Justice by Design: The Case for Equitable and Inclusive Smart Cities for Animal Dwellers

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1. Introduction

Visionary urban architects such as Vincent Callebaut (vincent.callebaut.org) have produced ever more imaginative designs of future smart sustainable cities, where elegant structures and lush vegetation blend together beautifully in spaces that seemingly provide perfect environments for human life to thrive. Aside from a few birds flying above the city, animals are either absent from these tame and sterile floral jungles or contained within sky-scraping urban farms, their perhaps less tameable and less sterile presence seemingly instrumentalised to or expunged from such anthropocentric utopias.

Urban planning theorists such as Houston et al. (2018) have challenged humanistic conceptions of cities as "*places of enlightened human value and technological mastery*" (p.193), because they perpetuate the dangerous idea of human separation from the rest of the biophysical world, giving rise to dichotomous categorisations between wanted and unwanted species, leading to the persecution of the latter; and because they assume the primacy of human interests over the interests of other beings, ultimately leading to the catastrophic changes the planet is currently undergoing. Instead, the authors urge city planners to acknowledge the complex "*multispecies and multi-thing*" (p. 200) assemblages and relationships among humans, animals, fungi, bacteria, plants, rocks, water and air, whose becoming with makes urban worlds; and to value all nonhumans' participatory contribution to urban worlds (Forlano, 2016), to enable the emergence of more inclusive and just cities.

However, while all organic and inorganic beings participate in the becoming of urban worlds, the diversity of agents involved needs to be acknowledged, precisely because humans' unwillingness to cohabit with other beings largely depends on our perception of these as potential competitors that may not be controlled. The space-temporal scale at which their agency manifests and the kinds of resources they seek mean that plants appear to be largely more controllable, less in competition with and often beneficial to humans. In contrast, many animals move more quickly, respond more autonomously and produce more detectable signals, without yielding to the urban social and imaginative order of modern humans (Wolch et al., 2000; Philo and Wilbert, 2000) nor to human social rules about animal mobility within urban physical and geographical borders (Braverman, 2013). Moving according to their own needs and desires, animals challenge human socio-geographical orders (Michael, 2004) and often seek the same kinds of resources humans seek. In other words, the human-animal biological kinship is likely to set humans and other animals on a collision course that renders *making kin* (Haraway, 2015) fraught with contradictions. If designing cities for cohabitation is to succeed in practice, moderating inter-agent competition and control in a way that de-centres the human will be fundamental. Design models that can address this challenge in the context of human-animal relations are more likely to be extendable to a broader range of nonhuman agents.

In this regard, the development of *smart cities* provides an unprecedented opportunity. So-called *smart* technology is increasingly able to plan and manage complex systems by collecting and analysing vast amounts of multimodal data, and by making and implementing principled decisions (Bibri and Krogstie, 2017) in relative autonomy. Thus, smart technology could play a fundamental role in de-centring human

interests within urban worlds. Throughout the history of our species, technological development has aimed at controlling, outcompeting, and ultimately exploiting the rest of the natural world, but this has evidently produced human-made imbalances that are destroying the planet. Although losing control and being outcompeted are considered two of the main threats that increasingly powerful artificial intelligence poses to humanity (Future of Life Institute, 2022), have we now reached a point when technology could have a role in re-distributing control, for example by enabling animals' agency, in order to redress the imbalances we have created? Could technology that de-centres the human promote and support a more relational approach to interspecies coexistence, akin to that which characterised some indigenous cultures (Graham, 2014)? If so, the question is what ethical and design principles should inform such technology to give rise to more environmentally and ethically sustainable cities.

With this in mind, the rest of this chapter discusses the implications of extending the principles of *equity* and *inclusivity* that inform existing conceptions of *smart sustainable cities* to animal dwellers, leveraging Nussbaum's theory of multispecies justice, according to which a just smart city would offer animals opportunities to pursue biologically relevant goals and achieve basic species-specific capabilities. Two cases of human-animal cohabitation then exemplify requirements that a *just smart city* would need to meet to enable multispecies cohabitation: supporting animals' sensemaking of and interaction with urban affordances, enabling them to autonomously pursue their biological goals; managing affordances by balancing the interests of one species against the interests of other species, as well as the interests of individuals against the interests of their species; accounting for different perspectives and narratives on interspecies relationships, when making and implementing decisions. Finally, the chapter proposes an iterative model of a *just smart city* in which technological interventions are informed both by principles of multispecies justice and by multispecies data, to enable the emergence of cohabitation forms that are incrementally equitable and inclusive for a growing range of species and individuals.

2. Smart sustainable cities for whom?

Smart technologies that combine big data analytics and context-aware computing - underpinned by digital sensing tools, cloud computing infrastructures, middleware architectures, and wireless communication networks - are becoming instrumental in the monitoring, analysis, operation and planning of cities (Bibri and Krogstie, 2017). As improving cities' *sustainability* becomes increasingly important, *smart sustainable cities* are expected to leverage these smart technologies to *meet the environmental, economic, social and cultural needs of its inhabitants* with *equity and inclusivity* (Bibri and Krogstie, 2017; Angelidou et al., 2017), without compromising the ability of others or future generations to meet their needs (ITU, 2014; Höjer and Wangel, 2015). Thus, in a smart sustainable city, technology would ensure that citizens have equitable access to the resources, services and opportunities they need to participate in society and enjoy a high quality of life within a healthy and pleasant environment that is not degraded by urbanisation or urban activity. This raises the question as to who counts as a citizen of such a city (Narayanan and Bindumadhav, 2019).

Generally, aspirations of intra- and inter-generational equity and inclusivity regarding the benefits afforded by smart sustainable cities seem to be fundamentally limited to humans, as reflected by smart city applications, which aim to address environmental sustainability challenges but disregard sustainability challenges to biodiversity (Angelidou et al., 2017), signalling a widespread lack of concern for nonhuman city dwellers, particularly animals (Acari et al., 2021). As Beatley and Bekoff (2013) point out, although some animal species (e.g. macaques, racoons, foxes, rats) have adapted to living in urban settings, they are often perceived and treated as a nuisance or a threat, accused of carrying disease, damaging property and imperilling human safety. When conflicts of interest between humans and animals arise, they are often resolved by dispatching the animals. Except for a few protected species, animals' presence in cities is usually tolerated only if they are seen to add value to humans' urban experience without affecting humans' interests. For those whose presence is tolerated, cities are often inhospitable, whether by design (e.g. spikes fitted to the edges of buildings' windows and doorways to prevent pigeons from perching) or by

indifference (e.g. glass-fronted buildings with which birds collide, misled by the surfaces' transparency). Instead, the authors advocate for the integration of animals' interests into city planning and practice, highlighting how this could benefit animals and humans alike; for example, *because green spaces that provide habitats for animals also benefit human health, because encounters with wildlife enrich human experience and because biodiversity is important for the preservation of the ecosystems that sustain human life*.

Riffat et al. (2016) propose measures that smart cities could take to address environmental issues, including more efficient transportation systems, better waste management, increased carbon emission capture, reduced atmospheric pollution, greater use of renewable energy, lower energy buildings, more compact urban design and increased green spaces. While improving human life, these measures would likely also ameliorate living conditions for, and indeed attract, animals by improving the liveability of urban spaces and by reducing cities' environmental impacts. However, *there is a fundamental difference between incidentally improving living conditions for animals and explicitly accounting for their interests, so that the urban environment can meet their needs with equity and inclusivity.*

3. A matter of justice

The notions of *equity* and *inclusivity* in the organisation of smart sustainable cities are aligned with the idea of *fairness* underpinning influential theories of justice developed within the field of political philosophy, particularly the *social contract* tradition represented by Locke, Rousseau and Kant, and reflected in Rawls (2001)' influential treaty. For Rawls, the functioning of a fair society should be informed by principles of justice that rational persons in an *original position* (where all are equal and have no vested interests) negotiate to reciprocal advantage. On this basis, while humans have a duty of compassion towards animals consistent with human dignity, the treatment of animals is not an issue of justice, since their lack of rationality and self-representation prevents them from negotiating and attaining societal membership.

Among the critics of contractarianism, Nussbaum (2006) rejects the assumption that those who negotiate the social contract must have equal capacity for rational reasoning and self-representation (a criterion that would also exclude humans with cognitive disabilities). She argues that, while animals might not be able to negotiate mutually advantageous principles of justice with humans, they are nevertheless subjects of justice for whom such principles must be negotiated. For Nussbaum, animals are *agents capable of a dignified existence, with corresponding needs for flourishing and related goals they actively pursue, to which they have a moral entitlement*. Therefore, how humans treat animals is not an issue of compassion, it is an issue of justice; their maltreatment is not contrary to human dignity, it is contrary to animal dignity.

Influenced by Aristotle's view that animals and humans are fundamentally akin because they are all made of organic matter (Deckha, 2015) and by Marx's conception that one's true functioning depends more on the opportunity one has to engage in life activities than on quantifiable resources (Sen, 2009), Nussbaum's interspecies theory of justice articulates fundamental entitlements for creatures of different types. Her *capability approach* differs significantly from utilitarian approaches, such as Bentham's hedonism (1789-1823 ed.) or Singer's preference-satisfaction (1980), because it regards the balance between pleasure and pain too crude a measure to evaluate animals' functioning. Within her approach, animals' functioning is evaluated based on the opportunity they have to pursue the capabilities they value (e.g. an animal may choose to engage in an activity that has value for them even if this causes them pain). Furthermore, unlike utilitarianism, the capability approach does not justify violating the rights of individuals to advance societal interests (i.e. reducing the pain of many does not justify inflicting pain on the few).

Nussbaum identifies *basic capabilities* for flourishing that animals are entitled to pursue: staying alive; maintaining one's bodily health and integrity; experiencing sensory and cognitive stimulation; enjoying nurturing emotions and attachments; setting goals and plans; forming intra- and interspecies affiliations and managing one's social life; having control over one's environment and safeguarding one's territorial integrity. Importantly, the relevance of capabilities is species-specific (e.g. being killed causes greater harm to animals capable of making plans frustrated by death than to animals with no such capacity). Additionally,

relevant capabilities need to be fulfilled to an *adequate* threshold, below which justice is not done and above which inequalities are not unjust. While this does not eliminate conflicts of interest between competing needs, requiring some animals' (including humans') non-essential capabilities to be limited to enable the fulfilment of other animals' essential capabilities, it removes the need to admit species equality as a precondition for multispecies justice.

The capability approach to multispecies justice suggests that a *just smart city* would recognise animal dwellers' entitlement to a *dignified and flourishing existence* according to their species' needs and would afford them, with *equity* and *inclusivity* (Bibri and Krogstie, 2017; Angelidou et al., 2017), the opportunity to pursue *biological goals relevant to their basic capabilities* at least to an *adequate* extent. Indeed, the capabilities identified by Nussbaum (2006) closely correspond to equivalent human needs identified for smart sustainable cities (ITU, 2014): animals' goals might pertain to building, inhabiting and traversing structures and spaces (*environmental goals*), to acquiring and managing resources (*economic goals*), to forming and maintaining social groups (*social goals*), to gaining and transmitting knowledge and skills (*cultural goals*). Thus, a just smart city would provide opportunities for animal dwellers to nest and travel safely; to hunt, forage and store food; to communicate, meet and mate; to learn from others and their surroundings. While many urban environments disregard the needs of animal dwellers or deliberately seek to exclude them, others are far more welcoming, allowing animals to mingle with humans and to take advantage of the opportunities provided by the city. One example is the city of Istanbul's relation to its cat population.

4. Sensemaking, interaction and the pursuit of goals - Istanbul's Cats

Along with over 15 million human inhabitants, Istanbul is populated by over a million cats (BBC News, 2016). The documentary *Kedi* (Torun, 2017) illuminates the world of felines living in the streets of this urban setting and the relationships they forge with humans.

In Islam, cats have a special status (Hart, 2019) and the Muslim religion plays an essential role in shaping human-cat relations in the city, where countless water bowls and piles of dry cat food are scattered everywhere. Cats are largely allowed to take advantage of the city's urban architecture and practices: outdoor restaurant chairs provide comfortable resting places, awnings provide strategic lookout posts, and ledged buildings provide easy access to higher apartments; open markets are playgrounds where to frolic and hunt, jumping from place to place and snatching fish from stalls, while shopkeepers make unconvincing attempts to push back. Neither domesticated nor feral, the cats are free-living, and their caregivers devote much time and money to keep them safe and relatively healthy. When they show up ill or injured, usually someone takes care of them and the local community sometimes share the financial burden of necessary veterinary treatment. Caregivers' and cats' life stories are thus intertwined, as humans and animals 'rescue' each other (Porter, 2018): caregivers provide for the cats and, in turn, the cats give them purpose and joy.

However, the cats' existence and the human-feline bond in Istanbul are being threatened by accelerated urban development, the intensification of capitalism, and ongoing material and cultural changes (Hart, 2019). Highways soon to be constructed will pose deadly dangers for the cats. New high-rise buildings will have no ledges or adjacent trees, so cats will not be able to enter higher apartments. The loss of old markets, narrow streets and awnings will leave the cats unable to climb, hide, and interact with residents. In *Kedi* (Torun, 2017), caregivers express their concern: "*We're more worried about what will happen to the cats than what will happen to us. If this area gets demolished, and it's very likely, they will be without anyone*". Caregivers wish the design of modern buildings considered the cats' needs, because they belong to the city as much as its human inhabitants: *"The cat embodies the indescribable chaos, the culture and the uniqueness that is the essence of Istanbul. Without the cat, Istanbul will lose part of its soul*" (Torun, 2017).

Thus, Istanbul's reality recognises cats' entitlement to co-own the city, which provides them with opportunities to shelter, travel, hunt, forage, communicate, socialise and explore; and which humans willingly share with them, collectively caring for them, while respecting their autonomy as users of the urban space. But the cats' status as integrated urban dwellers, the cat-human bond and Istanbul's very

identity are threatened by urban developments that can take away their ability to make sense of and interact with their urban surroundings in pursuit of their *environmental, economic, social* and *cultural* goals.

To pursue such goals, and achieve their essential capabilities, animals need to be able to interact with their surroundings effectively. To take advantage of their surroundings' potential for interaction, what Gibson (1977) called *affordances*, animals need to be able to make sense of their surroundings' elements within their *umwelt* (Uexküll, 1909), that is within their world-model. This is informed by the animals' capacities of perception and interaction, and by their biological goals. Thus, sensemaking requires that the elements of animals' surroundings be perceivable to them and responsive to their behaviour, consistent with semiotic mechanisms accessible to them and outcomes relevant to them, whether animals interact with their natural environment or with technological infrastructures and systems (Mancini, 2023). For example, glass surfaces are difficult for birds to perceive, giving them the illusion that they can fly through, which often results in them crashing to their death (a typical example of *mis-perceived affordances* - Gibson, 1977); birds might perceive that buildings' windowsills afford perching on but may be prevented from interacting with those structures effectively by 'bird spikes'. In neither scenario, does the city enable the animals to achieve goals biologically relevant to them: the former because it does not allow them to make sense of barriers that prevent them from safely traversing a space; the latter because it prevents them from taking advantage of an affordance that would provide them with a place to rest, socialise and nest. Conversely, as Smith et al. (2017) note, structures such as wildlife crossings that feature local natural material and vegetation enable animals to make sense of a passage and to safely traverse an otherwise dangerous space to reach places where they can find food, build shelters, socialise with conspecifics, and develop their territorial knowledge. Communicating affordances unambiguously enables animals to make sense of what they can and cannot do, either encouraging them to pursue attainable goals or discouraging them from pursuing dangerously unattainable goals, such as attempting to cross a busy highway.

As the case of Istanbul's cats exemplifies, although the city is designed for humans, its urban architecture and practices afford the animals opportunities to fruitfully interact with their surroundings; and a culture that fosters humans' acceptance of the cats' presence allows them to take advantage of those affordances, which in turn allows humans and cats to form mutually beneficial relationships. But what about other relationships and competing interests? When a species is favoured over others, how are the other species impacted? What about the mice and rats, who also live in the city and who are hunted down by cats (Torun, 2017)? When a species is allowed to expand in an urban environment providing limited resources, what happens to that species' many individuals who remain invisible, and succumb to starvation and disease (Arcari et al., 2021)? In brief, how is the flourishing of one species to be valued in relation to the flourishing of another species and how are the interests of individuals to be valued in relation to the persistence of their species? These dilemmas are highlighted by the relationships that, until early 2022, connected humans, dogs and other animals at the Ukrainian site of Chernobyl.

5. Individuals, ecologies and decisions - Chernobyl's Dogs

The Chernobyl nuclear disaster, in 1986, led to the evacuation of all residents within a 30-kilometre radius of the plant. Over the years, this "exclusion zone" became a liminal space: a cultural icon of pollution and death, and, in parallel, an apocalyptic urban paradise evolved into a nature reserve (Turnbull, 2020).

When disaster struck, the authorities forced fleeing residents to permanently abandon their companion animals and soldiers were ordered to shoot all the dogs to prevent radioactive contamination from spreading. However, despite attempts to exterminate them, and despite Ukrainian winters' harshness, food scarcity, wolves, disease, and radioactivity, some dogs survived (McDowall, 2018) and their great-great-grand-puppies still lived there in early 2022. The documentary *Dogs of Chernobyl: The Untold Story* (Camilleri and Chesnel, 2020) depicts the silent streets of the exclusion zone, a monument to life that stood still, to families who left behind memories and dreams. For the dogs, this eerie habitat offered hiding places, empty roads, and drinking water; but also multiple survival challenges, which made them bigger, stronger, and 'street-wise' through natural selection.

Until early 2022, every day, factory employees and checkpoint guards went to work in the exclusion zone, where hundreds of feral dogs roamed. Due to their hazardous conditions, which condemned them to hard and short lives, the dogs were the subject of concern for the workers. In this liminal space, bonds formed between humans and dogs (Turnbull, 2020). Neither wild nor domesticated, the dogs had a special status, coming and going as they pleased through the zone's checkpoint, being both aloof and attached to checkpoint guards. The guards did not see themselves as dog owners, but some had formed partnerships with the canines, giving them names, and providing them with food, shelter and medicines. In turn, the dogs defended the checkpoint and accompanied the guards on duty, providing a sense of home in a toxic and deserted place (Turnbull, 2020).

The locals and the volunteers of US charity Clean Futures Fund, whose mission was to help humans and animals in the exclusion zone, disagreed on how to categorize and treat Chernobyl's dogs (Turnbull, 2020). The locals believed that the dogs were accustomed to their living conditions and belonged in the exclusion zone's wilderness. Rather than radioactivity, they believed that freezing winters and wolves were the real danger for the animals. However, charity volunteers were keen to rescue the dogs from the radioactive zone and, if possible, send them abroad for adoption as pets. They examined every dog's condition to decide what was best for them: puppies, vulnerable or poorly acclimated dogs were candidates for adoption; but, for dogs who had grown up in the exclusion zone and were used to its conditions, transplantation into a "domestic situation" was not deemed in their best interest.

Thus, the liminal reality of Chernobyl's dogs existed in tension between different perceptions and narratives about who the dogs were, where they belonged, what they needed. Were they citizens of the zone's wilderness, self-determining negotiators of their own mutualistic relations with humans? Were they disaster victims needing to be rescued from radioactive toxicity and other dangers to live within the safer bounds of domesticity? Were they not integral part of a new ecology that also sustained predators such as wolves? Did their preferential status in the humans' perception justify disregarding the wolves' survival needs? How would these kinds of evaluation, and any corresponding responses, be negotiated in a just city, and by whom?

A *just smart city* would need to address these kinds of tensions between individuals' identity, autonomy and wellbeing, on the one hand, and the interspecies dynamics that maintain ecological systems, on the other hand. Thus, whilst enabling individual animals to make sense of and fruitfully interact with urban spaces and processes, the city would aim not to interfere with the multispecies ecologies existing within its bounds, in order not to advantage or disadvantage any one species and, thus, perturb the dynamics upon which said ecologies depend. Bekoff and Pierce (2009) demonstrate how different species have their own sense of fairness, which regulates their social interactions, and allows individuals to function within their social order. However, where, due to human activity, a particular species had a disproportionate advantage or disadvantage in relation to others, intervention might be required to neutralise the effect. This might involve limiting advantaged species' ability to pursue non-essential goals, while enhancing disadvantaged species' ability to pursue essential goals, by managing the opportunities for interaction that different species are afforded. For example, in North America, Eastern Bluebird populations have suffered greatly with the introduction of House sparrows and Starlings, both invasive species that outcompete Bluebirds for nesting sites; the deployment of artificial nesting boxes, whose entrance is too narrow for Starlings and too shallow for Sparrows, discourages these larger birds while encouraging nesting for the smaller Eastern Bluebird (Rosenzweig, 2003).

Nussbaum (2006) argues that justice is fundamentally concerned with the experience of individuals and that the continuity of species is only morally relevant to the extent that their decline involves individuals' suffering. For example, if the individuals of invasive prey species had to be culled, being killed by expert snipers would be less harmful than being torn apart by predators introduced as a control measure. However, while prey animals have evolved to sense and respond to predators in a way that enables them to take evasive measures (Lima, 1998), they are less equipped to evade snipers' weapons, which impacts their ability to stay alive and calls into question the ethics of surreptitious killing. Additionally, the patterns of prey animals' avoidance behaviour stimulated by the presence of predators create ecological niches that

allow other species, and their individuals, to flourish. For example, the reintroduction of wolves to Yellowstone National Park triggered a beneficial trophic cascade in the ecosystem (Fortin et al., 2005). Indeed, the ecological dynamics supported by biodiversity regulate key biotic and abiotic processes on the planet, providing the biosphere's long-term capacity to persist and adapt to abrupt and gradual changes (Steffen et al., 2015), so that generations of individuals can flourish.

As technological development has enabled humankind to progressively separate from and subjugate much of the natural world, the complex interconnections that make ecosystems have been increasingly disregarded to advance human interests with ever more disastrous consequences. So, how can humans make decisions on what interests should be prioritised by the just smart city, and what narratives should justify what interventions? If not humans, who should make and implement such decisions?

6. Imagining a *just smart city*

As we argued, a multispecies equitable and inclusive smart sustainable city would need to *meet the needs of **all** its inhabitants* (human and nonhuman) without compromising the ability of others or future generations to meet their needs; and that this would entail enabling its multispecies dwellers to *make sense of their urban surroundings and interact with them effectively to achieve biologically relevant goals*. With these fundamental principles in mind, we imagine what such a city might look like, the processes that could enable its functioning and the steps that would be needed to incrementally adapt existing cities to a more just model. Istanbul's example has highlighted the importance both of urban affordances, which enable animals to interact effectively with the urban environment, and of human sociocultural values that permit them to take advantage of said affordances, fostering a collective investment in mutually beneficial interspecies relationships. At the same time, Chernobyl's example has highlighted how different human sociocultural perspectives may impose particular values on ecological dynamics that, albeit unpalatable, may still need to be respected independently of human value systems. Thus, applying our proposed principles to the complex realities of existing urban multispecies dynamics raises key ethical and operational questions. For example, how to create lists of *species* to be considered? How to determine what *capabilities* different species value? How to define a minimum threshold for their *adequate* fulfilment? How to decide what each species *need*s to fulfil their basic capabilities? How to negotiate different species' conflicting needs? How to determine measures to compensate for the impacts of inherent urban and human activity? How to deal with human beliefs and norms that might influence the potential to adopt change? Who would get to decide the answers to these questions and how would the process be regulated?

The use of smart technology in ecological studies is on the rise as a way of addressing increasingly complex research questions and global challenges such as climate change and biodiversity loss (Allan et al., 2018). The *just smart city* would embody a gradual evolution of this trend, informed by multispecies justice principles, gradually shedding light on the kind of questions mentioned above. Starting from existing cities' physical and socio-cultural context, it would grow incrementally and iteratively, gradually evolving into an agent of *interspecies mediation and control re-distribution*. Figure 1 illustrates the different activities of a possible design cycle and, below, we discuss operational and ethical challenges that might arise at each stage, and how smart technology might help address them.

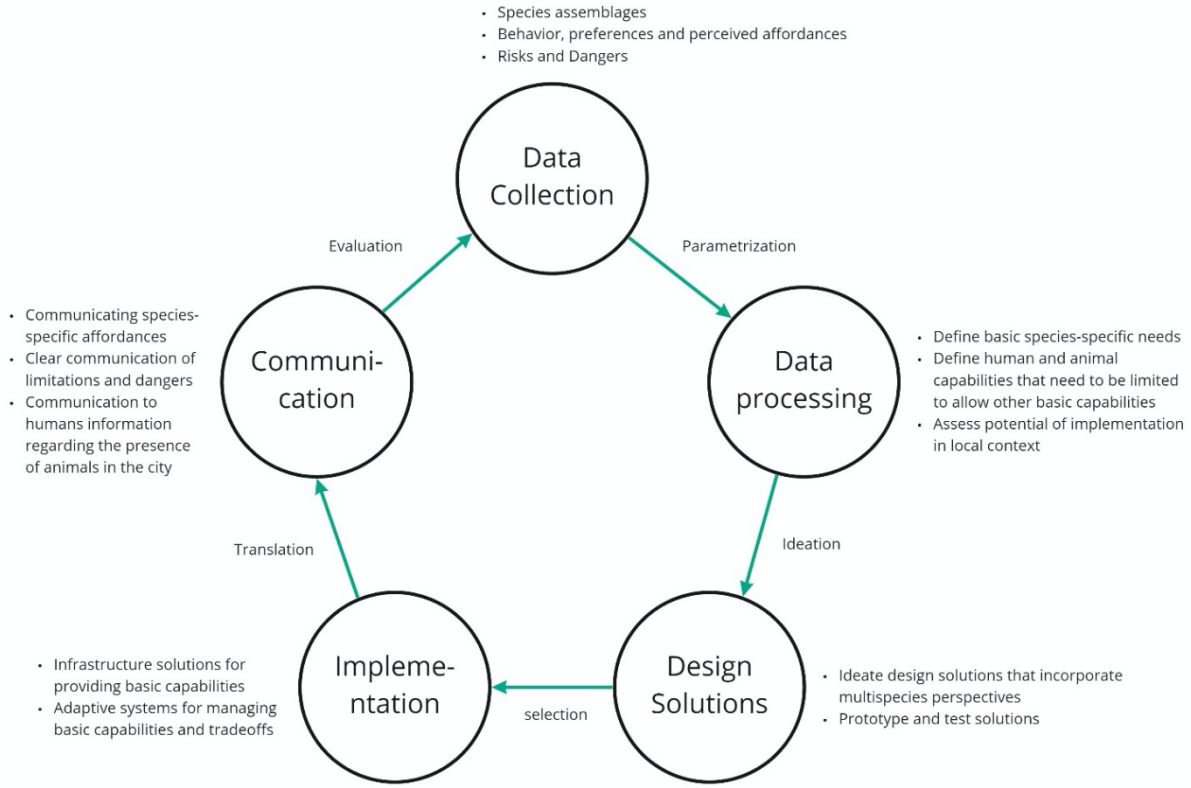

Figure 1: The *just smart city* iterative evolution process including the different objectives of each stage.

Data collection would be an essential activity of the *just smart city*. Ambient sensors could collect large amounts of data regarding the presence, frequency and behaviour of different species within the urban environment, helping to shed light on species assemblages, behaviours, and preferences as to where and how they feed, nest and socialise; what dangers they face and what benefits the city already affords them. Notwithstanding the importance of protecting monitored animals' security and privacy (Paci et al., 2022), this data would help address some of the questions raised above within the context of specific cities. Monitoring applications could also support nature-based citizen science projects, enabling human citizens to take part in monitoring and collecting ecological data, with the added value of increasing emotional and cognitive connections to nature (Schuttler et al., 2018). In turn, this could encourage public acceptance of animal presence in cities, and foster a culture of shared responsibility and collective caregiving (e.g. group monitoring of aspects of animals' behaviour to coordinate caregiving practices). As a starting point, the data collected would serve to highlight unjust situations for different species, which could be addressed incrementally through the existing governing mechanisms of the city. As more data was collected, it would be possible to identify different species' requirements for achieving basic capabilities (e.g. based on species-specific measures related to activities such as mating, feeding, and locomotion) and shift towards self-governing systems based on algorithmic decision-making. These would serve as regulating mechanisms for ensuring that different species' needs were met to a minimum threshold defined based on collected data. Of course, how, where, when and by whom data was collected might strongly influence decisions and outcomes (Kontokosta and Hong, 2021). These concerns would be greater regarding species for whom there was no available data (e.g. if the animals were too small or too evasive) and, therefore, no representation in decision-making. However, where species-specific data was missing, proxy measures, such as relevant parameters of ecosystem health, could be leveraged (Stephens et al., 2015).

While not immune to design bias, considered **data processing** approaches could help interpret the data in ways appropriate to the local urban context. For example, data regarding animals' behaviour could be

combined with existing ecological and ethological knowledge to define basic species-specific capabilities based on what animals seem to value in specific situations. Because cities are novel ecosystems where animals' behaviour might vary from that of wild populations (Luniak, 2004), it would be important to assess their behaviour in the local urban context to understand what the specific site does or should afford them. This could help assess to what extent different animals were able to achieve their basic capabilities in their current urban settings and identify the best trade-offs towards achieving a minimum threshold for all. In cases where species groups were severely disadvantaged by human activity, compensatory measures could be proposed.

Insights generated and requirements identified through data processing could inform the ideation of **design solutions** that take into consideration multispecies perspectives as well as the local sociocultural context. **Implementation** of these solutions could vary in form and scale, including infrastructure features embedded into the design of the city such as green corridors, animal crossings, ponds and vegetation; and influence planning decisions, including where and in what ways the city should expand or regenerate. In this respect, a most interesting promise of smart technology might be its ability to generate agile and adaptive solutions that allow the city to shift and respond to the needs of multiple species over time and space. These solutions could include smart mobility regulation systems that allow safe crossing for different animals, sporadic feeders that respond to periodic changes in resources, seasonal reservations that protect animals during more vulnerable periods, adaptive lighting systems that reduce light pollution in response to certain animals' presence, and even transformative infrastructure, such as buildings that shift their shape to meet various species' needs.

As the smart city collects data and generates insights and decisions based on defined basic species-specific capabilities, it should **communicate** its affordances to different species in a clear and species-specific way, allowing individuals to make sense of their environment and interact with it in a meaningful way. This would be important also if the smart city recognised that certain animals' behaviours needed to be limited, which would require communicating such limitations. For example, a dangerous road should communicate where it does and also where it does not afford crossing (e.g. by featuring species-specific 'traffic lights' that deliver clear warnings).

The ways in which different animals perceive the affordances of the city, based on their world model, is influenced by many factors largely unknown to us humans (Uexküll, 1909). The process of collecting data, decision-making, and communication should therefore be iterative and ongoing. Ongoing monitoring could inform a better understanding of different species' perceived affordances based on their interaction with urban infrastructure and resources, and help identify where affordances were misperceived. Adaptive solutions, harnessing artificial intelligence and real-time data processing, could respond to changes in the environment and behaviour of residents, and provide increasingly relevant and perceivable affordances while reducing affordance misperceptions. In addition, involving human citizens in the monitoring and support of animal dwellers could familiarise the 'otherness' of animals, awaken biophilic sentiments, and improve environmental attitudes and behaviours, helping to overcome anthropocentric dichotomies (e.g. beneficial/harmful, desirable/undesirable - Houston et al., 2018).

The ongoing iterative learning necessary to realise this vision could start by addressing only a handful of nonhuman species and gradually include more species, as better understandings are attained regarding the dynamics at play within the eco-socio-technical systems produced by the interactions among species, ecologies and technologies. At the same time, although smart technologies could help redress the anthropocentric imbalances of current cities, they are likely to reflect human biases affecting every stage of the process, including data collection, processing and interpretation, as well as design, implementation and communication. Elsewhere, we propose an approach to support the design of animal-centred technology informed by multispecies justice principles, including design strategies to *disrupt* systems that go against animals' capabilities, to *reconfigure* anthropocentric notions that discriminate against animals, and to *pollinate* design thinking with animal-centred values; and a commitment to *expanded empathy* in pursuit of a deeper understanding of animals and their needs (Mancini et al., 2022). In the context of the *just smart city*'s evolution, such an approach could help challenge some of the human biases when considering

possible choices related to the different stages of the process. However, there is no doubt that humans would need to be willing to learn from what the just smart city might have to teach us and gradually allow it to do its work, which would be more likely to happen if we gradually discovered that handing over some of our control had vital environmental and societal benefits.

7. From just smart cities to planetary sustainability

Humans are but one among countless threads weaved through an infinitely complex web of life that sustains all species. Yet, blinkered by anthropocentric interests and empowered by anthropocentric technology, we have disintegrated its delicate structures and undermined its systems' functioning. It is now incumbent upon us to use our technology to find sustainable forms of multispecies coexistence and prevent the ecological collapse that threatens all species, including humans.

Cities are ecological microcosms, both metaphor and metonym of the way in which we coexist with the multispecies individuals who inhabit the planet. As global urbanisation is expected to expand for decades to come (United Nations, 2014), it is essential for future smart cities to recognise the citizenship of multispecies dwellers and afford them *equitable and inclusive opportunities to attain their essential capabilities*, as a matter of justice as well as of planetary ecological preservation. The examples of Istanbul's cats and Chernobyl's dogs highlight some of the fundamental complexities that designing this kind of *just smart cities* would have to account for. This is a daunting task to say the least. But it is a task that can be tackled incrementally and iteratively, capitalising on the potential of big data analytics and context-aware computing, underpinned by digital sensing technologies, cloud computing infrastructures, middleware architectures, and wireless communication networks, which are expected to underpin the functioning of future sustainable smart cities (Vincent Callebaut Architectures, 2014).

While futuristic visions of smart cities seem to still be largely anthropocentric, here we imagine an alternative ecologically and ethically sustainable vision, as a future destination towards which we attempt to provide a roadmap. In this vision, the city itself becomes an agent of *interspecies mediation and control re-distribution*, while the technology that powers it recedes quietly into the background and makes room for nature to take a more meaningful place in city life, helping human citizens to connect with nature experiences (Colding and Barthel, 2017), to embrace more relational approaches to multispecies coexistence (Graham, 2014), and to make kin with fellow urban critters (Houston et al., 2018). While many critical questions will need to be addressed, in order for just smart cities to become reality, the application of data collection and processing technology, informed by biologically and ecologically grounded principles of multispecies justice, could gradually enable some of the answers to emerge from the ground up. If successful, such technologically supported co-existence could redefine our relationships with other species not only within but also outside cities: beyond improving urban living and urban environments, designing *just smart cities* could provide a model for achieving ecological justice and sustainability for the planet as a whole.

Authors' note

While working on this chapter, we learnt that the site of Chernobyl had been occupied by Russian military forces. We remain profoundly concerned for the safety of Chernobyl's animals and humans. This chapter is dedicated to them in solidarity.

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