 (PDC '18)*, 51:1--51:3. DOI:https://doi.org/10.1145/3210604.3210619
- [42] Donna Houston, Diana Maccallum, Wendy Steele, and Jason Byrne. 2017. Make kin , not cities! Multispecies entanglements and ' becoming-world ' in planning theory. (2017). DOI:https://doi.org/10.1177/1473095216688042
- [43] Rachel Jacobs, Steve Benford, Mark Selby, Michael Golembewski, Dominic Price, and Gabriella Giannachi. 2013. A Conversation Between Trees: What Data Feels Like in the Forest. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*, 129–138. DOI:https://doi.org/10.1145/2470654.2470673
- [44] Yoshifuyu Karakasa, Hirohiko Suwa, and Toshimizu Ohta. 2007. Evaluating Effects of RFID Introduction Based on CO2 Reduction. In *Proceedings of the 51st Annual Meeting of the ISSS-2007, Tokyo, Japan*.
- [45] Nanda Khaorapapong. 2016. Connected Seeds sensors. Retrieved September 17, 2017 from <https://github.com/haddadi/cs-sensor-unit>
- [46] Bran Knowles, Lynne Blair, Mike Hazas, and Stuart Walker. 2013. Exploring Sustainability Research in Computing: Where We Are and Where We Go Next. In *Proceedings of the 2013 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '13)*, 305–314. DOI:https://doi.org/10.1145/2493432.2493474
- [47] Henri Lefebvre. 1991. *The production of space*. Oxford Blackwell.
- [48] Henri Lefebvre. 1996. The right to the city. *Writings on cities* 63181, (1996).
- [49] Henri Lefebvre. 2009. *State, space, world: Selected essays*. U of Minnesota Press.
- [50] Ann Light, Irina Shklovski, and Alison Powell. 2017. Design for Existential Crisis. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, 722–734.
- [51] Donna Lipowitz. 2017. Connected Seeds film. Retrieved February 5, 2018 from <http://www.connectedseeds.org/connected-seeds-film>
- [52] Jen Liu, Daragh Byrne, and Laura Devendorf. 2018. Design for Collaborative Survival: An Inquiry into Human-Fungi Relationships. *Proc. CHI* (2018), 1–13. DOI:https://doi.org/10.1145/3173574.3173614
- [53] Thomas Lodato and Carl DiSalvo. 2018. Institutional Constraints: The Forms and Limits of Participatory Design in the Public Realm. In *Proceedings of the 15th Participatory Design Conference: Full Papers - Volume 1 (PDC '18)*, 5:1--5:12. DOI:https://doi.org/10.1145/3210586.3210595
- [54] C A Lowry, J H Hollis, A de Vries, B Pan, L R Brunet, J R F Hunt, J F R Paton, E van Kampen, D M Knight, A K Evans, G A W Rook, and S L Lightman. 2007. Identification of an immune-responsive mesolimbocortical serotonergic system: Potential role in regulation of emotional behavior. *Neuroscience* 146, 2 (2007), 756–772. DOI:https://doi.org/https://doi.org/10.1016/j.neuroscience.2007.01.067
- [55] Anna Luusua and Johanna Ylipulli. 2017. Nonanthropocentric design and smart cities in the anthropocene. 59, 6 (2017), 295–304.
- [56] Luisa Maffi and Ellen Woodley. 2012. *Biocultural diversity conservation: a global sourcebook*. Routledge.
- [57] John McDonagh. 2014. Rural geography II: Discourses of food and sustainable rural futures. *Prog. Hum. Geogr.* 38, 6 (2014), 838–844.
- [58] Anna Minton. 2012. *Ground Control: Fear and happiness in the twenty-first-century city*. Penguin UK.
- [59] Jason W Moore. 2017. The Capitalocene, Part I: on the nature and origins of our ecological crisis. *J. Peasant Stud.* 44, 3 (2017), 594–

630. DOI:<https://doi.org/10.1080/03066150.2016.1235036>
- [60] Paul D Mullins. 2017. The Ubiquitous-Eco-City of Songdo: An Urban Systems Perspective on South Korea's Green City Approach. 2, 2 (2017), 4–12. DOI:<https://doi.org/10.17645/up.v2i2.933>
- [61] Elinor Ostrom. 2015. *Governing the commons*. Cambridge university press.
- [62] Val Plumwood. 2010. Nature in the active voice. *Clim. Chang. Philos. Transform. possibilities* (2010), 32–47.
- [63] Maria Puig de la Bellacasa. 2011. Matters of care in technoscience: Assembling neglected things. *Soc. Stud. Sci.* 41, 1 (2011), 85–106.
- [64] Maria Puig de la Bellacasa. 2015. Making time for soil: Technoscientific futurity and the pace of care. *Soc. Stud. Sci.* 45, 5 (2015), 691–716. DOI:<https://doi.org/10.1177/0306312715599851>
- [65] Mark Purcell. 2002. Excavating Lefebvre: The right to the city and its urban politics of the inhabitant. *GeoJournal* 58, 2/3 (2002), 99–108. DOI:<https://doi.org/10.1023/B:GEJO.0000010829.62237.8f>
- [66] Mark Purcell and Shannon K Tyman. 2017. Cultivating food as a right to the city. 9839, July (2017). DOI:<https://doi.org/10.1080/13549839.2014.903236>
- [67] Alexandra Regan Toland. 2016. Dust Blooms. Retrieved September 19, 2017 from <https://artoland.wordpress.com/2016/06/28/dust-blooms/>
- [68] Anna Seravalli. 2018. Infrastructuring Urban Commons over Time: Learnings from Two Cases. (2018), 1–11.
- [69] Jack Shenker. 2017. Revealed: the insidious creep of pseudo-public space in London. *The Guardian*. Retrieved August 31, 2018 from <https://www.theguardian.com/cities/2017/jul/24/revealed-pseudo-public-space-pops-london-investigation-map>
- [70] Nancy Smith, Shaowen Bardzell, and Jeffrey Bardzell. 2017. Designing for Cohabitation: Naturecultures, Hybrids, and Decentering the Human in Design. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '17), 1714–1725. DOI:<https://doi.org/10.1145/3025453.3025948>
- [71] Yolande Strengers. 2014. Smart Energy in Everyday Life: Are you Designing for Resource Man? *Interactions* 21, 4 (2014), 24–31. DOI:<https://doi.org/10.1145/2621931>
- [72] Lucy Suchman. 2007. *Human-machine reconfigurations: Plans and situated actions*. Cambridge University Press.
- [73] Alex S Taylor. 2017. What Lines, Rats, and Sheep Can Tell Us. *Des. Issues* 33, 111 (2017), 54–65. DOI:<https://doi.org/10.1162/DESI>
- [74] Annika Wolff, Daniel Gooch, Jose J Caverio Montaner, Umar Rashid, and Gerd Kortuem. 2016. Creating an Understanding of Data Literacy for a Data-driven Society Creating an Understanding of Data Literacy for a Data-driven Society. *J. Community Informatics* 12, 3 (2016).
- [75] Campaign for Seed-Sovereignty. Retrieved September 18, 2017 from <http://www.seed-sovereignty.org/EN/>
- [76] Connected Seeds Celebration. Retrieved February 5, 2018 from <http://www.connectedseeds.org/celebration-seeds-launch-event-part-1>
- [77] 2013. Household income in Tower Hamlets. Retrieved September 18, 2017 from https://www.towerhamlets.gov.uk/Documents/Borough_statistics/Income_poverty_and_welfare/Research-Briefing-2013-04-Household-Income-final.pdf
- [78] 2016. Poverty in your area 2016. Retrieved from <http://www.endchildpoverty.org.uk/poverty-in-your-area-2016/>
- [79] 2017. Connected Seeds Exhibition.
- [80] 2017. Connected Seeds visualisation. Retrieved September 18, 2017 from <http://www.connectedseeds.org/data-visualisation/>