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More-than-Human Computer Interaction for Urban Food Governance

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Abstract

Digital technologies such as sensors, blockchain and artificial intelligence are increasingly being used in global food production and consumption, including in urban contexts through the notion of the “smart city”. Food governance is addressed through logics of efficiency in supply chains, increasing profits for shareholders of large companies, but doing little to address unsustainable social and environmental inequalities. Human computer interaction (HCI) designers and researchers are increasingly interested in algorithmic governance of smart cities, raising concerns around issues of control, agency, access, and benefit. Against these concerns, some HCI researchers have also started to question a human-centred perspective to designing socio-technical systems, drawing on *more-than-human* perspectives to consider the interrelations and interdependencies between human and non-human others within the food web. In this chapter, we draw these emerging perspectives within HCI together to consider the ways in which new technologies such as blockchain can be used in urban food governance. We present a case study of co-designing futures of algorithmic food governance with grassroots urban communities that account for multispecies actors, labours, and relationships. The project surfaces new possibilities for computation to intervene in urban food governance in ways that are more sustainable and fair.

1. Introduction

Networked sensing devices, cloud computing, mobile phone technology, and more recently artificial intelligence (AI) and blockchain (the technology underpinning cryptocurrencies such as Bitcoin), are increasingly entering all aspects of people’s lives. These technologies are transforming industrial global food production and consumption into a data-driven business, at the expense of ensuring social and ecological justice, wellbeing and security. Within urban contexts, computation has been central to creating visions of “eco-smart cities”, where food governance is typically addressed through logics of efficiency and optimisation in supply chains, waste management, and the consumer experience (e.g. through shopping or eating experiences). Set against such visions of efficiency, governance is delegated to networked infrastructures, including algorithms and big data, which are intended to produce profit and carbon optimisations through real-time data gathering, analysis and control (Gabrys, 2014). For example, the measurement, mapping and sensing of soil and crops have been used to maintain and maximise yields, and algorithms have become central to logistics, helping to reduce crop losses and optimise supply chains that distribute food. Computational and algorithmic systems have also become central features of future visions for urban food production.

The digital technologies at the centre of these global transformations are being harnessed to optimise and centralise agricultural production, as well as provide urban consumers data about food provenance and safety at a price beyond the reach of most people (Wang, 2020). They are shaping access, control, participation and benefit, across all domains of life including social, economic, political, and health for both humans and non-humans. Built and maintained by the dominant capitalist, colonial, human-centred, and patriarchal paradigms (Costanza-Chock, 2020; Zuboff, 2019), they are amplifying existing inequalities, and provide a very narrow, human-centred perspective of how urban food governance could be mediated

by technology. Technology here does little to address government, societal or environmental problems that are tied up in the ways in which food is produced and consumed, such as food insecurity, mass crop species decline, or degradation of arable soils. The benefits remain in the hands of an elite few including major shareholders of on-demand restaurant delivery companies, large supermarkets, and food brands, as well as big tech companies harvesting the data.

A technocentric, human-centred and consumer-focused solutionism (Morozov, 2013) emphasises overly simple and reductive logics for addressing the challenges of sustainability within urban food systems. Within such logics, citizens' ability to participate in food governance is reduced to either individual consumer choices, or contributing as passive nodes in a network of optimisation and efficiency (Gabrys, 2014). Additionally, scholars have identified significant barriers to access and participation with these complex technologies that inhibit work on widening civic engagement with them, because questioning how these technologies are or should be designed and deployed, and for whose benefit, requires a high level of technological literacy (Wolff, Gooch, Cavero Montaner, Rashid, & Kortuem, 2016), in addition to civic, environmental, and food literacies. Rather than technology providing a solution to the problems of food governance around access, control, and participation in decision-making processes, it has amplified social and environmental inequalities. Furthermore, governance is retained by a limited number of actors, wielding much of the power for their own benefits.

It is against these issues and concerns that we seek in this chapter to move beyond a human-centred, efficiency-focused approach to what we think of algorithmic urban food governance and ask: How might we widen participation in decision-making processes around urban food production and consumption? How might emerging technologies enhance, or hinder, issues around food governance including access, control, and accounting within urban food systems? And how might we envisage algorithmically-mediated urban food governance of the future that is more sustainable and just?

To answer these questions, this chapter draws on and ties together a number of emerging strands of Human-Computer Interaction (HCI) research, a multidisciplinary field of research that seeks to understand the ways in which computation affects the lives of its (typically) human users. We build on recent HCI work that looks at the role of digital technologies, and in particular blockchain, to support more democratic governance of urban systems through the urban commons (Antoniadis, Apostol, Gaved, Smyth, & Unteidig, 2015; Baibarac & Petrescu, 2017; Balestrini et al., 2017; Parra-Agudelo, Choi, Foth, & Estrada, 2018). We also draw on recent work in HCI that has started to move beyond human-centred design, to consider the ways in which the *more-than-human* (including seeds, birds, trees and soil, but also non-living actors such as sensors and infrastructures) cohabit urban space (Clarke et al., 2019; Smith, Bardzell, & Bardzell, 2017), and are interdependent in food systems (Dolejšová, Wilde, Altarriba Bertran, & Davis, 2020). We build on HCI design research into inclusive and speculative methods for engaging marginalised participants in co-designing for urban futures with emerging technologies (Nissen et al., 2018; Pschetz, Pothong, & Speed, 2019; Rankin et al., 2020). We draw these strands together by presenting a co-design research project that set out to question the role of blockchain technologies in food futures over three workshops at an urban farm in London, UK. As a case study, the project provides a means of exploring futures of algorithmic food governance that are more sustainable and just.

We begin the chapter with an overview of how blockchain is being used currently in food governance, highlighting emerging work around multispecies governance. We then present the case study detailing the speculative and participatory engagements with diverse participants over three workshops. We conclude with reflections on how the workshops

created the conditions for considering more-than-human relations, and how they surfaced speculative futures that challenge a human-centred, efficiency-focussed perspective of urban food governance, through a collective articulation of designing for more-than-human food futures, care, and the commons.

2. Blockchain and food governance

Blockchain is a general purpose technology that offers the potential to create new types of decentralised autonomous organisations (called DAOs) and non-extractive value exchange. Blockchain facets such as tokenisation (a process by which something of value is represented by a digital token to be used in a blockchain platform) and smart-contracts (pieces of code that run autonomously when certain conditions are met) provide affordances to help manage resources more fairly and transparently. For example, they allow for contributions of diverse actors to be identified and tracked within an economic system, without the need for a central authority, and they provide mechanisms for transparent voting and decision-making. For these reasons blockchain is increasingly viewed as a governance technology, including for self-organising and commons-based communities and collectives (Pazaitis, De Filippi, & Kostakis, 2017; Rozas, Tenorio-Fornés, Diaz-Molina, & Hassan, 2018). Blockchain also offers the potential for embedding the interests of non-humans into urban systems and infrastructures (Elsden, Gloerich, Spaa, Vines, & de Waal, 2019), providing the mechanisms for multispecies and "algorithmic creatures" (Hee-jeong Choi, Forlano, & Kera, 2020) to become agents within governance systems.

The global blockchain market has expanded from a technology used primarily in financial systems to one that has entered many different industries and application areas. This includes food systems, where it is being used to increase food traceability, safety and provenance, and in inventory management in supply chains (Feng Tian, 2016). For example, BeefLedger (Foth, 2017) is a blockchain product being developed for traceability of beef products from Australia to China, where there are consumer doubts over the product's authenticity; UK company Provenance has created a blockchain-based platform for increasing transparency, traceability and certifiability along food supply chains for both producers and consumers (Provenance, 2015); AgriBlockIoT (Caro, Ali, Vecchio, & Giaffreda, 2018) uses Internet of Things (e.g. networked sensing), AI and blockchain to automate data recording, verification and execution of processes within industrial agricultural systems (Lin, Shen, Zhang, & Chai, 2018). In these examples, food governance is reduced to a logic of efficiency that seeks to optimise and centralise agricultural production. Rather than improving food access and security for communities, or repairing the ecological destruction caused by food systems, in these visions, algorithmic governance helps concentrate benefit and control in the hands of an elite few (Wang, 2020).

Elsewhere, blockchain is being developed for restorative and regenerative agriculture and more sustainable economies. For example, Regen Network ("Regen Network," n.d.), Nori ("Nori," n.d.) and GainForest (Dao et al., 2019) are three blockchain-based platforms that incentivise regenerative land use, carbon capture in soil, and the reversal of destructive land use practices that contribute to CO^2 emissions such as clearing forests for monocultural crop production. Investors can pledge money to farmers, indigenous communities, and enterprises around the world to support their endeavours to regenerate the land. The regeneration practices are measured, monitored, and verified by algorithm-driven analysis of data from satellite images and AI, with smart contracts paying out rewards to those farmers and enterprises who meet the predetermined conditions over a set amount of time. Regardless of the intentions of the stakeholders and supporters, these examples share a deterministic or techno-optimistic view of food governance, relying on technologically-mediated digital marketplaces as a solution. They also take a human-centred perspective of

food systems, where only human stakeholders are able to participate in accounting and economic systems.

The work we are presenting as a case study in this chapter has been inspired by terra0, a critical and speculative project using blockchain that has emerged from participatory arts practice. In terra0, a forest becomes a Decentralised Autonomous Organisation (DAO) on a blockchain. The project "is a conceptualization of a self-owned forest; an ongoing art project and a self-utilising piece of land" (Seidler, Kolling, & Hampshire, 2017). When sensors report that trees have reached the level of maturity for logging, the terra0 DAO can sell its own logging rights for cryptocurrency which it spends on managing itself, eventually buying itself back from the artists. The project looks to automation not to deliver efficiencies but to give the forest autonomy and agency through the blockchain, and free it from human-centred value extraction. The project does not attempt to solve predefined or specific problems; rather it is to open a space for questioning. Blockchain provides the means for experimenting with different forms of algorithmic governance that take into account the complex ecological relations between human and more-than-human entities.

For us, the more-than-human perspective is a powerful device for thinking about how authority, agency, and values are distributed across actors and emerge through unfolding relations. Drawing on more-than-human scholars (Galloway, 2021; D. J. Haraway, 2016; Puig de la Bellacasa, 2017; Tsing, 2015) who are challenging human exceptionalism and privilege, we recognise that human survival is interwoven with that of non-human others. The analysis of indigenous epistemologies and ontologies (Lewis, Arista, Pechawis, & Kite, 2018) challenges technological reductionism with a commitment to "human flourishing", which by default requires flourishing of other-than-humans, asserting the status of all things on the earth as beings in a network of kinship relationships, and refusing their reduction to subjects of or vehicles for exploitation, extraction and depletion. More-than-human food governance, therefore, requires attending to these relations, and a recognition of the interdependencies and interconnections of more-than-human actors in the food web. In the following section, we will present a case study, Algorithmic Food Justice, a research project which aims to explore co-designing algorithmic food governance at the intersections of more-than-human perspectives, commons-based governance, and blockchain.

3. Algorithmic Food Justice: a case study

Algorithmic Food Justice was a pilot project that took place in late 2019 at Spitalfields City Farm, a 1.3 acre urban farm housed on the site of a former railway goods depot near London's financial centre, which has been running since the late 1970s. It is located in Tower Hamlets, one of the most economically deprived boroughs in the UK, characterised by high population density, large-scale immigration, ethnic diversity, poverty and income inequality among residents. The borough has the highest rate of child poverty across the UK and its population suffers from a range of food-related illnesses, including diabetes and childhood obesity. Health inequalities are further compounded by the abundance 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 (Caraher, Lloyd, & Madelin, 2009).

The site hosts varied food growing areas and community facilities such as a shared outdoor kitchen, and is home to farm animals such as rescue hens, rare-breed pigs and ducks. Most of the day-to-day labour is performed by volunteers. Food is grown all-year round in rotation, with seeds being planted to replace the food that will soon be harvested. Through its community gardens, volunteering opportunities, its various educational programmes and fresh produce sales, the farm works towards improving food access, security and sovereignty for local, marginalised communities.

The project explored co-designing more-than-human food governance futures using blockchain in 3 workshops that brought together a diverse group of participants, including community growers, community organisers, artists, researchers and technologists, who we recruited from our well-established networks. Many of the participants were familiar with our participatory approach to design from prior long-term participatory research at the farm that the first author has conducted (Heitlinger, Bryan-Kinns, & Jefferies, 2013, 2014; Heitlinger, Bryan-Kinns, & Comber, 2018). We used playful and creative activities to experiment with alternative configurations of value and to open up a space where humans and non-humans such as plants, animals and soil, as well as technologies and their infrastructures, can play a part in food governance of the future. We used mapping exercises, fictional roleplay and paper-based prototyping to create a series of visions of food futures that considered more-than-human justice, and new imaginaries for algorithmic governance. These speculative and participatory methods were used to both open up a space to explore how non-humans can play a part in food governance, as well as to better understand the affordances and implications of emerging technologies that are not yet widespread, and may be beyond participants' lived experience. We considered Spitalfields City Farm as a test case for prototyping sustainable food futures, but also drew on participants' experiences of other community gardens.

Workshop 1: Mapping the Future Farm

In the first workshop participants explored the agencies and interrelationships between multispecies members of community growing spaces. Participants drew on their expert knowledge of food growing to map human and non-human stakeholders in the city farm, now and in the future. These open-ended activities facilitated a space for experienced growers to draw on their knowledge and make visible the myriad of more-than-human entities involved in small-scale regenerative agriculture, including their needs, contributions, and roles in resource flows. Participants were asked to consider resources beyond those with a financial value, such as volunteer labour, oxygen, time, and care, and to think about who manages those resources. Discussions revolved around the often invisible but important labour of care work that happens in community gardens. Participants noted how care work was not adequately recognised or compensated, for example in funding schemes, and tended to be completely elided in industrial agricultural systems. This mode of knowledge production from the grower's perspectives produced rich materials to ground the scenarios developed for the second workshop.

Following the discussion about resources, on a large piece of paper, participants also mapped interconnections between multispecies stakeholders of the farm in the present day, and in the year 2030 (as a preparatory step for the development of Workshop Two) (Figure 1). Rather than a managerial mapping of assets, we ended up with an expansive range of heterogeneous entities including bacteria, local schools, parakeets, stag beetles and natural shade, with a heterogeneous understanding of their needs and contributions across ecological, public—and often poetic—spheres. The mapping of the present-day farm also surfaced growers' own experiences of precarity and the stress they felt navigating precarious funding regimes, which often relied on their extensive volunteer (care) labour. The map of the future farm gave us a sense of desired futures of food governance, incorporating better labour conditions and expanding ecologically sound techniques such as permaculture farming and a circular economy for materials, which were usually side projects in urban farming at present.

Workshop 2: Now London is a City Farm
While the focus of the first workshop was mapping the more-than-human actors in our food systems, in the second workshop we used a type of roleplaying game called a Live Action Role Play (LARP) as a research tool to open up a playful space to imagine and critically examine possibilities for more-than-human actors to take part in governing a future food commons.

Set in 2025, in the aftermath of a “Great Food Emergency”, the aim of the game was to transform London from an extractive financial centre into a global city farm in which all of London’s available spaces and infrastructures are turned over to creating a thriving food commons for its biodiverse inhabitants. Participants were given different roles to play within fictional scenarios and played out multispecies relationships, new economies, and radical decision-making processes for sustaining a city-wide commons. Players’ actions were informed by scenarios based on what we learned in the first workshop as well as real-world events, and current facts about food and environmental injustices, as we tried to establish new decision-making systems and urban infrastructures.

Participants came from a mix of growers, organisers, researchers, and also technologists including people familiar with blockchain concepts. They were split into 2 groups, representing 2 different decision-making bodies: one roleplayed within the Greater London City Farm Assembly (GLCFA - representing the city-wide perspective); the other roleplayed within E1 City Farm Assembly (E1CFA - representing a local community farm like Spitalfields City Farm) (Figure 2). In each assembly, participants took on representative roles from committees that included: Coordination, Health, Agriculture, Security, Culture, Justice, Resources and Waste management, Education, Energy, Infrastructure, and Liaison.

At the start of the game, each person filled in an official looking Identity Certificate from which they chose both a human character and a “companion species” (drawing on Haraway, (2008)) to represent. Companion species included: birds, insects, farm animals, honey bees, soil, plants, trees, sensors, water, air, weather. The cast of human and non-human characters were drawn from the list of stakeholders generated in Workshop 1. The players wore a badge with a picture of their chosen companion species to remind them to account for the interests of both their human and companion species (Figure 3). The game began with a ritual. Participants were asked to close their eyes, imagine their human character in one hand, their companion species in the other hand, rub their hands together until they felt heat, and then to clap. They were told that after the clap they would speak (for the duration of the game) for both their chosen human character and for their companion species.

The meeting agenda revolved around questions of membership, fair shares and conflict resolution that are also being experimentally negotiated in blockchain commons initiatives (Pazaitis et al., 2017; Teli, Lyle, & Sciannamblo, 2018; Troncoso & Utratel, 2019) and were based loosely on economist Elinor Ostrom's 8 design principles for governing the commons (Ostrom, 1999). While the agenda items were researcher-led (based on Ostrom's design principles), the scenarios were developed from "matters of care" (Puig de la Bellacasa, 2017) that arose in discussions in the first workshop. To illustrate with an example, in workshop 1 discussions arose around changes that could be made to the land to better support pollinating insects, including lower impact agriculture, organic measures, the creation of new habitats, and banning pesticides. This "matter of care" was used as a basis for a script for the second agenda point: *Review of the sharing policy* (based on Ostrom's design principle 2). The Chair (one of the authors) introduced the agenda item with the following script: "*The next item on the agenda is a review of how we're managing resources, and ensuring that everyone's contributions are rewarded. … An issue that's come up recently in the sharing policy: so the bees, as you know…have been on strike now for six months. They've stopped working.*" The Chair continued: "*How was the Justice Committee proposing to resolve the dispute between the bees and the gardeners?*" The representative from the committee called on then responded, representing both their human and companion species' interests at the same time. In this example, the justice representative replied, "*We are piloting various multispecies assemblies, which have representatives of all sorts of actors on the farm, to give equal voice to them all. But also working closely with infrastructure to meet the bees' demands. Which on the whole don't seem too wild and quite fair*." Other members from other committees would then be called on to join in the discussion, and the speculative roleplay of more-than-human governance issues unfolded from there. Developing scenarios out of the previous workshop was important as it enabled participants to see their knowledge and experience put to work in the development of a future system. These scenarios helped us to imagine our emerging food commons, and work out a system of governance that would produce and distribute food for the benefit of all species.

Participants speculated on algorithms to facilitate urban food governance of the future, including an extensive digital infrastructure of control through automated digital credits system, a food tracking app linked to a distribution centre, identity scanning on the farm gates and some (contentious) proposals to build profiles of farm members using personal data and aggregations of their social media feeds. But the proposals, which echo the intensification of today's algorithmic logics, were derailed when the EC1FA Culture representative raised the question of how these systems would apply to more-than-human members, leading to the realisation that these digital infrastructures had failed to account for more-than-human materiality or meaning. Some proposals turned towards harnessing digital technologies for interspecies communication and wellbeing for example through a "very dense network of sensors across the city, which measure the health of the urban biome…through that, we could gauge the happiness of the various species…you know [the] relationship with our species" (EC1FA culture representative). This idea moves beyond governance through control, towards interspecies relationships and balance.

Many researchers have already noted the difficulties of doing future-focussed work with more-than-human others, noting that this inevitably leads to researchers speaking on their behalf (Pitt, 2016). This issue is especially fraught when addressing how more-than-humans come to be included within human modes of governance, particularly in approaches that centre justice —for example in participatory design (Bastian, Jones, & Moore, 2016). There is a risk that humanist concepts like justice or democracy collapse when considering more-than-human ontologies. As one workshop participant asked: "Is justice an anthropocentric concept though? You couldn't expect a carnivorous animal to be just to its prey—how would you mediate between a cat which has to eat rodents and things, between its things it's feeding on?" (GLCFA resources representative).

This led to a consideration of relations of interdependence more commonly found in more-than-human ontologies, where processes rather than subjectivities are foregrounded:

> **'**If you look at soil as a model. Mostly, if you create the right conditions and the structure is right, then most organisms will exchange fairly and that usually works. And there are a few that will take and not give back, but still overall, the system works. So I think it's about ...how to create a wider system that creates the right conditions for things to work. But not always, and that's ok.' (GLCFA coordination representative)

What constitutes more-than-human *injustice* is easier to agree on than a shared concept of justice: "Driving other species into extinction is a no-no" (energy representative).

Workshop 3: Prototyping the Food Commons

The aims of the final workshop were to 1) codesign blockchain-based conceptual prototypes for governing a more-than-human food commons and 2) critically stress-test these prototypes to better understand the implications for algorithmic food governance including what could go wrong.

In the morning session participants with experience of blockchain governance and local currencies created conceptual prototypes for new types of organisations to manage the more-than-human food commons. Participants were given a selection of 8 scenarios, developed out of the previous workshops, on which to build new blockchain-based distributed autonomous organisations (DAOs) and automated decision-making (through pieces of code called smart contracts). Each scenario highlighted conflicted and entangled relations between humans, other species and planetary systems. Each explored a different challenge for commons management, pertaining to membership, local rule-making and conflict resolution. Each was assigned a speaker/role, an assembly, a companion species (from the first workshop), a quote from one of the characters in the LARP in workshop 2, and

a keyword relating to one of Ostrom's corresponding design principles. Participants used these scenarios for context, and worked with paper-based prompts as design materials to define their DAOs, and deal with governance issues such as establishing membership protocols, voting mechanisms, processes for establishing and changing the rules, and acknowledging and rewarding the contributions and value flows between multispecies members in order to sustain a food commons, as well as relations with external organisations. In three groups, participants worked to produce the following three prototypes:

1) The first group chose Scenario 1: '*Should we expand our membership structure to include others from local city farm "nodes"?*' This referred back to the mis-claimed salad Agenda item, played by the E1CFA Coordination Rep:

"The individual that was involved…tend[s] to a lot of the sensors that are in the park outside Bethnal Green. They built up a lot of credits within their own farm membership. And they incorrectly assumed that our farm was part of their network of food sharing….And because they weren't part of the same shared group or food node as we are - that was where the confusion came in."

The keyword was membership, and the companion species was sensors.

The group devised an 'umbrella' DAO, called DAO-n to Earth, that helps to coordinate the exchange of tokens (currencies) between all the farms in the London Food Network. The exchange rate is set automatically according to the soil health data of each community, as measured by networked sensors and AI, and calibrated over time. The better the quality of soil in a community, the higher the value of its local currency. Humans are incentivised to take care of the soil, by staking a currency's value to the work done to regenerate the soil in a specific local area. The DAO-n to Earth group explained that they are designing for soil health above all else, because it benefits a wider group of species (rather than the humans alone). Care for ecosystem health is woven into the dynamics of food production and exchange.

2) The second group chose Scenario 7: '*How can we make the most of all the resources available, by using 'waste' as 'assets' to nourish other members of the farm?*' The gameplay excerpt is provided below. Here, the GLCFA Education Rep is speaking as Soil to the Resources Rep:

E: **"**Can I speak as soil. With my soil hat on. The pile of waste that you're talking about. Is it just human excrement?"
R: "It's a mix of farming manure like cattle and sheep."
E: "So everything organic. So for me, that's food. So I wouldn't call that waste, that's wonderful."

On the card we also provided a keyword ("resources") and a related companion species ("farm animals").

This prompt triggered an interesting discussion of value. They experienced value as relational and ever-unfolding, an experience which they sought to capture in the design of a socio-technical system that nurtured multispecies relations. The Fellowshit of Dark Matter DAO consisted of an app, where humans could post waste materials and make them freely available to others within the community, thereby earning tokens that work as currency which can be used within a broader system of value exchange. They also planned a weekly ritual, to provide a way for humans to inhabit multispecies perspectives, and spot opportunities for waste materials to be used for their own species' ends. The DAO promotes a multispecies 'circular economy' with an expansive sense of value that is not only focussed

on material utility but the meaning of unfolding interspecies relationships as they exchange materials and tokens within a digital-physical ecosystem.

3) The third group chose Scenario 4: "*How do we acknowledge the contributions of different species'* which had a particular focus on plants:

"Speaking for the plants, I think there hasn't been overall enough acknowledgment of what sacrifices we make. Because principally we are generating most of the air and most of the food. So particularly as there's been a move towards vegetarianism and veganism. When this was first mooted we did originally discuss having rituals that actually thanked the plants and I don't know what's happened to that. I just know that the plants are carrying a load here that no-one is acknowledging." (GLCFA Infrastructure Rep)

The group's keywords were *contribution* and *fair share*, and the group's companion species was plants.

The Corn Council DAO seeks to repair the alienation humans experience from the conditions of food production, and proposes a system for repairing the disconnect between humans and other species. The DAO rewards humans with tokens for spending time with plants in a non-instrumental way, as well as for care-taking work such as pruning and watering. Tokens allow members to participate in voting proposals about the farm's management. Each crop in the farm has its own council and the DAOs are managed through an umbrella DAO.

In the afternoon session we invited a wider group of community growers and organisers to join in with their expertise of multispecies relations, food-growing, and community governance to try and fuse these forms of knowledge in critically examining how these DAOs might serve local and wider multispecies interests, as well as all the awful things they might do by accident. Knowledgeable growers helped reconfigured tech-focussed imaginings and added important depth and nuance to multi-species relationships and ecosystems by 'stress testing' the DAOs, by situating each DAO on a matrix with axes of dystopian/utopian, and discrete/federated.

4. Discussion

In the following sections we discuss how the project presented possibilities for what food governance could look like in the sustainable smart city of the future, when we include diverse, marginalised citizens and move beyond a human-centred and efficiency-focused perspective of algorithmic food governance—instead considering multispecies relations, labours of care, and notions of the commons.

Designing for More-than-Human Food Futures

Within the efficiency logics of algorithmic governance in the profit-driven global food systems, marginalised actors such as more-than-human, small-scale farmers, and low-income, immigrant communities are often overlooked and neglected. The workshops helped to make visible these actors as well as the relationships and flows between them.

Participants envisaged scenarios of food governance in a future London, where technological infrastructures like blockchain and sensing systems are harnessed, not to concentrate profits and intensify agricultural production for the benefit of a few human stakeholders, but rather to provide the mechanisms to facilitate ecological repair and regeneration across human and non-human communities. Rather than focus on the needs of individual actors within food systems, technology was used to help incentivise the expansion and health of mutually beneficial multispecies relations. Wider urban food systems were also

transformed beyond those of individual neighbourhoods, through systems of exchange and calibration. For example, in the DAO-n to Earth prototype, the system accounted for soil health across the city. For example, a sudden degradation of soil health, for example through contamination, triggers a market crash as well as a mechanism to incentivise members of other farms on the network to help clean it up.

Like with terra0, the possibility arose for an urban food system consisting of its actors, labours, and governance mechanisms, to maintain its own ecological balance, by establishing itself as an autonomous self-organising agent. For example, in the DAO-n to Earth prototype blockchain presented possibilities for "*imagining [the system] as a collective organism and not as these individual parts that are always competing with one another*" (workshop participant). Rather than relying on efficiency logics of the "eco-smart-city", in these visions cities are rendered smart because of the potential for them to function as self-regulating and self-repairing organisms.

Designing for Care in the Eco-Smart City

Food in the smart city typically promises convenience and efficiency, providing an end-user consumer with a perfect product at the touch of a button. In such visions, the production of food is abstracted from the labour required to maintain and care for such systems, and consumers are alienated from the lives on which our food depends, typically a devalued migrant, precariously-employed labour force, as well as myriad other species, the soil in which it is grown, and the contingencies of climate. A feminist notion of care asks "who will do the work of care, as well as how to do it and for whom" (Puig de la Bellacasa 2011). The Algorithmic Food Justice workshops surfaced visions of urban food futures where the labours of care that are typically invisible, taken for granted or marginalised in the dominant food regimes are recognised, valued and rewarded.

In these futures, technology has the potential to reconfigure value from something to be enclosed and extracted, into a system that hinges on care. For example, in the Fellowshit of Dark Matter DAO organic waste is transformed from something that is devalued and erased in the dominant food system, into a valuable resource for microorganism stakeholders, and is recognised as such. As one participant explained, "*People are incentivised to move matter from the wrong place to the place where it can have its value realised*." Likewise, in the Corn Council DAO, the time spent caring for plants is recognised as a valuable asset and accounted for. While in the DAO-n-to-Earth DAO, the practices of caring for soil are made visible and brought into a sociotechnical system of accounting and governance.

It is only by moving beyond a human-centred perspective of food governance to recognise the interrelations between humans and non-humans on which all life on earth depends, that we can begin to recognise the diverse value required to restore our damaged planet. A focus on care suggests a way to shift from exploitative, extractive, colonial, capitalistic paradigms of food governance, towards one in which power relations are restructured, and value redistributed more fairly and sustainably.

Designing for a Multispecies Commons

While some urban farms are profit-driven enterprises, many grassroots urban agricultural sites, such as Spitalfields City Farm and other community gardens we have worked with in the UK prioritise the collective needs of diverse, socially marginalised inhabitants (human and otherwise) over individual profit. As researchers interested in food governance, we can learn from these communities about how cities of the future could be transformed into a food commons that benefits collective human and non-human communities, and the ways in which digital technologies could be employed for the common good.

Participants speculated on food governance for a heterogenous set of more-than-human actors in accounting systems, as a way of addressing the inequalities and power imbalances within the current industrial food systems. Blockchain facets such as exchangeable tokens in the form of a community currency, and non-exchangeable tokens in the form of reputation, were used in the prototypes to help manage the community rules in ways that are fair for the multispecies collective. For example, in the Corn Council DAO, caring for crops is valued and incentivised with reputation tokens, which a member can then use to help the DAO evolve by proposing and voting on new proposals. In the Fellowshit of Dark Matter DAO, contributions towards furthering relations between multispecies members are collectively assessed and rewarded. Likewise, in DAO-n to Earth, reputation is allocated to individual farms according to the health of their soil over time, through a "Proof of Healthy Soil" protocol and as measured through AI-based sensor networks called "Soil Sentinels". Reputation can be used to change the algorithms of the overall DAO. The rules recognise and incentivise the work for sustaining the commons, contributing to its overall health and abundance. Rather than aiming to deliver efficiency within the commons, the projects surfaced futures in which blockchain, AI and sensor networks are used to include multispecies stakeholders in the governance of an urban food commons.

Conclusion

In this chapter we presented a case study that allowed us to consider how else urban food governance might be mediated through technology in the sustainable smart city of the future, beyond top-down, efficiency-led, human-centred, and profit-driven logics. We build on recent work in HCI design research that seeks to democratise the ways in which emerging technologies such as blockchain and AI are shaping our urban environments, including the governance of food systems. This research works to increase participation of diverse inhabitants who are often marginalised in discussions around the design of smart cities, in order to leverage bottom-up understandings of urban sustainability and to imagine more liveable and just cities of the future.

This study raises challenges and tensions. Firstly, there are significant barriers to access to emerging technologies such as blockchain, particularly for grassroots communities who may not have the skills required. Building on prior HCI research (R. E. Clarke, 2020; Heitlinger, Clarke, Clear, Chopra, & Dilaver, 2019), speculative and participatory activities including roleplay and fiction are effective ways of engaging non-technical participants in envisaging futures with unfamiliar technologies.

Secondly, as documented in other similar projects, an algorithmic approach to creating formal accounting systems of value, and introducing external rewards in what was previously informal and intrinsically motivated risks creating perverse incentives and abuses of power (Cila, Ferri, De Waal, Gloerich, & Karpinski, 2020; Pazaitis et al., 2017).

Thirdly, critical theories show that while the more-than-human may make room for multiple subjectivities, it may not serve those who have historically been excluded from the category of human in the first place, such as people of colour (Crenshaw, 1990; Forlano, 2017). A feminist ethics of care shows how we might pay attention to neglected humans as well as nonhumans, in order to re-configure value in ways that contribute to more sustainable and just urban food governance.

Finally, we recognise that despite scaffolding more-than-human autonomy through algorithmic automation, the project took place within a human frame, created by human designers and developers and played by human actors. Likewise, we recognise that grassroots urban good growing communities and their visions for fairer food governance are not separate from the neoliberal capitalist system within which they function. But because of

their values, and the inclusive practices in care time and space, working with such communities presents opportunities to lever open the totalising human-centred, efficiency-driven and profit-motivated visions of algorithmic food governance in smart cities, and see where shifts can begin to occur.

These tensions and challenges highlight the urgency of including insights of heterogeneous, marginalised actors and voices in the design of algorithmic food governance systems, in order to avoid intensifying inequalities. Without a variety of stakeholders working on these technologies, accelerationist tendencies and injustices in urban food governance will be exacerbated. It is the combination of speculative and participatory approaches with diverse stakeholders, as well as a focus on commons-based and more-than-human values, that we see the most fruitful opportunities for computation to be used in urban food governance in the future, in ways that are more environmentally and socially just.

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