# Non-human Personas: Including Nature in the Participatory Design of Smart Cities

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**Abstract.** For the past decades humans have been placed at the centre of designing information and communication technologies (ICT), leading to the rise in prominence of human-centred design. The field of smart cities has equally adopted notions of citizen participation as a way to ensure that technological solutions improve people's livelihoods. However, these kinds of processes treat the urban environment as separate from nature, promoting human comfort and convenience over planetary health and wellbeing. Motivated by these growing concerns that highlight the urgency to reconsider how we define and practice participation in smart cities and in human-centred ICT solutions more broadly, this article assesses how the personas method can be adapted to include more-than-human perspectives in the design process. Based on a case study, which involved designing smart urban furniture for human and non-human use, we introduce a framework for developing and employing non-human personas. As a key element of the framework, we describe a middle-out approach for forming a coalition that can speak on behalf of the non-human species that are impacted by design decisions. We demonstrate how the framework can be used through its retrospective application on two research-led smart city projects. The article concludes with a discussion of key principles for creating and using non-human personas in design projects.

**Keywords:** Design tools, more-than-human, non-anthropocentric, non-human, participatory design, personas, post-anthropocentric, smart cities.

## 1 Introduction

Since the rise of the smart city and the popularisation of smart city 'imaginaries' by large technology corporations [1], the field of smart city technology development has gone through a significant transformation. Early smart city applications were technology-led [2–5] and criticised by scholars for their technocentric approach [1, 6]. Smart city technology providers aspired to sell their products to city governments, hence focusing on technological solutions to urban challenges, such as energy grids, water management, transport systems and public security [7]. While information and

communication technology (ICT) continues to play a significant role in smart city solutions, the language used in smart city policies and initiatives has shifted to emphasise the role of citizens and people [8, 9]. To support this transition in practice, scholars have argued for new processes that allow citizens, communities and organisations to collaborate [10] and to embrace a more participatory approach to city governance [11].

This transition from a technology- to a people-centred approach resembles the rise of user-centred design in the software industry in the late 1990s. Similar to early smart city solutions, early software systems were rolled out in response to technological innovations [12], with little to no consideration of the end-user, often resulting in products that were difficult to use [13]. As personal computing devices became more widely adopted, spreading from offices to our homes and public spaces [14], user-centred design materialised as a methodology for creating software applications that are intuitive and easy to use [12]. Early efforts focused on the usability of software applications, measuring and improving their effectiveness, efficiency and user satisfaction [15, 16]. Frameworks and methods to better understand users and their needs and to identify usability issues emerged from industry practice (e.g. [17, 18]) as well as research studies (e.g. [19–21]) with the fields of human-computer interaction (HCI) and interaction design becoming the main venues for disseminating research and educating the future workforce. As the field matured, the term 'user-centred' was gradually replaced with 'human-centred' to capture the need to also consider other human stakeholders that may not be the end-users in a design process [22, 23].

Human-centred design has been adopted for developing smart city solutions, from urban interfaces [24] to online platforms [25], as a way to address the issues associated with a technocratic approach to smart cities by starting with the needs of users, citizens and communities. In particular, participatory design (PD) offers a promising framework for implementing a human-centred approach in smart cities as it considers people as "experts in their own lives" [26] while also emphasising the democratic and political perspective of participation inherent in the original framing of PD [27]. To that end, PD postulates that "people who are affected by [a] decision or event, should have the opportunity to influence it" [26]. However, in recent years, scholars have raised concerns regarding the potentially harmful side effects of PD and other human-centred approaches as methodologies that prioritise the wellbeing and needs of humans above broader social, ethical and environmental concerns [28, 29].

The article makes two contributions to the literature discussing the potential impact of human-centred ICT solutions on non-human beings and the natural environment more broadly. As a theoretical contribution, the article draws on previous work from the fields of HCI, interaction design and smart cities to make a case for the inclusion of non-human stakeholders and their needs in the participatory design of smart cities. As a practical contribution, the article introduces a framework for non-human personas to capture the needs of non-human stakeholders and to assess how they are impacted by design decisions. The framework is based on a smart urban furniture design case study in which we used non-human personas. In addition to introducing the framework, which consists of four steps, the article demonstrates its retrospective application on two research-led smart city projects. The article concludes with a discussion of key principles for creating and using non-human personas in smart city projects and in design projects more broadly.

## 2 Background

This section first reviews literature documenting the rise of more-than-human concerns across the fields of HCI, interaction design and smart cities. It then describes the use of personas as a tool in human-centred design and reviews relevant literature, including previous references to non-human personas, in the human-centred design literature.

### 2.1 The rise of more-than-human concerns

The term 'more-than-human' has been adopted in the HCI, interaction design and smart cities literature to refer to concerns that extend beyond human considerations. This includes non-human artificially intelligent agents [30]; however, in this article, we use the term to refer to non-human species (animals and plants) and ecosystems.

For a long time, the fields of HCI and interaction design were not overly concerned with how to consider non-human species and ecosystems as their outputs were mostly limited to the virtual sphere of 'cyberspace.' Arguably the 'digital turn'—while leading to the proliferation and uptake of HCI and interaction design—has shaped their current identity, i.e., what is included as part of the body of work in these fields and their methods. While *de facto* design practices in landscape, permaculture, animal husbandry and scientific research accommodate for species and ecosystems, they have been peripheral to HCI and interaction design. The growth in HCI has been tied to advancements in digital technologies and a drive to address human problems in order to maintain the supremacy of humans over the world.

However, with the advancement of ubiquitous computing and pervasive technology in the early 2000s beyond just office and domestic spaces, the virtual sphere of cyberspace collapsed and converged with the real world to create hybrid physical-digital spaces. In parallel, the HCI and interaction design community started to grapple with how it can best contribute to tackling issues of environmental sustainability and climate change with the first series of academic workshops and papers emerging around 2007–2008 [31, 32]. Early examples of 'green HCI' or 'sustainable HCI' entailed behavioural approaches using persuasive technology, which Dourish [33] critiqued for their limited focus on individual users. Dourish argued that HCI needs to be in pursuit of scale making in order to tackle threats of a planetary scale such as climate change. Knowles et al. postulated that realising a sustainable future must be the responsibility of all HCI researchers, not just sustainable HCI, and to orient around climate change rather than 'sustainability' [34]—echoing Dourish's sentiment. These calls for systemic change were further corroborated by other commentators [35–37] and provide a critical foundation for the rise of non-human concerns in HCI and interaction design more broadly.

In addition to questioning the dichotomy between use/usability and impact/scale, the implicit role of HCI and design in fuelling commercial operations has been critiqued as part of calls for alternative economic models [34], such as the notion of commoning in participatory design processes [38] and post-growth politics as a framework to use design's potential to address the big issues our planet faces [39]. Monteiro argues that designers should act as the gatekeepers "to make things better than they are," calling

out the tech industry for prioritising shareholder primacy over what is good for the world [29]. This body of work rightly prompts HCI and interaction design researchers to reflect on their complicity in driving digital consumerism and technological solutionism [40], which in turn are accelerating the planetary ecocide.

Given the widespread penetration of digital technologies, their negative effect on the environment can no longer be neglected [41]. Digital technologies and ubiquitous computing have reached almost all aspects of people's lives, and they have changed the way people relate to each other and interact with their surroundings. The increased use of digital services like search engines, the reliance on mobile devices and the rise of blockchain and cryptocurrencies have an overwhelming effect on energy use [42, 43] and resource exploitation [44]. Forlano suggests that it may be time to decentre the human, particularly as design moves from the studio into the city [28]. DiSalvo and Lukens raise similar concerns, extending them to other domains and applications like farming robots [45]. Drawing on the work of philosophers like Deleuze and Actor-Network Theory, they propose to position humans as "a single factor in a larger system of relations and interactions between humans and nonhumans" [45].

Positioning these concerns within the context of smart cities, Heitlinger et al. organised a workshop at the 2018 Participatory Design Conference, which focused on more-than-human futures [47]. As they flag in their position paper, the adoption of participatory design in smart cities was intended to increase the involvement of non-human voices that would otherwise not be considered. The fallacy, however, has been to implement this approach from a perspective that treats urban space "as separate from nature, and for human inhabitants alone" [46]. To bring more-than-human perspectives into the participatory design of smart cities, Clarke et al. introduced the idea of a speculative urban walk [13] and outlined a research agenda for sustainable smart city futures [49]. We contribute to this body of work by introducing non-human personas as a tool that has the potential to bring non-human concerns into participatory design processes.

### 2.2 Personas as a tool in human and more-than-human-centred design

The notion of personas was first introduced by Cooper as hypothetical archetypes [50]. Originally focusing on goal-directed archetypes of end-users, the method subsequently found its application to capture different kinds of stakeholders beyond the end-user. Personas are an effective way to make sense of and synthesise research data [51, 52], to communicate user needs within the design team [52] and to keep the perspective of users and other important stakeholders at the forefront throughout the design process [53]. Despite criticism, for example, for being seen as a "universal fix to issues within the product design process" [50] and issues associated with interpreting personas [54], they are an effective way to "guard against basing design decisions on our own preferences and biases" [51], and to build empathy for the users [55] and make assumptions explicit [50, 56].

The personas method has previously been applied to represent non-human species in the form of 'animal personas,' for example, to consider non-human stakeholders in designing sustainable food systems [57]. Its extension to include non-human

stakeholders in a design process has also been proposed by and for the user experience community [58], although, to date, lacking accounts of its use in real-world projects. The extension of the persona to non-human species aligns with the critical perspectives and practice in law, philosophy and animal studies that extend the sociocultural and legal construct of personhood from human to non-human animals as a counter to human exceptionality [59]. The method has further been adapted to demonstrate how an entire ecosystem can be represented, using so-called 'ecosystemas' [60].

## 3 Methodology

The article draws on three smart city projects to generatively develop a non-human personas framework. The process of developing the framework involved three phases, which are outlined in this section.

### 3.1 Phase 1—Smart urban furniture case study

To explore the use of non-human personas in smart city projects, we devised a study into smart urban furniture. Going through a concrete design study (albeit speculative in nature), allowed us to create artefacts while at the same time reflecting on the role of those artefacts during the design process. Urban furniture was chosen as a focus as it represents an application of smart city technology that requires a direct consideration of citizens as end-users. We consider smart urban furniture an example of a smart city application, or 'city app' [61], as it provides a digitally augmented interface between people and the city. Previous HCI and interaction design literature has reported on similar interventions, including transforming an urban trash bin to gamify the act of rubbish disposal [62, 63] and sparking encounters through a shape-changing bench [64]. Smart furniture has also been extensively covered in the smart cities and urban studies literature [55], and it represents a prominent example for the commercial application of smart city technology, from smart benches to smart bins.

The study was implemented by one of the authors as their capstone research project and dissertation, working closely with one of the other authors. This means that the data collection from participants took place for the purpose of submitting an educational assignment. Therefore, no formal approval from the University's human research ethics committee had been obtained, which is why we are not able to report on any participant data nor include direct quotes. Yet, the participant data informed the student design work, which is what the article focuses on. Thus, we describe the process and outcomes based on the designer's reflection.

The aim of the case study was to design smart urban furniture in a way that allows for the harmonious cohabitation of humans and natural ecosystems. To address this aim, the study focused on two research questions. First, how can smart urban furniture be designed for human and non-human stakeholders to create green cohabitation spaces in urban environments? Second, how can participatory design methods contribute towards creating a collaborative design approach that involves human and non-human stakeholders?

To address these questions, the study implemented a participatory action research approach [47, 48] that included a workshop and interviews with design students and design academics. A total of 13 people participated in the workshop (held over two sessions with six and seven participants respectively). Two of the authors, who were not involved in the case study, took part in the workshop. During the workshop, participants were taken through brainstorming, concept creation and concept critique activities. All participants were invited to participate in a post-workshop interview, with three people accepting this invitation. The purpose of the interview was to revisit the initial concepts and to receive feedback on the progress and direction of the design iteration. Due to COVID-19, the workshop sessions and interviews were held via Zoom. Miro was used for participants to complete the design activities during the workshop. The final design was informed by a thematic analysis of the participant data (not included in this article due to ethical clearance) as well as a literature review and a survey of commercial solutions (not included here as this is beyond the article's scope).

### 3.2 Phase 2—Developing the non-human personas framework

The framework presented in this article was developed through analysing the non-human personas and the designer's reflective account of going through the process of developing the personas and using the personas (both as a designer and in the workshop and interviews). This process involved the first author reviewing the student capstone thesis documenting the case study, clarifying any questions and gaps in the report with the capstone student and their supervisor (both included as authors). The framework was then iteratively refined through discussions with all authors, bringing in two additional external perspectives. Importantly, the two additional authors had previous experience with non-human personas [65, 66] and more-than-human perspectives in the participatory design of smart cities [67, 68]. We further drew on our experience with middle-out design as an approach for bring together representatives from top-down and bottom-up organisations in community engagement [69], integrating this approach into the framework as a way to form a coalition that is able to speak on behalf of non-human living beings.

### 3.3 Phase 3—Applying the non-human personas framework

To demonstrate how the framework can be used in a smart city context, we retrospectively applied it on two research-led smart city projects—a shared autonomous pod [48, 70, 71] and the Citizen Voices in Cities (CiViC) dashboard [72]—both projects that the first author was directly involved in. The two projects sit on opposite scales in terms of their integration into the environment to highlight how non-human personas can provide value in different design contexts. The autonomous pod project focused on designing an external human-machine interface to communicate the pod's internal status and intent to nearby pedestrians. Thus, it involved designing an interface that is situated within an urban environment. In contrast, the CiViC dashboard was developed as a software application, designed to be used on desktop computers in an office

environment. It visualises data sourced from social media platforms as a way for city authorities to gauge citizens' opinions on large urban developments. For the purpose of demonstration, we outline how each of the four steps of the non-human personas framework could be addressed if it were used in the two projects. No primary data was collected due to the hypothetical nature of the demonstration, but we offer suggestions for how this data could be collected in live projects.

## 4 Smart urban furniture case study

Within the broader field of smart cities, this case study set out to investigate ways of restoring the connection between humans and non-humans within urban environments through applying a more-than-human approach to the design of smart furniture. Following previous literature on more-than-human participation [24] and considerations for such an approach in particular in regard to digital technologies in cities [73, 74], the study considered non-human species in the design process.

The personas method was chosen to represent the primary users of urban furniture. Based on preliminary research, urban dwellers with limited access to green spaces were selected as human users, specifically considering office workers and tenants in urbanised areas (Figure 1, left). As non-human 'users,' the study selected flora and fauna representatives that are native in the Sydney seaside suburb of Manly, which was the chosen geographical location for the study. Specifically, the study considered representatives of possums, birds, bees and plants that are native to the chosen location (Figure 1, right).

### 4.1 Human personas

Given the focus on those that would directly make use of the urban furniture and the conceptual stage of the proposed intervention, the study only considered direct users as human stakeholders. This left out the perspectives of other stakeholders that play a role in the design of city apps, such as public authorities, maintenance workers, business owners and others [75]. Despite this limitation, the proposal that resulted from the design process could serve as a provocation prototype [50] to engage in conversations, for example, with representatives from the relevant local government and other administrative bodies to further iterate the proposed solution.

Based on a review of studies on urban green space use and human/non-human cohabitation (e.g. [76]), office workers and property owners in urbanised areas were identified as instances of urban dwellers and selected to be represented in the form of human personas. The review also yielded data on those stakeholders that was used as a foundation for creating the personas. Thus, the human personas were based on secondary data only, which on the one hand was a limitation of the study but on the other hand was consistent with how the non-human stakeholders were created. In terms of structure, the human personas followed a commonly used template [77, 78], including a backstory, motivations, frustrations, the ideal experience, goals, aspirations and feelings.

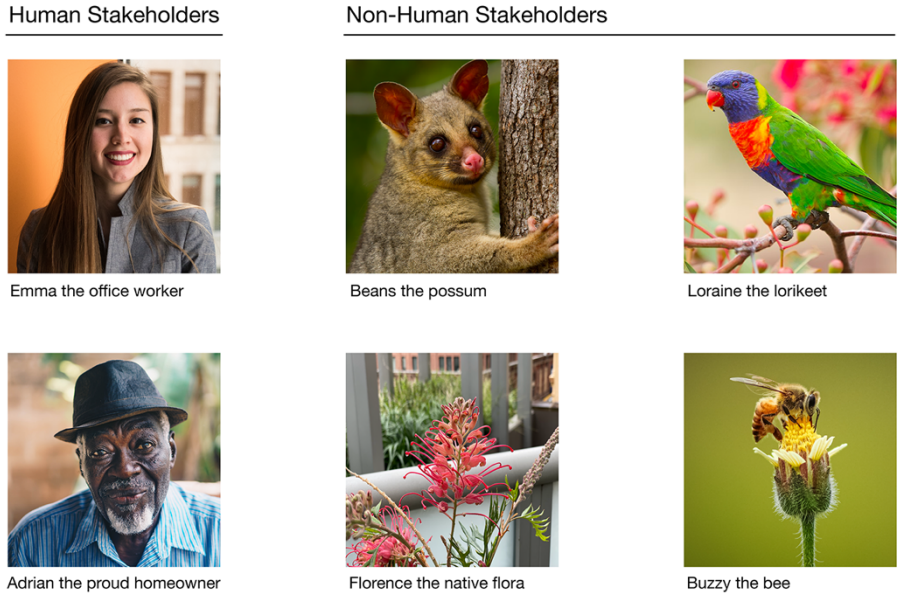


**Fig. 1.** The human and non-human personas that emerged from the background research about smart urban furniture use in the chosen urban location. Image copyrights: Emma persona by Christina on Unsplash, Adrian persona by Fred Kearney on Unsplash, Beans persona from commons.wikimedia.org/wiki/File:Brushtail_Possum_IMG_5005.jpg, Florence persona by Joel Fredericks, Loraine persona from commons.wikimedia.org/wiki/File:Rainbow_Lorikeet_-_AndrewMercer_IMG08212.jpg, Buzzy persona by Ankith Choudhary on Unsplash.

### 4.2 Non-human personas

For the non-human stakeholder identification, the case study started by focusing on ringtail and brushtail possums as native species commonly found in urbanised areas in Australia, making them common urban dwellers that could benefit from urban furniture designs. Possums often thrive in cities, as there are food sources such as residential gardens. Threats to possums living in urban areas include loss of tree hollows as cities cut down trees, replacing them with young trees that take years to form hollows, roadkill and attacks from domestic animals such as cats and dogs. These factors have led to the displacement of many native possums associated with urban development.

Interventions, such as nesting boxes installed in trees [75], are already attempting to compensate for the loss of natural habitat and are a constructive approach towards cohabitation with urban possums [79]. However, these interventions are not as readily adopted by local communities due to the perception of possums being a pest [50]. Attempts to relocate possums into less urban areas have seen mixed results, due to predators such as foxes and competition with other possums. The relocation strategy

has since been replaced by a policy that favours co-living and cohabitation with possums instead.

As additional non-human stakeholders, the case study identified a number of representatives of the native flora, looking for candidates that, though not native to inner city areas, would be able to thrive in an urban location while also providing a source of food and nesting materials for possums. This led to the inclusion of the following plants: red spider flower and narrow-leaved bottlebrush, which are both food sources for possums, and old man's beard (also known as traveller's joy), which is a vigorous twiner providing climbing opportunities for possums. To function as a healthy ecosystem, bees and birds as pollinators were also identified as critical. The selection of plant species also led us to include honeybees, which are common in the chosen location, and rainbow lorikeets as a native bird species.

**Table 1.** The characteristics developed for possums, drawn from existing literature, which informed the 'Beans, the possum' persona.

| | |
|---|---|
| **Lifestyle / backstory** | Beans the possum is usually up during the night while it is quieter and there is less going on around Beans. Compared to during the day when there is plenty of activity from other species, Beans prefers to sleep throughout the day. |
| **Motivations of the persona** | Beans usually prefers a place high above the ground away from other species that might harm him. Beans also does his best to stay out the way of others as other possums are very protective of their established territory. |
| **Frustrations the persona experiences** | Sometimes Beans is captured by humans and is transported to a location away from where he usually scavenges for food and resides. Being held in an enclosure while Beans is transported and being displaced causes great stress to Beans. These displacements are usually fatal. |
| **Issues faced by persona relating to habitat** | It's getting harder for Beans to find a home to rest as trees are being slowly replaced by concrete. The current alternative of a tree to call home is within rooftops of human structures, finding a small opening like a crack to make his way into rooftops. But as Beans is most active at night, he disrupts sleeping humans and this causes humans to attempt to scare Beans out of their house. |
| **Issues faced by persona relating to food** | Most of the time Beans can find food he is familiar with, consuming flora and insects around the area located in gardens or in the trees. Occasionally Beans encounters human food and eats it without knowing it may not be healthy for him; sometimes it makes him sick afterwards. |

Following further research on those identified species and how they are impacted by urbanisation, we decided to group the possum species into one possum persona as their needs and issues overlapped. Similarly, we decided, for the purpose of the case study to group the flora representatives. The personas were informed through secondary data collated from existing research literature and followed a similar structure to the human personas—including a backstory, motivations, frustrations and issues relating to habitat

and food identified from the literature (Table 1). We excluded details about their ideal experience, goals, aspirations and feelings as we were not able to derive this information from secondary data. The non-human personas served as a representation to amplify the agency of the non-human stakeholders, who would not be able to make themselves heard in the participatory design process [72].

### 4.3 Employing the personas

The personas were used as a design tool throughout the design process, as a way to inform the initial concept design and to evaluate potential solutions and their features (Figure 2, left and centre). During the workshop sessions and interviews with designers and design academics, participants were invited to provide a critique of the initial design concept taking the perspective of the non-human personas. For instance, this led to a discussion about and the consideration of the potential impact of wireless charging stations on the wellbeing of birds. As a consequence, wireless charging stations were removed from the final design proposal.

When iterating the design concept based on the collected data from the workshop and interviews, each decision was evaluated against the human and non-human personas, as suggested by the personas method [80]. For example, a rainwater system was added to serve both irrigation of the plants and as a water source for possums, bees and birds. The effect of illuminating the seating area at night was also carefully considered in terms of its potential impact on possums and other nocturnal species, and to reduce further contribution to light pollution [81]. As a consequence, the final design proposal accounted for sensors and two different types of light-emitting diodes (LEDs). The sensors would activate white LEDs to provide clear visibility and safety at night, whereas in the absence of human users, red LEDs would subtly illuminate the space without interfering with nocturnal species. These considerations raised questions and opportunities for further technological explorations, such as the development of sensors that would be able to distinguish between human and non-human presence. The final design concept was represented as a three-dimensional rendering (Figure 2, right) along with specifications for materials, safety and the lifecycle of materials.

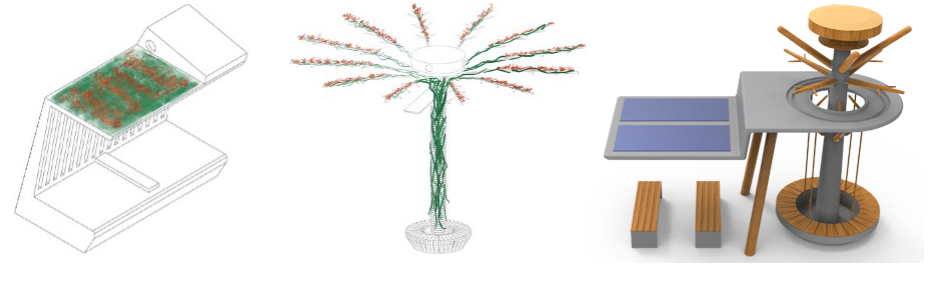

**Fig. 2.** Two early sketches of the design proposal (left and centre) and a three-dimensional rendering illustrating the final design proposal and its key features to allow for the cohabitation of humans and non-human species (right). (Image courtesy: Dan Vo)

### 4.4 Reflection on the use and value of non-human personas in the case study

The proposal for a smart urban furniture that promotes cohabitation of humans and possums and other species remains a speculative design intervention. We acknowledge that many challenges would need to be addressed for the proposal to be implemented as a real product. Rather than suggesting that this would serve as a blueprint for future urban furniture products, the case study aimed to explore an alternative approach to designing a smart urban intervention. In particular, and relevant to the contribution discussed in this article, going through the design process that prominently considered non-human stakeholders from the outset, enabled us to address a new set of questions and gain insights about the representation of non-human stakeholders in a design process. Designing for non-human users is not a new area within HCI and interaction design. Previous studies have investigated the design of buttons for dogs [82], environmental enrichment experiences for elephants [83], and how to co-design an interactive installation to enhance the wellbeing of orangutans [49]. However, the case study discussed here goes beyond those kinds of studies as it considered human and non-human users in concert.

The non-human personas proved successful at prompting and supporting expert participants with critiquing a design proposal through the lens of non-human stakeholders. From the designer's perspective, the non-human personas served as a reminder to keep the issues of non-human species in mind when making design decisions. To that end, they took on a similar function to human personas in interaction design projects, helping designers, to "keep our users in mind every step of the way" [58]. Both through the workshops and through using the personas when making design decisions, the non-human personas prompted the exclusion and inclusion of specific features. It remained unclear, however, to what extent the non-human personas accurately encapsulated and represented the lifeworld of the respective species. Moreover, we were not able to capture their needs and desires in a holistic and reliable way. To address some of these limitations and building on the insights from the presented case study, we propose a framework for developing and employing non-human personas, which we introduce in the following section.

## 5 The non-human personas framework

An important and frequently discussed consideration when creating personas pertains to how the persona and its characteristics are derived. Personas should be based on primary data collected through field research [55], which may include interviews and observations. This kind of primary data is more difficult to collect when it comes to creating personas for non-human species. Although, primary data could be obtained using methods like contextual observation, this can be challenging when it comes to some species, such as nocturnal animals or underwater lifeforms. Observations are further likely to miss intricate concerns and aspects of the observed non-human species. Critically, this kind of data collection raises ethical questions, not covered through traditional human research ethics protocols, as the researcher might negatively interfere with the species and their ecosystem.

In the case study presented above, secondary data derived from academic literature and publicly available reports was used to inform the non-human personas. However, this approach is limited as it may dismiss critical considerations that are not documented in the literature. Tomlinson et al. [28] suggest developing representations of ecosystems through a collaboration between designers and biologists or ecologists, and others with relevant expertise. They go on to highlight an opportunity for a new role or profession to serve as an advocate for a specific ecosystem during the design process. Frawley et al. [65, 66] used both primary and secondary data to create animal personas. Focusing on farms and food systems, they drew on interviews with farmers and observations of chickens in commercial and backyard settings. Drawing on Latour, Forlano suggests that designers are well-placed to operate as advocates for non-human stakeholders when it comes to city-making and navigating top-down and bottom-up strategies [84, 85].

In this section, we build on these observations and the middle-out engagement literature [55, 80–82] to propose an approach for collecting primary data about non-human species through involving representatives from the top and the bottom. As such, the middle-out engagement forms a central component of the proposed framework for creating and employing non-human personas, resulting in a 'coalition' that is able to speak on behalf of a non-human species in a knowledgeable and productive way. The framework involves four steps (Figure 3), which are detailed below.

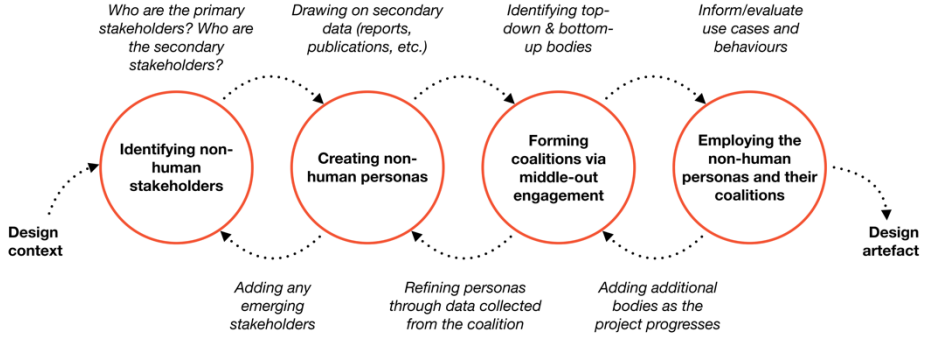


**Fig. 3.** The four steps of the non-human personas framework. The diagram captures the fact that developing the personas is an iterative and ongoing process.

### 5.1 Step 1—Identifying non-human stakeholders

The first step is to identify which living beings may need to be considered in a design process. Following the literature on personas, this should ideally include both primary and secondary stakeholders. In interaction design, the primary stakeholders are typically described as the end-user. In our case study, end-users comprised both human city dwellers and possums as per the initial design brief. Since the term 'users' is associated with humans interacting with products, we employ the term 'primary stakeholders' in our framework instead.

Secondary stakeholders encompass other groups that may be affected or have an interest in the design intervention [50]. In our case study, birds, bees and certain plants were identified as secondary non-human stakeholders as they are key representatives of the broader ecosystem that possums are part of and important contributors to ensuring the health of the ecosystem. Thus, a useful strategy for identifying relevant non-human stakeholders in design situations where non-human species are considered as primary stakeholders from the outset, is to start with those species and to then review the role of other living beings that are part of and contribute to the species' ecosystems. Throughout the design process, the classification of primary and secondary stakeholders may change based on input from the coalition (step 4) or other insights. For example, it may be argued that plants growing around the bench should also be considered primary stakeholders, which would have likely led to a different design proposal.

In many cases, the impact of digital technology and ubiquitous computing applications on the natural world is not immediately obvious. In other words, many design projects do not consider non-human primary stakeholders at the outset. The majority of these kinds of applications are and will continue to be designed to address human concerns. While a growing body of work from animal-computer interaction and other domains explore how to design digital technologies for non-human species [86], our aim in this article is not to argue for a shift towards designing for non-human species. Rather our aim is to encourage designers to always look for non-human stakeholders that may be impacted by their design decisions, even in situations where there are no obvious primary non-human stakeholders as 'users' of the designed system. In other words, the framework is constructed to allow its application in projects that involve primary non-human stakeholders as well as situations that only involve secondary non-human stakeholders.

For the latter scenario, it is more challenging to identify the non-human stakeholders, and designers may need to augment this step with other methods. For example, the impact ripple canvas can be used to identify a network of secondary and tertiary actions and mapping out intended and unintended consequences of a design intervention [87]. Unintended consequences typically offer insights into a design intervention's impact on the natural environment. Examples for such consequences are the use of resources that may impact an ecosystem (e.g. space and electricity demands by server farms) and issues associated with the post-use life of electronic products (e.g. products ending up in landfill).

Some secondary non-human stakeholders are closer and more obvious than one might think. For example, as Sznel points out, in 2020, COVID-19 was the "most important non-human stakeholder of every business and public service around the world" [55]. In the case of COVID-19, the presence of the virus within communities may influence how design interventions are implemented, for example, avoiding touch-based input control mechanisms [51].

### 5.2 Step 2—Creating non-human personas

In the second step, an initial archetype representation for each of the identified non-human stakeholders—both primary (if applicable) and secondary—is created. This

involves reviewing literature, articles and/or relevant reports, and synthesising data points according to the non-human persona structure (e.g., using a deductive content analysis). Based on common guides for human personas, previously published animal personas [52] and the structure employed in our case study, we suggest the following categories for non-human personas: Type/species, age/lifespan, local population, needs/motivation, food/food sources, challenges/stressors, 'interacts with' and habitat. However, similar to human persona structure guides, these categories are not fixed, and can and should be adapted according to the specific design situation.

As with human personas, a non-human persona should be an aggregate of stakeholders that share common behavioural characteristics [55]. In our case study, we developed one aggregate possum persona as we found the ringtail and brushtail possums to have common characteristics based on the review of relevant literature. A name and a picture are added at this stage, to make the persona seem like a real living representative of their species—the same way a fictional name and picture make a human persona seem like a real person [65, 66]. We suggest adopting the third-person form to represent the data for each of the categories, following the observation by Frawley et al. that this acts as a reminder "that the character remains grounded to a human perspective" [35].

### 5.3 Step 3—Forming coalitions through middle-out engagement

The third step in our non-human persona framework is to assess whether the persona accurately represents the identified non-human stakeholders and to add any missing information that is important within the context of the design project. This may lead to a revision of some or all of the categories and includes the formulation of a descriptive narrative of the species' typical behaviour. To achieve this, we adopt an established middle-out engagement approach [38, 88]. Middle-out engagement combines the collective knowledge of stakeholders from the top (government agencies, private enterprise) with those from the bottom (local communities, non-governmental organisations, Indigenous peoples). The approach has been successfully employed by the authors in a range of community engagement projects in order to ensure human voices from people on the ground and grassroots organisations are heard and amplified. In the case of non-human stakeholders, representative community groups standing in as proxies for non-humans will often have much more nuanced knowledge about local species. Traditionally interaction design has largely focused on using participatory design methods to include humans involved in bottom-up initiatives associated with political activism and social agendas [89]. This repertoire of participation and engagement now needs to expand to also include the agency of non-humans represented by grassroots movements and environmental groups that have often been excluded from decision-making around strategic planning and policy development.

Although the organisations in charge of these top-down actions may not have the same level of knowledge about a local issue, their 'buy-in' is critical for the efficacy and long-term success of an initiative. This has recently been reiterated in the participatory design literature under the label of 'institutioning' [36]. When it comes to non-human stakeholders and their concerns, the involvement of institutional

organisations plays a key role as they control regulations, policies and other governance aspects that have an impact on the non-human stakeholders.

The middle-out engagement approach is used to identify people that will form a coalition that is able to collectively speak on behalf of a non-human stakeholder (Figure 4). For example, top-down representatives could include people working in government agencies that drive policy and regulatory requirements for environmental and species protection, and ecologists that are undertaking investigative work for land management, agriculture and infrastructure development. Bottom-up representatives could include people that come from grassroots entities, such as conservationists, animal welfare groups, wildlife carers and Indigenous peoples, who have a strong connection to land and country [13, 90]. The middle-out engagement seeks to gather the expertise, knowledge and interests of these bodies as they pertain to the wellbeing of the identified non-human stakeholders. By employing a dialectical approach [52] in order to meet in the middle, there is an opportunity to move outward and forward, creating a unique coalition for each of the non-human stakeholders.

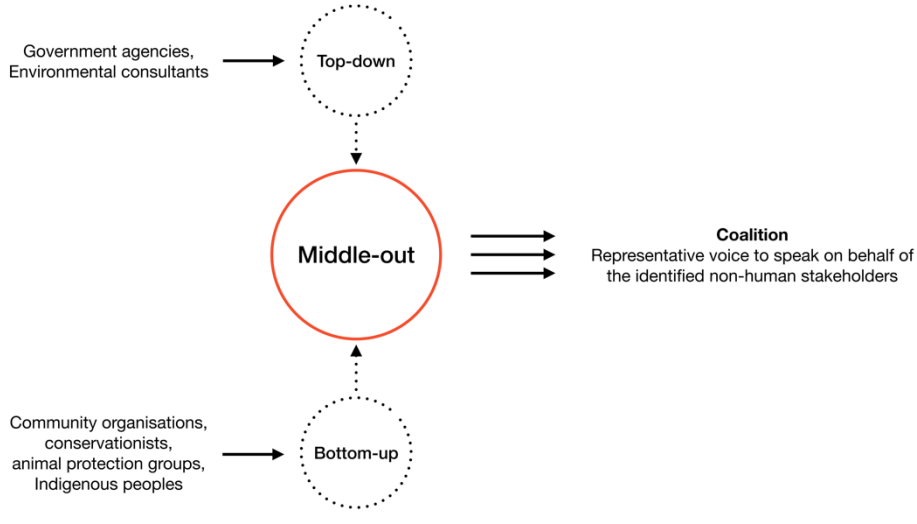


**Fig. 4.** The middle-out engagement approach for forming a coalition that is able to speak on behalf of an identified non-human stakeholder.

Once formed, each coalition is presented with the preliminary non-human stakeholder, inviting them to critique the representation and to add additional data. This can be achieved through employing participatory methods, such as workshops, focus groups and yarning circles, involving representatives from all bodies that make up the coalition. A key outcome from these participatory sessions is the collective development of a descriptive narrative of the behaviour of the identified non-human persona. These narrative descriptions provide rich data that bring the persona to life [51, 52], ideally through a vivid story concerning the needs of the persona in the context of the design intervention [67, 68]. It is possible that during this step a persona is split into multiple representations if unique characteristics and behaviours are identified,

and/or that additional stakeholders are identified. For example, male and female representatives of a species may exhibit different behaviours, or a species' needs may change over its lifetime.

### 5.4 Step 4—Employing the non-human personas and their coalitions

Upon revising the non-human personas and adding narrative descriptions, they can be used in the design process alongside and in the same way as human personas. As illustrated in our case study, this includes using them from the designer's perspective to assess design decisions as well as with expert participants, for example, in design workshops as a way to prompt participants to critique a design solution through the perspective of non-human stakeholders. The same way that human personas serve as a way to keep the user centre stage [69], non-human personas act as a reminder to consider the direct and indirect impact of design decisions on the natural environment.

The coalition also remains a readily accessible resource throughout the remaining timespan of a design project and beyond, carrying the voice of the identified non-human stakeholders. Designers can use the coalition, for example, to test early prototypes of a design intervention, to provide advice on the launch of a product or to regularly assess potential unintended consequences once a design has been deployed.

## 6 Applying the non-human personas framework

In this section, we demonstrate how the framework can be applied to identify non-human stakeholders and to create representative personas using two research-led smart city projects (Table 2). By outlining the practical decisions we took in each of the steps of the framework, we hope to make the non-human personas framework accessible to a broad audience. The projects used as examples here did not originally include any considerations of non-human stakeholders. The steps outlined in this section are, at this stage, purely hypothetical for the purpose of demonstrating the framework.


**Fig. 5.** Two smart city research projects were used to demonstrate the retrospective application of the non-human personas framework: Shared autonomous pod (left) [67, 68] and the CiViC dashboard (right) [91].

**Table 2.** The non-human personas framework and its steps illustrated through two smart city projects.

| **Step** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **Description** | **Identifying non–human stakeholders** | **Creating non–human personas** | **Forming coalitions through middle–out engagement** | **Employing the non–human personas and their coalitions** |
| **Example 1: Autonomous pod** | ***Primary stakeholder***<br>- Dogs<br><br>***Secondary stakeholders***<br>- Dogs<br>- Cats<br>- Possums<br>- Ibis<br>- Microbats<br>- COVID-19 | ***Secondary data***<br>- Animal law guide for NSW<br>- RSPCA: Taking my dog on a road trip with my family<br>- Transport for NSW: Assistance Animal Permit<br>- City of Sydney: Pet & animal services | ***Top-down bodies***<br>- NSW Transport<br>- NSW Pet Registry<br>- RSPCA animal shelter<br><br>***Bottom-up bodies***<br>- Dogs NSW<br>- Animal Welfare League NSW<br>- National and local Facebook groups (e.g. Australian Pet Owners Group and Darlington Dogs) | ***Persona***<br>- Decide on user cases<br>- Signalling and sensors<br>- Driving behaviour<br>- How sensors work and what they recognise<br><br>***Coalition***<br>Test prototype with the coalition using 360-degree video prototypes |
| **Example 2: CiViC dashboard** | ***Secondary stakeholders***<br>- Eucalyptus trees<br>- Koalas<br>- Birds<br>- Insects | ***Secondary data***<br>- CSIRO Publishing: Eucalyptus, Wildlife and Nature Conservation<br>- Eucalypt Decline in Australia, and a General Concept of Tree Decline and Dieback | ***Top-down bodies***<br>- NSW Office of Environment and Heritage<br>- Australian Industrial Ecology Network<br><br>***Bottom-up bodies***<br>- Treenet<br>- Australian Koala Foundation<br>- Friends of Koalas<br>- Eora nation people | ***Persona***<br>- Ensure relevant environmental data is included<br>- Assess long-term impacts on the environment<br>- Assess levels of community engagement<br><br>***Coalition***<br>Test dashboard features with coalition through co-design workshops |

### 6.1 Shared autonomous pods and non-human stakeholders

We selected this project as an example as it involves the integration of digital technologies into urban space. In that way, it is similar to the presented case study on urban furniture and has a direct tangible impact on the natural environment. However, different to the case study, the autonomous pods were designed for human users only. The project involved interaction design researchers working with robotic engineers and urban planners. The autonomous vehicle (AV) platforms (Figure 5, left) have the

sensing and computation capacity to eventually operate fully autonomously. The vehicle's small form factor allows it to operate safely in low-speed road environments (under 40 km/h) and close proximity to pedestrians. Fitting up to two people, the AV prototype was designed to function as a shared pod to transport people between the nearby train station and the university campus and around the university campus, which sits across two Sydney suburbs. As interaction designers, we focused on devising a low-resolution lighting display serving as external human-machine interface to communicate the vehicle's intent and awareness to nearby pedestrians and riders [68].

**Step 1.** Applying the first step of the framework, no obvious primary non-human stakeholders were identified. As secondary stakeholders we identified species that may be at risk of being hit by an approaching AV. To that end, we included possums and ibises as native species as well as cats and dogs as domestic animals. Dogs may further need to accompany their owner and ride along in the vehicle. Microbats, which live on the university campus, were added as their sense of navigation could potentially be affected by sensors used in the AV. We also added COVID-19, as the virus has an impact on how people are able to share a vehicle. Details for this and the following steps are provided in Table 2.

**Step 2.** We focus on dogs as a stakeholder to demonstrate the second and remaining steps of the framework. Using a combination of online search and snowballing, as well as drawing on our knowledge of work in this area, we identified a number of academic works (e.g. [69]), online articles and reports as sources to collate data about dogs and transport (cf. Table 2). This led us to a report on assistance dogs, which prompted a discussion about how, for example, guide dogs would interact with an AV. We consequently decided to add guide dogs as a primary stakeholder. This demonstrates the iterative nature of the framework, as new stakeholders may be added at any step along the way. In a live project, this data would be used to create a dog persona, for example, captured as 'Jackie,' the Jack Russell terrier, who lives near campus and sometimes takes his owner for a walk across campus to get to the nearby park.

**Step 3.** In the third step, we collated relevant organisations that we were familiar with and searched for additional organisations specific to the local area, categorising them into top-down and bottom-up initiatives (cf. Table 2). As this remained a hypothetical exercise, for the purpose of illustrating the framework, we did not approach these organisations. In practice, the subsequent action would be to recruit at least one representative from each of the organisations and to form a coalition, bringing them together, for example, through a focus group, for the purpose of reviewing and augmenting the 'Jackie, the Jack Russel terrier' persona.

**Step 4.** This step was not implemented due to the hypothetical nature of the example, however, in this step, the designers would be able to use the developed dog persona and other personas to evaluate how the AV's external human-machine interface and driving behaviour would interact with the identified species. These considerations might also inform the development of the AV's sensors, for example, ensuring that the AV reliably not only identifies people but also ibises roaming the campus. The coalition could be brought back at a later point to test a further developed prototype of the AV in scenarios involving some of the non-human stakeholders. These tests could be facilitated using a 360-degree virtual reality prototype [50] given the complexity of doing field tests of AVs.

### 6.2 The Citizen Voices in Cities dashboard and non-human stakeholders

The second example is based on the CiViC (Citizen Voices in Cities) dashboard project, which was developed for local government authorities (LGAs) to support other community engagement initiatives in regard to large urban developments [42]. The dashboard collates and visualises public posts made on social media, demonstrated through Twitter (Figure 5, right). The objective was to gather voices and opinions from citizens beyond those typically attending traditional community engagement activities. For the implementation of the project, we worked with representatives from two Australian LGAs (one in the Greater Sydney region and one in Greater Brisbane region) and implemented the dashboard as a prototype presenting data for those LGAs. The CiViC dashboard was developed as a web platform built on a continuously updated database of online data and offering different visualisations to explore this data, using sentiment analysis and clustering.

**Step 1.** There is an overwhelming list of non-human species that are directly impacted by urban developments and hence should be considered in the design of the CiViC dashboard. After reviewing potential candidates, we selected eucalyptus trees, koalas, birds and insects considering Sydney as a location for the dashboard. Though we did not carry out this step, the impact ripple canvas method [92] could be used to look for more distant unintended indirect consequences. For example, this may lead to identifying the negative effects of data centres that are required to generate the data in the first place and to host the database and server infrastructure used by the dashboard. These effects may include electricity consumption, which has been widely discussed and documented [93], affecting the Earth's atmosphere, waterways and ecosystems [92]. Details for this and the following steps are provided in Table 2.

**Step 2.** We focus on the eucalyptus tree to demonstrate the second and remaining steps. Eucalyptus trees are an important stakeholder because of their wide contribution to habitat resources of many non-human animal species [93]. We subsequently identified secondary data available through government websites and reports, news articles and academic works that document the impacts of urban development, agriculture and climate change on eucalyptus trees (cf. Table 2). In a live project, this data would then inform a persona, for example, captured as 'Carcoola' the eucalyptus tree that lives in the Sydney Hills District amongst many native and foreign plant species.

**Step 3.** We employed the same process as in the previous example, by collating relevant organisations that have a connection to eucalyptus trees and categorising them into top-down and bottom-up initiatives (cf. Table 2) implementing a middle-out approach. If this step were to be actioned, we would recruit at least one representative from each of the organisations to form a coalition, bringing them together, for example, through a focus group, for the purpose of reviewing and augmenting 'Carcoola, the eucalyptus tree' persona.

**Step 4.** Using the directly impacted persona of 'Carcoola' may prompt additional ways of sourcing, aggregating and visualising the data collected from social media platforms. For example, the dashboard could be designed to include readily available filters for looking for posts about eucalyptus trees and other non-human species or from relevant representative organisations.

# 7 Discussion

Based on our investigation of non-human personas, this section discusses key principles for creating and using non-human personas. We adopt the definition from Löwgren and Stolterman [94], who suggest that "methods should be seen as tools for developing the designer's abilities." Following that definition, non-human personas can be seen as both a method and a tool. The principles discussed in this section capture both perspectives. Although the principles (as well as the overarching non-human personas framework) are grounded in a smart city context, they are formulated in a way to enable their use in HCI and interaction design projects more broadly. The section also discusses the limitations of non-human personas and the presented framework.

## 7.1 Key principles for creating and using non-human personas

***Improving the designers' understanding.*** As a method, non-human personas enable designers to develop a better understanding of the needs of non-human stakeholders and the impact of their design decisions on living beings. In that way, developing non-human personas has the potential benefit of augmenting the designer's understanding of direct and indirect impacts that design decisions may have on the natural environment.

***Assessing design decisions.*** Non-human personas enable designers to carefully assess design decisions through the lens of the species they represent, without having to constantly go back to the coalition that carries the voice of the non-human stakeholder. It is important, however, to be aware of potential biases that could be introduced into the design process through relying on persona representations [58].

***Externalising gaps.*** We see potential value in representing and rendering visible non-human stakeholders even if in constructing a non-human persona we externalise gaps in our knowledge or misunderstandings. Only when made explicit can assumption be corrected, challenged and critiqued [94, 95]. Other tools and methods may be needed to support and augment this process, and in some cases having a specialised advocate directly embedded in the design team, as suggested by Tomlinson et al. [13, 52], may be required to better understand the complex entanglement of human and non-human actors in urban environments [95, 96].

***Advocating for non-human species.*** As a tool, non-human personas have the potential to support designers in advocating for non-human stakeholders, who would otherwise not have a voice in the design process. They enable designers to keep the needs of and potential impacts on non-human stakeholders visible in a tangible way throughout the design process, which is in line with the documented benefits of human personas [28] and participatory design [93]. In line with Forlano [49], we argue that designers are well-placed to take on that role, in a similar way as they took on the role to advocate for users and their needs.

***Flexibility and adjustments.*** As Löwgren and Stolterman highlight, the choice of a particular method depends on the particular design situation at hand and the people involved [94]. The flexibility of the original persona method may have contributed to its widespread uptake in interaction design. Depending on the situation and the people involved, designers tend to apply personas in creative and flexible ways [53]. Hence, the non-human persona framework is intended as a starting point with the possibility for interpretation and adjustments as required by the specific design situation, team and resources.

***Iterative refinement.*** As highlighted in the presented framework (Figure 3), we suggest that developing and using non-human personas is an iterative and continuing process. This is supported through previous literature documenting the value of iteration, for example, for data-driven human personas [97]. Specific to the presented framework, we identified three situations where it may be beneficial to return to one of the previous steps in the framework. First, employing the non-human personas and their coalitions may reveal other top-down or bottom-up bodies that need to be added to the coalition to extend the perspectives and knowledge about the non-human species represented in the persona. Second, data collected from engaging with the coalition can and should be used to refine the non-human personas, which will help with eliminating assumptions that may have been made when first constructing the persona. Third, as the non-human persona is being refined, other non-human species may emerge that are part of the same ecosystem and need to be considered in the design process.

### 7.2 Limitations

There are documented limitations of personas, such as uncertainties about their validity [98], the risk for them to be biased by the designer's mindset [98] and to be used to justify decisions after the fact [99]. These limitations equally apply to non-human personas, although, we believe that employing a coalition has the potential to address some of the limitations. However, ultimately the use of a non-human persona and its interpretation will be affected by the designer's biases. It is, therefore, important to acknowledge that non-human personas are not a fix for all environmental issues caused by digital technologies and how people interact with them in their daily lives. The value of non-human personas as a tool is intrinsically linked to its application and the designer's ability to productively use the tool throughout a design process.

We also need to acknowledge that non-human personas when misused could even be harmful to the species they represent. For example, selectively including information about the represented species could hide critical issues, or non-human personas could maliciously be used to identify and eliminate animals and plants considered threats or nuisances within an urban development project. We must also acknowledge that the way we have conceptualised the non-human persona framework purposefully limits the designer's attention to the design process in action. There is a risk that the designer may fall back into the habit of considering just reducing harm rather than identifying design solutions of mutual benefit for humans and non-humans alike. It also begs the question what motivated (and who paid for) the design project in the first place, which often remains embedded in a human-centric economic framework.

While we demonstrated the framework through two examples, we have not yet assessed the framework and the use of non-human personas through empirical data collected in live projects. We intend to do this in our future work, and we hope that others will find the presented framework useful for adopting non-human personas in their work and contribute through their own case studies and accounts. In particular, empirical data will be able to show to what extent and in what ways non-human personas can influence design decisions in projects that do not consider primary non-human stakeholders at the outset. An interesting perspective here could be to study their potential to manifest a political layer in design projects, an effect that has been observed with human personas [100]. In a similar way, non-human personas may prove an effective way to engage design students in environmental considerations and developing an awareness about unintended consequences of digital technologies, juxtaposing human-centred curricula.

## 8 Conclusion

With urban populations rising, urbanisation and population growth represent major contributors to resource shortages and climate change [101]. To grow sustainably and to combat climate change as a whole, cities need to implement new strategies and approaches that do more than just focus on the efficient management of energy, water and other resources [72, 102, 103]. In response to these issues, new smart city frameworks are emerging that replace the technocentric top-down initiatives developed by large tech corporations with approaches that focus not only on sustainability but also on social impact [104, 105] and a net positive design [106, 107]. To achieve this, many smart city initiatives have turned to citizen participation as a way to draw on the collective knowledge of the public [65, 66]. However, as our review of previous work across HCI, interaction design and smart cities highlighted, more-than-human participation is critical given that the urban environment cannot be seen as separate from the natural world.

To contribute to this emerging body of work, we presented a framework for non-human personas, developed based on a case study and informed by previous literature, including work on animal personas [107] and middle-out engagement [108–110]. We outlined how non-human personas can be used in situations where human and non-human stakeholders are equally considered as ‘users’ from the outset (as in the smart urban furniture case study). We further demonstrated how the non-human personas framework can reveal more-than-human perspectives when designing ICT solutions through retrospectively applying it to two smart city projects. We found that beyond ensuring that the needs of non-human stakeholders are considered when making design decisions, taking a more-than-human approach can also highlight areas for innovation, such as developing new kinds of sensors.

Returning to the focus on smart cities, our assessment of personas as a tool for representing non-human stakeholders, led us to raise questions about the role and shape of more-than-human participation in future smart cities. Could we contemplate an entirely post-anthropocentric non-human-led design process, which nonetheless recruits and employs the labour and skill of human designers in service of more-than-

human outcomes and benefits? Yet, how would we surrender our human design abilities for the proliferation of more-than-human lifeworlds without the obligatory lens of human perception and interpretation interfering with the non-human intent? These are timely questions not just for design research in general but for the smart cities field specifically, as post-anthropocentric cities [108] can and should take a leadership role in addressing the environmental crises and averting a planetary ecocide. We believe that design research can positively influence the direction of smart cities if some of these open questions are addressed in future research. It is these ontological and axiological inquiries the environmental humanities have been pondering for quite some time [109–111] that will continue to make for fascinating and urgent scholarship to advance design research into the future and guide smart cities to become genuinely sustainable.

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