

How much citizen science does city science need?

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About a decade ago, the technology-enabled rise of (big) urban data and the concept of the ‘smart city’ started fuelling scholarly debate about a new urban science. This also included innovative and empowering perspectives which linked tech- and data-enabled urban planning, modelling and monitoring with public participation and stakeholder engagement to tackle cities’ most complex and challenging problems (Goodspeed, 2015; Townsend, 2015). Townsend concluded in one of his seminal articles that the ‘great challenge for new urban scientists won’t be creating new knowledge but creating the frameworks that establish an open and level playing field for all involved’ (ibid), including citizens, local communities and other city stakeholders. A few years later, in an editorial to this journal, Yang and Yamagata (2019) contemplated the complexity and uncertainty of urban systems and the challenge of designing and managing them, reflecting again on the new era of the ‘smart city’ and its wider implications. Almost as an afterthought, they noted: ‘Cities should not be designed as automatic machines that are based on top-down control, but we are still not quite sure how citizen science, crowdsourcing or other bottom-up processes will be realized for shaping sustainable, resilient and just communities that benefit from these new technologies’ (ibid). Batty (2023) has since called for new initiatives to bridge urban theory and practice, especially in the face of increased organisational complexities, diverse actors, emerging technologies and public participation opportunities. He pointed at the insufficient integration of theoretical tools into practical decision making and attested that public participation remained a half-hearted process, still failing to meaningfully deliver solutions to complex urban problems. Arguably, we are in a better position today to highlight how citizen science as a form of public participation and its methodological siblings including community (-based) monitoring (Danielsen et al., 2022), volunteered geographic information (VGI) (See et al., 2025), crowdsourcing (Haklay, 2013), citizen observatories (Hager et al., 2021) or participatory urban mapping (Brown et al., 2018) can contribute to establishing such operational frameworks and approaches, as well as to enabling more inclusive and sustainable cities by implementing them.

Citizen science has grown dramatically in recent years, with cities emerging as key hubs of participation and data creation. One well-known example is OpenStreetMap (OSM). It is considered human’s greatest collective, open source and volunteer-led initiative to map the Earth’s surface and one of the most successful, collectively maintained and regularly updated open datasets in history. Just in the last 60 minutes of writing this piece, 900 contributors made 184,688 map edits in 113 countries.¹ It was started in an urban area – Regent’s Park in London – in 2004 (another decade before Townsend’s article). By 2009, Map Kibera,² which is based on OSM, was the first ever-created map of Kibera in Nairobi, considered then one of the largest informal settlements in Africa. This community-driven effort literally put people on the map, acknowledging their existence in the city. As a result, city officials, who could no longer ignore this large community of city dwellers, started to consider Kibera in urban planning processes. Map Kibera is still ongoing today and has become a thriving ‘interactive community information project’, which has expanded to other informal settlement areas (Mathare and Mukuru), all

backed by the Map Kibera Trust whose mission is to ‘increase influence and representation of marginalized communities through the creative use of digital tools for action’.

Though notable exceptions exist, the citizen science activities, which rely on human observation on the ground, are largely geared toward urban areas and human settlements, addressing topics around pollution, heat, greenspaces, odour and noise, traffic and flooding, to name just a few examples. These and many other citizen science initiatives are shaping policy by providing credible local data and mobilising civic action. Data from Sensor.Community³ are now integrated into the Netherlands’ official ‘Measure Together’ platform, where the National Institute for Public Health and the Environment calibrates volunteer measurements to support local decision making (Crowd4SDG, 2022). The Making Sense project translated community sensing into municipal action in Barcelona, where residents’ noise data prompted revised street-cleaning schedules (Coulson et al., 2017), while the Curious Noses project influenced Flemish election debates and strengthened the case for Low Emission Zones (Van Brussel and Huyse, 2019). Additionally, the D-NOSES project advanced odour governance by developing a municipal model to guide odour regulation, highlighting the utility and potential of citizen science and odour pollution for the EU Action Plan ‘Towards Zero Pollution for Air, Water and Soil’.⁴

The urban bias in citizen science data is evident, even, where the subject matter is not primarily considered an urban-first topic. Let’s have a look at iNaturalist,⁵ for example. It is one of the greatest human and planetary endeavours to document and map presence-only biodiversity, which is overall the richest and most abundant outside urban areas. However, zooming in on Brazil, the country with the largest share of Earth’s biodiversity in terms of species richness and one of the highest levels of species abundance, one finds that the biodiversity records on iNaturalist are densest around urban centres and main travel routes (Figure 1). The same picture emerges in other places, where rural and natural environments are generally more accessible and populated (Figure 2).

Given the (un-)intentional urban focus of many citizen science projects and datasets and considering recent efforts to grasp urban-specific citizen science since 2013 through systematic reviews (Beck and Mitkiewicz, 2025; Bonhoure et al., 2025), some interesting ‘opportunity niches’ (ibid) emerge. The benefits of urban citizen science are generally well understood and supported by best-practice examples, both in terms of citizen engagement and in delivering urban data and insights. Furthermore, citizen science is considered a promising mechanism to enhance ethics and

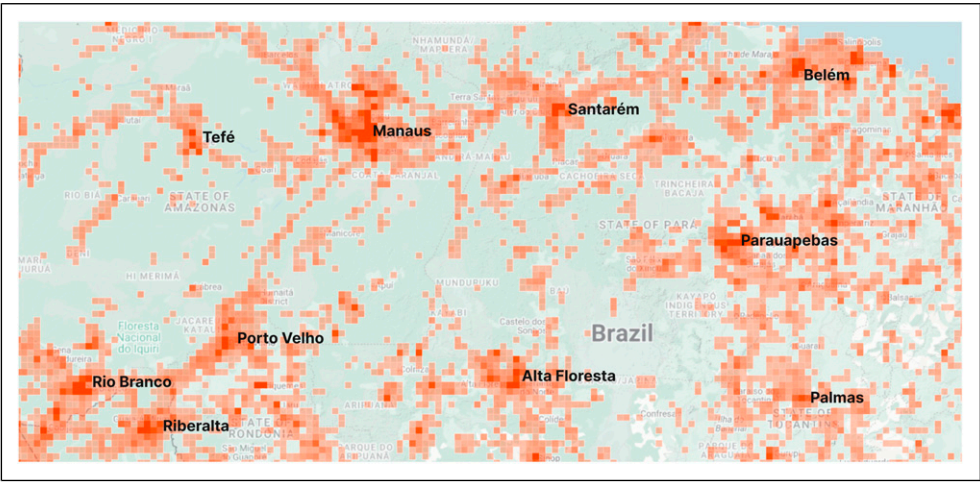


Figure 1. Annotated map visualisation of biodiversity observation density in Brazil from iNaturalist.com, Map data © 2025 Google (07.10.2025).

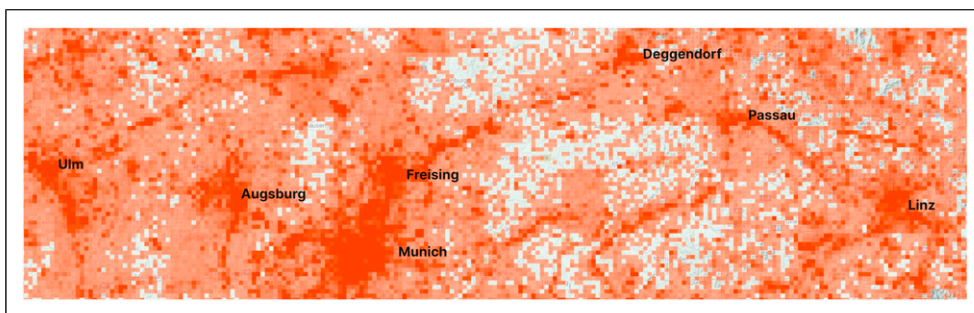


Figure 2. Annotated map visualisation of biodiversity observation density in South Germany/Upper Austria from [iNaturalist.com](https://www.inaturalist.com), Map data © 2025 GeoBasis-DE/BKG (©2009), Google (07.10.2025).

transparency of the research process as well as reaching and helping to amplify often marginalised voices and perspectives in addressing urban planning and sustainability challenges. Despite extensive urban datasets and proven participatory value, citizen science continues to be underutilised in both city science and urban planning.

At the same time, scholars have begun examining legal implications and policy dimensions of citizen science practices and data. For example, in the context of environmental governance, discussions have focused on the UNECE Aarhus Convention, which guarantees people's rights to access information, participate in decision making and access to justice in relation to environmental concerns (Berti Suman et al., 2023). While access to information and justice are essential, Berti Suman et al. also deliberately argue and advocate for an amendment to the UNECE Aarhus convention,⁶ suggesting a fourth right to not only access but also 'to meaningfully contribute data' (ibid). Furthermore, studies led by colleagues at the International Institute for Applied Systems Analysis have highlighted the contribution potential of citizen science data to monitor the indicators of several endorsed, but non-binding policy frameworks, such as the UN Sustainable Development Goals (SDGs) (Fraisl et al., 2020; Fritz et al., 2019), the World Health Organization's Triple Billion Targets (Fraisl et al., 2023) and the Global Urban Monitoring Framework (Moorthy et al., in review), making the case for citizen science as a game changer in policy reporting from local to global levels.

Shifting from developments in citizen science to a broader societal viewpoint, we have entered a decade where the climate crisis started tangibly manifesting long predicted extremes, hitting cities with full force, including severe heat, extreme fires, storms and flooding. At the same time, Artificial Intelligence is emerging at pace, full of both promise and peril. Combined with advances in big data and super-high-resolution satellite imagery, it opens new frontiers for urban analytics and disaster response. We also observe a brutalisation and polarisation of political opinion and actions, including profound attacks on science, evidence-based debate and informed decision-making, as well as an undermining of critical environmental laws, agreements and political commitments. And despite these challenges, cities remain sources of inspiration, daily showcasing innovation and the power of collective action.

Citizen science as a foundational element of city science

To drive meaningful change in today's ambiguous environmental, social and political climate, city science must embrace and consider embedding citizen science at its core, rather than treating it as a

token gesture. Here, we identify five priority areas, where city science can take a leap towards this integration.

- **Enable tech- and data-assisted civic participation:** Civic participation in mapping, monitoring, analysing and creating urban environments and services should be central to city science and planning. Technologies and data must be used ethically and for collective benefit, ensuring they advance well-being and equitable decision-making, including potential rights for citizens to share and contribute data.
- **Empower inclusive engagement:** Citizen science has long grappled with biased participant representation but is now championing inclusive approaches and delivering them more widely, engaging commonly underrepresented and vulnerable groups. These approaches can help city science broaden participation and include diverse perspectives into knowledge creation.
- **Build purpose-driven alliances:** Scientists and committed public administrations should seek strategic alliances that share responsibility in supporting inclusive, evidence-based endeavours aimed at shaping well-informed, more just and participatory urban futures.
- **Foster collaborative sense making:** Joint interpretation should be supported through robust, transparent information to strengthen public understanding, counter misinformation and guide collective urban action.
- **Integrate citizen data into urban reporting:** By integrating citizen science, city science can strengthen its contribution to urban monitoring and reporting for local plans and reviews as well as global frameworks, such as the SDGs.

While individual success stories and proofs of concept exist at this intersection of science, urban management, public policy and civic life, we still need to make strides towards mainstreaming both conceptual frameworks and practical approaches for local implementation. Hence, dedicated research and innovation funding are paramount to unearth implementation barriers and identify pathways for developing effective tools, governance models and institutional structures. Funded by the European Union, projects like Urban ReLeaf,⁷ CitiObs⁸ and Greengage⁹ are currently underway to advance the uptake and validation of citizen observations to complement urban authoritative information systems. Other projects, such as Enforce¹⁰ and more4nature,¹¹ focus on empowering citizens to monitor, report and act in partnership with relevant public authorities in the context of environmental compliance assurance, in both rural and urban areas.

In Urban ReLeaf, a project we lead at the International Institute for Applied Systems Analysis, we collaborate with public bodies in six European cities (Athens, Cascais, Dundee, Mannheim, Riga and Utrecht). Together, we design citizen science and urban data collection campaigns, on air pollution, street-level temperature and heat stress, green infrastructure mapping and greenspace perceptions. These campaigns also pursue inclusive participation by developing relationships with and engaging vulnerable and marginalised groups to co-produce evidence and to inform the design of more inclusive green infrastructure and climate adaptation policies. Over two campaign seasons, more than 3000 participants have taken part contributing more than 500,000 data points and counting. Through dedicated engagement strategies and monitoring, our city partners are reaching ambitious inclusivity targets (e.g. 50% women participation and 30% participation from vulnerable groups). We still encounter some of the better-known implementation and uptake barriers (Beck and Mitkiewicz, 2025) including usability and accuracy issues of low-cost sensors and data, and the mobilisation and retention of participants longer-term, especially audiences which have been traditionally underrepresented in citizen science. Some of the barriers and challenges less

investigated include handling trade-offs of opportunistic versus prescribed data collection (sample design) and their respective implications on both engagement design and data analysis, requirements of cross-sector capabilities for data handling and analysis, cultural/sectoral differences in dealing with ethical and legal topics (e.g. handling personal data and information transparency) or figuring out the operational details of data flows, across institutions, data infrastructures and purposes.

Nonetheless, the policy-relevant applications of citizen science in the urban context are manifold. Facilitated by Urban ReLeaf, collected data and insights directly feed into urban strategies, policies and urban management and planning processes. In Cascais, citizen science activities and data help assess and validate the role of parks and urban greenspaces in local climate change adaptation planning. In Utrecht, residents of green-deprived neighbourhoods contribute heat and temperature data which inform the municipal Heat Action Plan as well as the provincial Climate Adaptation Implementation Programme. In Dundee and Riga, in contrast, citizen observations and data directly feed into space and development strategies, biodiversity plans, greening plans and air quality action programmes, including Dundee's Open Space Strategy and the Riga City Air Quality Improvement Action Program for 2026–2030.

Yet, beneath the technical and professional work of advancing citizen science at the interface of urban research, policy and society lies a much older truth about the reciprocal relationship between cities and their residents, best exemplified by the intertwined etymology of *city* and *citizen*. These very words share a root, reminding us that a city cannot exist without its citizens nor citizens without a city to belong to. Although *citizen* is often understood as a legal term and status with associated rights and obligations, we like to use it in a broader sense that also conveys a dual principle: the understanding of joint stewardship and care for the collective well-being of people and nature, as well as the right to be included as a recognised co-creator of our shared environment.

The urban citizen science we champion places people and communities at the centre and follows the impetus of an applied science that enables shared responsibility in doing things together to improve the conditions for all. Faced with a myriad of wicked problems that demand not only insights but concrete action – and with a plethora of technological opportunities at hand – city science today carries a mandate to deliver tangible, on-the-ground impact. To succeed in the long-term, it must work not just for citizens, but with them, acknowledging their ability to contribute to the science as well as their agency and power to drive meaningful change.

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Notes

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