frontiers | Frontiers in Sustainable Cities

TYPE Systematic Review
PUBLISHED 08 January 2025
DOI 10.3389/frsc.2024.1518618

OPEN ACCESS

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RECEIVED 28 October 2024
ACCEPTED 09 December 2024
PUBLISHED 08 January 2025

CITATION
Bou Nassar J, Calleja-López A, Sharp D, Anwar M, Bartram L and Goodwin S (2025) Characterising and reassessing people-centred data governance in cities. *Front. Sustain. Cities* 6:1518618. doi: 10.3389/frsc.2024.1518618

Characterising and reassessing people-centred data governance in cities

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The increasing deployment of digital infrastructures in cities highlights challenges in how people shape the conditions of data production that shape their cities and lives. As such, the need to centre data governance (DG) models around people is amplified. This paper unpacks and reassesses how people-centredness materialises at the level of DG in cities by conducting a scoping review of the literature on people-centred data governance (PCDG) in cities. Utilising twelve extraction categories framed by the conceptualisation of DG as a socio-technical system, this review synthesises identified themes and outlines six archetypes. PCDG is characterised by people-centred values; the inclusion of people as agents, beneficiaries, or enablers; the employment of mechanisms for engaging people; or the pursuit of people-centred goals. These coalesce into diverse PCDG archetypes including compensation, rights-based, civic deliberation, civic representation, data donations, and community-driven models. The paper proposes a nuanced reassessment of what constitutes PCDG, focusing on whether DG models include people in the emergent benefits of data or merely legitimise their exclusion, the extent to which embedded power dynamics reflect people's perspectives, the extent to which participation influences decision-making, and the model's capacity to balance power asymmetries underpinning the landscape in which it is situated.

KEYWORDS

data governance, people-centric, cities, smart initiatives, socio-technical system

1 Introduction

The deployment of digital infrastructures in cities increasingly mediates city life and people's access to urban and public services. Underpinned by various entities, this mediation often adopts a hegemonic approach to data production, in which the entity controlling the service or infrastructure controls the produced data *de facto* (Carballa Smichowski, 2019). Given that data collection schemes in cities are often realised through the enclosure of digital infrastructures or Public-Private Partnerships (PPPs) (Barns et al., 2017; Morozov and Bria, 2018), the problem with a hegemonic model stems from conflicting interests between the private sector (that holds the power in a deregulated data ecosystem); the public sector; and people living, working, or studying in cities (on whom these initiatives might be imposed). Data-related policies and regulations targeted personal, identifiable data through reforms characterised by notice and choice regimes (exemplified by opt-in/opt-out options) and rights granted to data subjects, including access to data, rectification, and the right to be forgotten (Goldenfein and McGuigan, 2023). However, these measures are often considered inadequate as they fail to address the social and relational aspects of data from which value is derived

(Viljoen, 2021; Zygmuntowski et al., 2021). This deficiency is further amplified as disruptive technologies, such as artificial intelligence, become more embedded in cities, posing challenges related to human autonomy and privacy and exacerbating existing social inequalities (Da Silva Carvalho et al., 2023; Calzada, 2018, 2023; Foth et al., 2021; Milchram et al., 2020). Therefore, there is an urgent need for governance approaches that anticipate the deployment of such technologies and address these associated risks (Micheli et al., 2020; Sanfilippo and Frischmann, 2023).

In this light, criticism has been raised regarding the absence or dilution of people's involvement in shaping the conditions of data production and asymmetries in the distribution of relevant benefits (Artyushina, 2020; Cardullo and Kitchin, 2019a, 2019b; Kitchin and Lauriault, 2018). This has prompted scholars to rethink the role of people in relation to data production in the city, captured here in two key arguments. The first regards people as co-producers of data and argues for the acknowledgment of their contributions to the value created from it and their inclusion in setting the conditions of its production (Arrieta-Ibarra et al., 2018; Ducuing, 2024). The second, which is rooted in Critical Data Studies, highlights how data is not merely representative of the city but rather plays a role in (re-)producing it, indicating the necessity of including people in data-related decisions to fulfil the right to the city—the right to shape the city that shapes them and their lives in return (de Lange, 2019; Harvey, 2008; Kitchin and Lauriault, 2018). Against this backdrop, the UN-Habitat's Flagship program, People-Centred Smart Cities, emphasised the need to put people at the core of digital transformations and corresponding data governance (DG) models (UN-Habitat, 2021), which determine power relations between entities impacted by or impacting data collection, control, sharing, and use (Micheli et al., 2020).

People-centredness broadly implies the incorporation of needs and perspectives of people into the development of systems. The UN-Habitat (2021) mentioned pillars of people-centredness such as inclusion, equity, empowerment, security, and participation. Nevertheless, its materialisation at the level of DG models in cities remains unclear. As evidenced by the literature, this ambiguity might be attributed to the absence of established terms in the field (Cardullo and Kitchin, 2019b; Liu, 2022; Micheli et al., 2020). Specifically, the confusion about what constitutes people-centred data governance (PCDG) might be stemming from the lack of explicit definitions, coupled with contestations over whether models suggested as PCDG, implicitly and explicitly, incorporate people's needs and perspectives in meaningful ways (Cardullo and Kitchin, 2019a; Lehtiniemi, 2017; Micheli et al., 2020; Rinik, 2020). This work aims to address this gap by grounding the concept of PCDG in the city. It introduces an evolving framework that consolidates and elaborates people-centred notions at the level of DG. To achieve this, a critical scoping review of PCDG in cities is conducted. The review starts with preliminary indicators of PCDG, shaped by literature. Through an iterative process, it aims to understand PCDG on a nuanced level, highlight its pillar aspects, and reassess it. The crux of this exploration rests on the presupposition of DG as a socio-technical system. The paper aims to answer three questions: (1) What are the overarching aspects of PCDG in the city? (2) What are the archetypes of a PCDG model in the city? (3) How can PCDG in the city be improved?

The definition of DG adopted in this paper is borrowed from Micheli et al. (2020). DG is perceived as a socio-technical system that determines (1) the power relations between entities and individuals involved in or affected by data collection, control, sharing, and use; (2) the value to be derived from data; and (3) the distribution of benefits (Micheli et al., 2020). The study focuses on four moments of data flow: (1) the conception of data which includes collection and other processes that shape its formation (e.g., decisions on what is datafied and corresponding investment schemes); (2) control, which involves exerting control over data and access to it; (3) sharing, which encompasses sharing mechanisms, protections, and conditions; and (4) the realisation of emergent benefits, which presupposes data use but focuses on shaping and deriving benefits that emerge from the data apparatus as a whole. The remainder of the paper is structured as follows. First, the methodology of the review is outlined. Second, the extracted themes and archetypes are presented and discussed. Finally, the conclusion is presented.

2 Methods

The study started with a preliminary review of the literature, which informed the search strategy and data extraction framework. This section presents these along with the methods corresponding to coding and analysis.

2.1 Search strategy

The search strategy was guided by prominent frameworks in the literature (Moher et al., 2009; Page et al., 2021; Tranfield et al., 2003). The search query was underpinned by three indicators that suggest a PCDG model: (1) people's participation in DG; (2) relevant models associated with the term "emerging" (Micheli et al., 2020) or "alternative" (Morozov and Bria, 2018) DG; and (3) descriptors, such as 'people-centred' and its cognate notions, when used in reference to a DG model. The query aimed to identify papers that (1) have a people-centred focus, (2) discuss DG, and (3) investigate the latter in the context of the city (Figure 1).

The review process commenced in October 2022, with the final extraction of passages occurring in October 2024. The search query was inserted in three databases: Scopus, Web of Science, and PubMed. The search covered years 2012 to 2024, since 2012 was the year academic publications pertaining to Big Data and "smart cities" started surging. 729 records were returned. Duplicates were removed (113), the rest underwent initial screening (616), and irrelevant records were dismissed (433). The remaining records underwent full-text screening (183). Articles were excluded if: they did not focus on people-centred aspects of DG (95), they did not focus on the civic context or data collected in urban spaces by information and communication technologies (ICTs) (28), the main text was not in English (9), they did not focus or sufficiently elaborate on DG models (6), and they were systematic literature reviews (3). 42 studies were included in the review (Figure 2). The backward snowballing method was used to identify relevant grey literature yielding 4 additional records. These included (1) three policy documents associated with Barcelona, Amsterdam, and New York, cities highly connected with the Cities Coalition for Digital Rights and mentioned in the obtained papers twenty, eight, and six times, respectively, and (2) the UN-Habitat's flagship report, Centering People in Smart Cities. A total of 46 papers were reviewed.

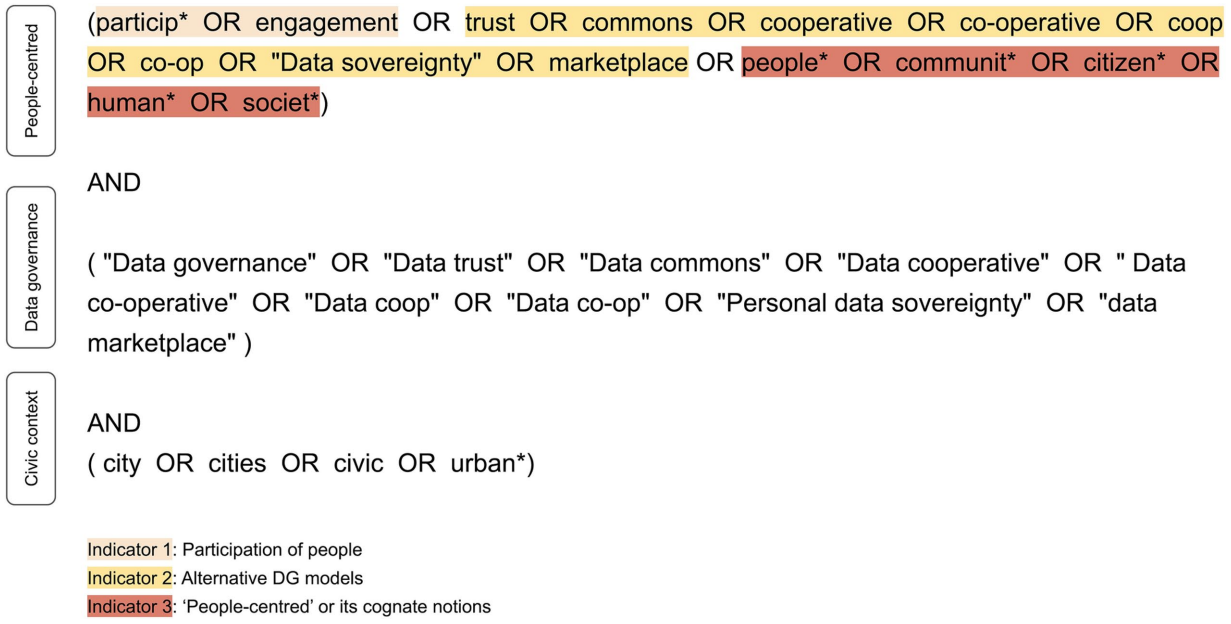

FIGURE 1
Overview of the search query.

2.2 Data extraction

The extraction of data was initiated by the identification of significant components of DG as a socio-technical system from a preliminary review of the literature. A socio-technical system is an assemblage that consists of various entwined apparatuses, including those related to the social, technical, and political, that interact and shape each other (Kitchin and Lauriault, 2018; Micheli et al., 2020; Slota and Bowker, 2016). A flexible approach was adopted where categories were modified iteratively through the course of the scoping review (Tranfield et al., 2003). The identified system components were used as deductive for extraction, which then enabled the generation of inductive codes. Additionally, a category entitled Meta, which comprises descriptions about the passages that encompass studied DG systems, was extracted. It included the following components:

- Content: the purpose of the passage (e.g., description or criticism).
- Notion: the notion of people-centredness corresponding to the respective model (e.g., citizen-centred or data commons).

2.2.1 Data governance as a socio-technical system

The conceptualisation of DG as a socio-technical system is presented in Figure 3 and elaborated below.

2.2.1.1 System characteristics

This category includes a description of the environment of the system and its scale.

- System environment: the enabling environment of the DG system (e.g., a DG model situated within a city-led or community-driven initiative).
- Scale of DG: the scale to which the DG system applies (e.g., city or neighbourhood).

2.2.1.2 Normative

This layer embodies the normative landscape within which the DG system emerges. It is influenced by the system environment and other factors that transcend system boundaries. It could be impacted or informed by the Actors layer.

- Ontology of data: the intrinsic nature of data specific to the respective system (e.g., data as a commodity).
- Values: the normative concepts underpinning the DG system (e.g., privacy).

2.2.1.3 Actors

This layer represents actors and emerges within the bounds of the Normative layer which shapes its characteristics by setting restrictions or implications. It is also influenced by the Technical layer, since limitations of what is technically possible impact the characteristics of its components.

- Agents: entities (or persons) playing active roles in the DG system.
- Beneficiaries: entities (or persons) that are direct beneficiaries of the DG system.
- People engagement: ways in which people are engaged.
- Claimed goals: articulated objectives to be achieved by the DG system. Claimed goals are perceived as narratives constructed within the Actors layer. While they carry normative implications, these are considered to be actor-related rather than reflecting the overarching goals of the system as a whole or determining its normative orientation.

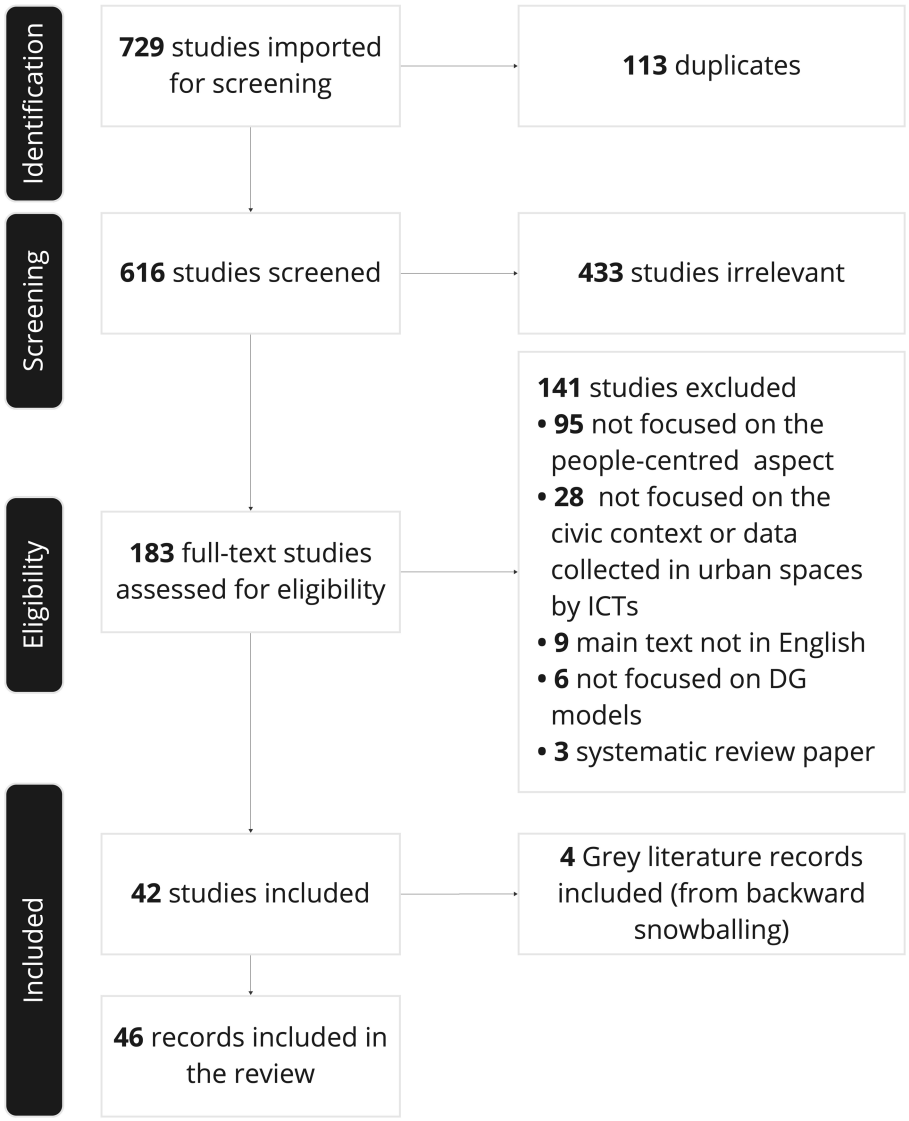

FIGURE 2
Identification and selection of studies via databases following the PRISMA guidelines.

2.2.1.4 Technical

This layer encompasses the technical aspects of the DG system. Its components are influenced by the Actors layer, which shapes its design and implementation.

- Type of data: the type of data based on its source or domain (e.g., personal data or mobility data).
- Technical infrastructure: the infrastructure supporting the technical aspect of the DG system.

The system is restricted to these components since it both aims to conceptualise DG and serve as a premise for the extraction of codes from passages. Consequently, its scope is limited to what is typically presented in these passages (e.g., the system characteristics category does not encompass temporal characteristics or comprehensively cover spatial ones).

2.2.2 Coding and analysis

Categories corresponding to each of the components mentioned above were extracted using inductive coding. Codes were refined iteratively. The coding was done via NVivo. Categories were added, merged, or split to better capture comprehensive views of the aforementioned system (Hummel et al., 2021). A category was coded if it was mentioned explicitly—e.g. democracy—or implicitly—e.g. "participants conveyed various ways citizens can be involved in data governance including ability to vote on data related policies" (Sharp et al., 2022, p. 12)—in a passage. In some studies, multiple categories were coded per component. Around 70% of the articles included all components, 20% were missing one component, and the remaining 10% were missing up to four components. To analyse the data, a charting technique was used to sift and sort the data in two main ways. The first data arrangement was in key

themes corresponding to each component. In the second arrangement, codes corresponding to each passage were charted into the framework of the DG system conceptualised earlier. PCDG archetypes were derived from the latter, by identifying passages with common components.

3 Results

3.1 Themes

Identified themes are presented in this section, structured according to the layers and components described in the conceptual DG model (Table 2). Components corresponding to the Meta and System Characteristics categories are outlined in Table 1.

3.1.1 Normative layer

3.1.1.1 Ontology of data

Broadly, the ontology of data was characterised in three distinct ways. The first approach focused on conceptualising data for governance by associating it with components already regulated by law or the market. In this category, data as property was explored. The latter was implied by ownership of or exclusive control over data coupled with the ability to decide whether or not to share it or sell it (Bornholdt et al., 2021b; Franke and Gailhofer, 2021). Whilst property rights or factual control over data might presuppose its treatment as a commodity, data as property was not confined to these aspects but extended to approaches that focused on protecting data subjects through ownership (City of Barcelona, 2015). Additionally, data as the self was proposed, promoting individuals' rights to their data (Doned and Belli, 2020). On another note, around 45% of passages mentioned

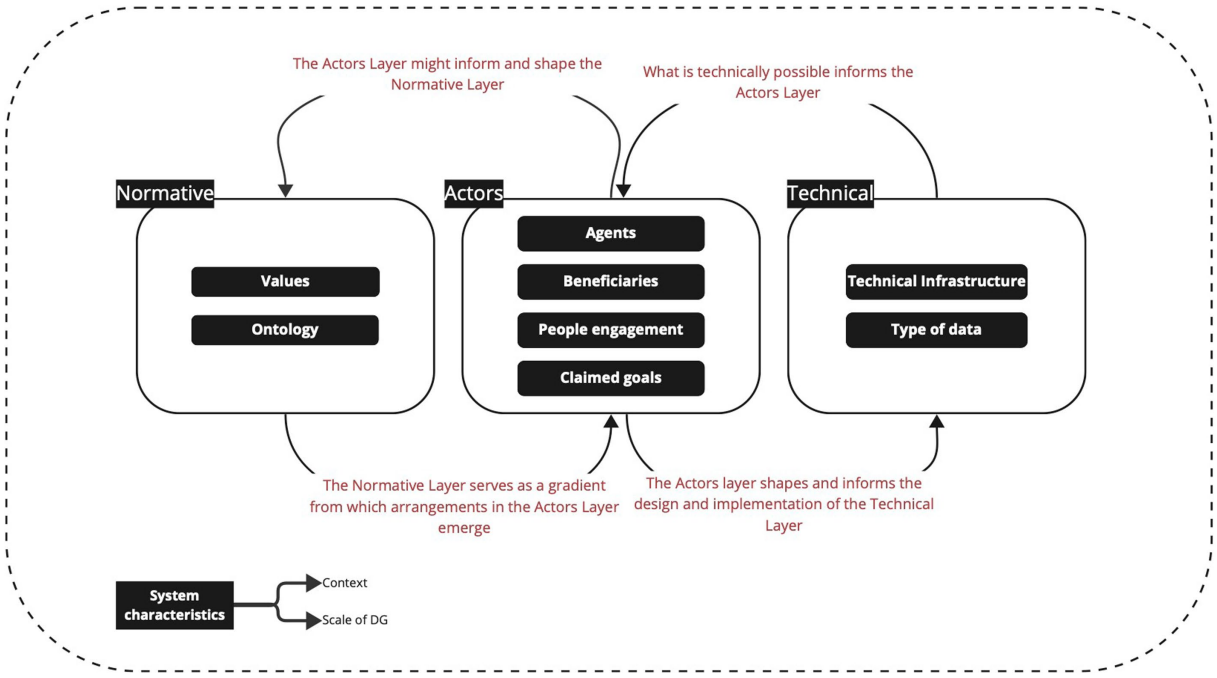

FIGURE 3
Components of data governance as a socio-technical system used as data extraction categories.

TABLE 1 An overview of the components of the meta and system characteristics categories, along with the percentage frequency of passages that included them (n = 46).

Content	Studied PCDG models 55%	Developed PCDG models 32%	Strategies or reports 9%	Criticised PCDG models 4%		
Notion	Alternative DG 61%	Cognate notions 41%				
System environment	City 35%	Co-op 15%	Partnerships* 13%	Agnostic 13%	Community 9%	Corporate 7%
Scale	City 59%	Neighbourhood, precinct, district, community 13%				

*Multiple stakeholders without a clear indication of a lead enabler.

TABLE 2 An overview of the three most prominent themes with the percentage frequency of passages that included them (n = 46).

Ontology: what is the nature of data?	Property 30%	Common good 20%	Public asset 11%
Values: what normative concepts underpin the system?	Privacy and security 83%	Control and autonomy 72%	Openness and accessibility 63%
Agents: who plays an active role in DG?	People 63%	Public sector 57%	Private entities 30%
Beneficiaries: Who are the primary beneficiaries?	People 90%	Public sector 37%	Private entities 26%
Claimed goals: what are the stated goals of the model?	Protecting data rights and establishing relevant strategies and governance 52%	Improving urban services, decisions, and policies 43%	Balancing power asymmetries 43%
People engagement: How are people engaged in DG?	Making data-related decisions 50%	Co-creating and deliberating 35%	Creating data and providing services 24%
Type of data: What type of data is governed by the model?	Urban data 74%	Personal data 67%	
Technical infrastructure: What technical infrastructures underpin DG?	Platforms 48%	DLTs 28%	Free and Open Source Software 9%

data as a good. The categorisation of goods in this context depended on restrictions (or lack thereof) underpinning access. For example, data as a public good indicated non-rivalry and accessibility by all (Bolten et al., 2017; Lee et al., 2022), whereas data as a common good was suggested when "modes of access to the data can be segmented between members of the commons and outsiders" (de Rosnay and Stalder, 2020, p. 16). Data was also regarded as a commodity, a good exchanged by data subjects for monetary compensation (Mohammadzadeh et al., 2019). In some cases, when an individual was regarded as a compensated data producer, data was regarded as labour (Franke and Gailhofer, 2021). Around 20% of passages described data as an asset (Akanbi and Hill, 2023). Particularly, data was seen as a (1) public asset (e.g., used for the development or optimisation of public services) (König, 2021), (2) a private asset (e.g., to be owned and controlled by a private entity for the extraction of value in various ways) (Artyushina, 2020), or a (3) personal asset (e.g., used by members of a co-op to optimise personal earnings) (Calzada, 2021). Finally, data as infrastructure was explicitly mentioned, however, its implications remain vague. For instance, the City of Barcelona (2015, p. 27) considered data as "public infrastructure" representing a "shared resource for the common good," while Franke and Gailhofer (2021) associated it with maximising access to data. On the other hand, Micheli et al. (2020) linked it with the production of value for citizens.

The second approach defined data by its functionality. It was characterised as a tool for sustainability (Paskaleva et al., 2017), social good (van Zoonen, 2020), and research (Milchram et al., 2020). Some passages explored the political capacity of data, describing it as a political artefact that enables "the emergence of individual and collective rights" (Calzada and Almirall, 2020) or as a democratic medium that supports democratic practices and shapes public policy (Franke and Gailhofer, 2021). Finally, data was suggested as a tool for regulating social relations, inherently linked to the production of knowledge (Mukhametov, 2021; Popham et al., 2020). In the third approach, the ontology of data was regarded as a component of the governance to be decided and addressed through mechanisms encompassed by the DG model (New York City, 2022; Foth et al., 2021).

Within a single DG system, the ontology of data was either singular or multiple. The latter could be attributed to the explicit distinction between the types of data being governed within the respective model. For example, the data trust developed by Sidewalk Labs (2018) and elaborated by Artyushina (2020, p. 8) distinguished between personal, identifiable data and anonymised data "collected in public and semi-private spaces" where the former was considered a private asset and the latter a public asset. Additionally, the ontology of data was found to be dynamic, particularly when data flowed from one subdomain to another within the system (Bornholdt et al., 2021b; City of Barcelona, 2015). For example, in the context of one open data-sharing space, "[d]ata collected from a user-operated sensor is consequently owned by the same user" and thus seen as property, unless the user decides to share it in the open space, at which it becomes a public good (Bornholdt et al., 2021b, p. 4).

3.1.1.2 Values

A synthesised, non-exhaustive list of commonly identified values is presented as follows:

- Privacy and security: Privacy was discussed on a spectrum of intensities ranging from privacy as a right (Doned and Belli, 2020; Singh and Vipra, 2019) to privacy as an available option (Bolten et al., 2017). Most discussions around privacy focused on the individual data subject, where issues pertaining to the collective were seen as beyond privacy (Singh and Vipra, 2019). Security was often mentioned in tandem with privacy. It was emphasised in models based on blockchain and those that include sensing applications (Wang et al., 2014).
- Control and autonomy: Two main aspects of control emerged: control over data and control over infrastructure. Control was sometimes linked to the notion of ownership (Calzada and Almirall, 2020). Others recognised the limitations of ownership as a concept in the context of data and highlighted the importance of control over "privacy settings" (Doned and Belli, 2020, p. 54), people's control over their data through digital rights (City of Amsterdam, 2021), or the public's control over digital

infrastructures (City of Barcelona, 2015). In addressing privacy-invading data practices, control was regarded as a facilitator of self-determination (Micheli et al., 2020) and autonomy (de Rosnay and Stalder, 2020). Informational and decision autonomy were particularly emphasised, highlighting an individual's capacity and right to (1) control data collected about them and how it is used, and (2) make independent decisions, respectively (König, 2021).

- Fairness: Fairness was frequently discussed in relation to the GDPR (Rinik, 2020), Privacy Impact Assessments (König, 2021), the distribution of data (Mukhametov, 2021), and transparency and participation in decision-making processes (Milchram et al., 2020). While the explicit definition of fairness was not made in most passages, Calzati and van Loenen (2023b) described it as the representation of interests of all actors through "a process that constantly reshapes its own power relations" A more concretely discussed aspect of fairness was economic fairness, which manifested in various specific forms: compensation for data sharing (Anthony, 2023; Franke and Gailhofer, 2021), enforcement of a collective's economic rights to their data (Singh and Vipra, 2019), and the empowerment of alternative economic actors (Calzada, 2018).
- Openness and accessibility: The openness of data was characterised by accessibility, involving free or public access to data (City of Barcelona, 2015), and interoperability, including adherence to open formats and standards (Paskaleva et al., 2017). Openness further encompassed data sharing (City of Amsterdam, 2021) and the creation of accessible data spaces open for participation by all (Bornholdt et al., 2021b). On the other hand, open infrastructures were linked to interoperability and the adoption of free and open source software, which were supported by appropriate procurement policies (Calzada, 2018). Beyond the aforementioned openness of data and infrastructures, discussions on accessibility highlighted the need for improved visualisations and enhancements in readability and intuitiveness (Bornholdt et al., 2021b; Sharp et al., 2022).
- Transparency and accountability: Transparency was mentioned in relation to procurement processes of digital infrastructure (Doned and Belli, 2020) and the specifics of data collection (City of Amsterdam, 2021), and access to data (van Zoonen, 2020). The use of clear and plain language was recognised as contributing to transparency (City of Amsterdam, 2021; Popham et al., 2020). One model specifically focused on transparency as a means to ensure the "genuineness of stored data" (Tan and Rodriguez Müller, 2020, p. 126). Several papers mentioned transparency as an enabler of accountability (Calzada, 2018; Mohammadzadeh et al., 2019). Accountability was seen to be concerned with data flows from collection to use (City of Amsterdam, 2021) and to materialise through independent oversight (König, 2021), class action lawsuits (Rinik, 2020), or consultations (König, 2021).
- Democracy and deliberation: Democracy related to decision-making processes regarding DG and was associated with aspects such as data ownership or control (Calzada, 2018). It was considered a criterion for evaluating DG models, focusing on their capacity to meet democratically stated needs (Calzada, 2021) and to align data ecosystems with democratic values (Calzada and Almirall, 2020). In some contexts, data itself was seen as an enabler of democracy, potentially informing democratic decisions, such as the needs and designs of public services (City of Barcelona, 2015; Tan and Rodriguez Müller, 2020). Democracy was commonly mentioned in tandem with participation (City of Barcelona, 2015; de Rosnay and Stalder, 2020), equating the engagement of people to a "democratic practice" (Calzada, 2018, p. 3). In some cases, the focus was on representative democracy. As a result, the direct involvement of citizens, such as through voting for DG practices (Sharp et al., 2022), was not deemed necessary (König, 2021) and was instead substituted by representations of the interests of data subjects specifically, or citizens generally (Artyushina, 2020; Rinik, 2020). In other cases, the need to shift beyond representative democracy towards the governance of data's "reuse according to values of the digital commons" was highlighted (de Rosnay and Stalder, 2020). In this light, the concept of deliberation was emphasised and demonstrated through extensive consultations and collaborations (Calzada, 2021), mechanisms to address concerns surrounding DG (Popham et al., 2020), and the creation of deliberative spaces (Sharp et al., 2022).
- Trust and integrity: Establishing a relationship of trust with data subjects, the public, or citizens was considered crucial for DG models. Fundamental to this trust was the involvement of public organisations in data collection (Milchram et al., 2020) and, in the context of data trusts, the fiduciary relationships representing people's interests (Rinik, 2020). Key practices to enhance trust included respecting privacy rights (UN-Habitat, 2021), ensuring data subjects' intentional data provision (Rinik, 2020), practising data minimisation (City of Amsterdam, 2021) and purpose limitation (van Zoonen, 2020), and safeguarding the independence of oversight bodies or representatives from potential data exploiters. Another dimension of trust pertains to trust in the data itself, highlighting the importance of data integrity. Accordingly, the assurance of data quality, validity, and reliability through DG practices was noted in the literature as essential for data sharing (Popham et al., 2020).
- Collectivism: A transition from individualistic governance of personal data, underpinned by property rights and privacy, to more collectivist frameworks operating within a data commons paradigm was advocated (de Rosnay and Stalder, 2020). The notion of data commons remains underdeveloped, encompassing a range of related yet distinct interpretations (de Rosnay and Stalder, 2020). However, a consistent theme across these interpretations is the collective governance of data aimed at serving the common good. Building on this paradigm, an emphasis on communal ownership and collective rights over data was made (Singh and Vipra, 2019). This was seen to be followed by substantial collective responsibility, but also a fairer distribution of benefits (Mukhametov, 2021). Finally, securing the right to the city was regarded as necessitating collective data rights that prompt solving urban issues faced by the collective (Calzada, 2018; de Lange, 2019).

3.1.2 Actors layer

3.1.2.1 Agents

People were portrayed as agents in more than half of the reviewed passages, with the term 'citizens' commonly used, and sometimes interchangeably with "residents" (City of Amsterdam, 2021). Some

discussions narrowed the focus to individuals who own data-generating devices (Franke and Gailhofer, 2021; Wang et al., 2014), such as smart vehicles (Mohammadzadeh et al., 2019). In the context of personal data, the focus was rather on data subjects (Balan et al., 2023; Rinik, 2020). People were viewed as initiators and drivers of data collection initiatives (e.g., community sensing projects) (de Lange, 2019), proposers and influencers of data related practices (City of Barcelona, 2015), individual decision makers within established data practices (e.g., decisions regarding sharing their own data) (Sharp et al., 2022), sovereign market agents (Mohammadzadeh et al., 2019), or participants in representation schemes and accountability mechanisms (Rinik, 2020). Papers regarded the public sector as an active enabler of PCDG (Foth et al., 2021), a participant in data exchanges (Pomp et al., 2021), or partaking in a trust (König, 2021). Co-ops were preferred by communities in multi-stakeholder projects over larger, less trusted companies (Milchram et al., 2020). In initiatives enabled by data co-ops, the latter held fiduciary obligations to data subjects, managing data on their behalf (Calzada, 2024; Calzada and Almirall, 2020). The involvement of academics was viewed positively in some cases (Milchram et al., 2020) but raised concerns in others (Sanfilippo and Frischmann, 2023), where the public felt like they were being experimented on. Finally, intermediaries were regarded as representatives of data subjects (Rinik, 2020) or communities (Calzati and van Loenen, 2023a), as oversight bodies (König, 2021), or mediators between "the supply and demand of data" (Verhulst, 2023, p. 11).

3.1.2.2 Beneficiaries

In most reviewed studies, people were portrayed as beneficiaries of the DG system. Several papers discussed DG models as serving the residents' interests (Calzada, 2021), the public interest (König, 2021), data subjects' interests (Calzada, 2021), or the interests of the members of the commons (Micheli et al., 2020). The public sector, specifically city councils, was also considered as a beneficiary, mostly in receiving support in the provision of services (Bayat and Kawalek, 2023; Tan and Rodriguez Müller, 2020). The private sector was seen as a beneficiary through its ability to access data (Bolten et al., 2017), the provision of a market for new data services aligned with a decentralisation (Micheli et al., 2020), or generating profits from collected data (Artyushina, 2020). SMEs, startups, co-ops, and academics were considered to benefit from access to data and the support received from cities to promote their services (Calzada, 2018, 2021; Creutzig, 2021).

3.1.2.3 Claimed goals

Reviewed passages frequently identified the improvement of public and urban services as a key goal, achieved through automation of services (Micheli et al., 2020), co-production involving the public (Tan and Rodriguez Müller, 2020), ensuring sustainable development (UN-Habitat, 2021), increasing innovation (Creutzig, 2021), and informing decision-making and public policy (Lee et al., 2022). The latter included the exploration of advanced analytics to support decision-making (New York City, 2022). Several papers noted the development of DG models to protect data and digital rights (Calzada, 2021; City of Amsterdam, 2021). The establishment of ethical data practices (Artyushina, 2020; Akanbi and Hill, 2023), particularly in response to AI challenges (Sanfilippo and Frischmann, 2023), accountability mechanisms (Rinik, 2020), and collective data ownership schemes (Singh and Vipra, 2019) were highlighted. Some models focused on enforcing personal data sovereignty (Bornholdt et al., 2021a; Tan and Rodriguez Müller, 2020) or technological sovereignty (de Rosnay and Stalder, 2020). Others promoted the stewardship of public interest (Petkova, 2024) or data subjects (Rinik, 2020).

Some models sought to balance power asymmetries against centralisation and commodification (de Rosnay and Stalder, 2020; Fernandez-Monge et al., 2024). This was articulated by highlighting the need to implement DG models to change the current data economy (City of Amsterdam, 2021) and return the value of data to citizens (City of Barcelona, 2015). The need to balance asymmetries with specific economic implications was emphasised, with DG models focusing on improving labour environments (Calzada, 2020, 2021) and compensation for data sharing or extraction (Wang et al., 2014). Finally, increasing the accessibility of data by providing the means and spaces to integrate sensors and data (Bornholdt et al., 2021a; Bornholdt et al., 2021b) or developing open data spaces (City of Barcelona, 2015) were mentioned.

3.1.2.4 People engagement

People's involvement in DG included being informed about data collection and use (Foth et al., 2021; König, 2021; UN-Habitat, 2021), being able to access and use data (Creutzig, 2021), and engaging in consultations (Popham et al., 2020) and data assemblies (Verhulst, 2023). More active forms of participation allowed citizens to propose and shape smart initiatives (Doned and Belli, 2020), through co-creation activities and living labs (Foth et al., 2021; van Zoonen, 2020), or determine the shape and form of their involvement (Calzati and van Loenen, 2023b). People were seen as involved in data-related decision-making by choosing whether to share data (Calzada, 2023; Rinik, 2020; UN-Habitat, 2021), and other times by controlling digital infrastructures (Bornholdt et al., 2021b; Milchram et al., 2020). They were considered to play a pivotal role in holding parties accountable through arbitration (Popham et al., 2020) and class action lawsuits (Rinik, 2020). People also contributed as co-producers of services by generating and sharing data with the public sector (Tan and Rodriguez Müller, 2020). People's contributions extended beyond public sector initiatives to include marketplaces and open data platforms (Bornholdt et al., 2021a; Mukhametov, 2021). Compensation for data creation and sharing was a notable aspect of these engagements (Artyushina, 2020). This also encompassed the provision of services such as data processing, storage, and verification (Bolten et al., 2017; Bornholdt et al., 2021b). However, the automation of systems and their associated complexities were viewed as obstacles to meaningful participation by people (Milchram et al., 2020).

3.1.3 Technical layer

3.1.3.1 Type of data

Data highlighted in the reviewed literature, referred to here as urban data, captures (1) human activity through interactions with digital devices in urban areas, such as pedestrian data (Bolten et al., 2017) or data from smart vehicles (Mohammadzadeh et al., 2019), or (2) the conditions, characteristics, or changes within urban environments that may infer human behavior, such as environmental data (Singh and Vipra, 2019). A specific reference to personal data was

made in 65% of the reviewed passages. The precise definition of personal data (e.g., distinctions between anonymous, pseudonymous, or identifiable personal data) was made in a very few passages either implicitly (City of Barcelona, 2015) or explicitly (Anthony, 2023; Artyushina, 2020).

3.1.3.2 Technical infrastructure

Technical infrastructure was mentioned in approximately 75% of the reviewed passages. Data-sharing platforms (New York City, 2022) and marketplaces (Bornholdt et al., 2021a; Pomp et al., 2021) were seen to increase accessibility to data and data-sharing spaces. Participatory decision-making platforms (City of Barcelona, 2015) provided access to digital decision-making spaces and reflected democratic values. Dashboards were regarded as "[a] technical solution for increasing transparency" (König, 2021) to "[facilitate] monitoring and follow-up of how public policies are being carried out in the city" (City of Barcelona, 2015, p. 28) or how personal data is used and processed (Da Silva Carvalho et al., 2023). On another note, DLTs, especially blockchain, were frequently discussed, focusing on enhancing data subjects' control and privacy (Calzada, 2023, 2024; Tan and Rodriguez Müller, 2020) and ensuring the trustworthiness of data through auditability in data-sharing contexts (Mohammadzadeh et al., 2019). Free and open-source software was emphasised as crucial for promoting control through technological sovereignty (Calzada, 2018) and enhancing transparency (City of Amsterdam, 2021). Finally, data repositories and lakes were noted in the context of centralised data models that aim to aggregate data from different sources and users (Artyushina, 2020). The cloud was also mentioned for data storage (Doned and Belli, 2020) and sharing (New York City, 2022).

3.2 Archetypes

The abovementioned themes coalesced into 6 archetypes of PCDG models illustrated in Figure 4. Table 3 presents the archetypes' domains, which is defined here as the scope of associated DG models in terms of data flow with the focus on four moments: conception, control, sharing, and the realisation of emergent benefits.

3.2.1 The compensation archetype

In this archetype, data either (1) turns from property to a commodity once the data subject demonstrates the willingness to engage in an exchange or (2) is considered as labour, where data subjects or citizens are seen as co-producers of data and compensated for their contributions. Its central values (e.g., privacy) enhance the willingness of individuals to generate and exchange data. Data consumers also benefit from models associated with this archetype as they improve access to data-sharing spaces. These spaces frequently utilise platforms to facilitate data exchange and might incorporate DLTs to protect the privacy of data subjects and ensure data integrity. Often, this archetype is presented as agnostic regarding its enabling actors (e.g., Anthony, 2023; Bornholdt et al., 2021a; Franke and Gailhofer, 2021; Mohammadzadeh et al., 2019; Mukhametov, 2021; Wang et al., 2014).

3.2.2 The rights-based archetype

In this archetype, data is perceived either as property or as the self, aimed at protecting data subjects' data-related rights. At the core of this archetype are control over data, privacy, and autonomy. Consequently, data subjects actively participate by deciding whether to share their data and with whom. This archetype specifically addresses personal data and employs DLTs. It could be enabled by the

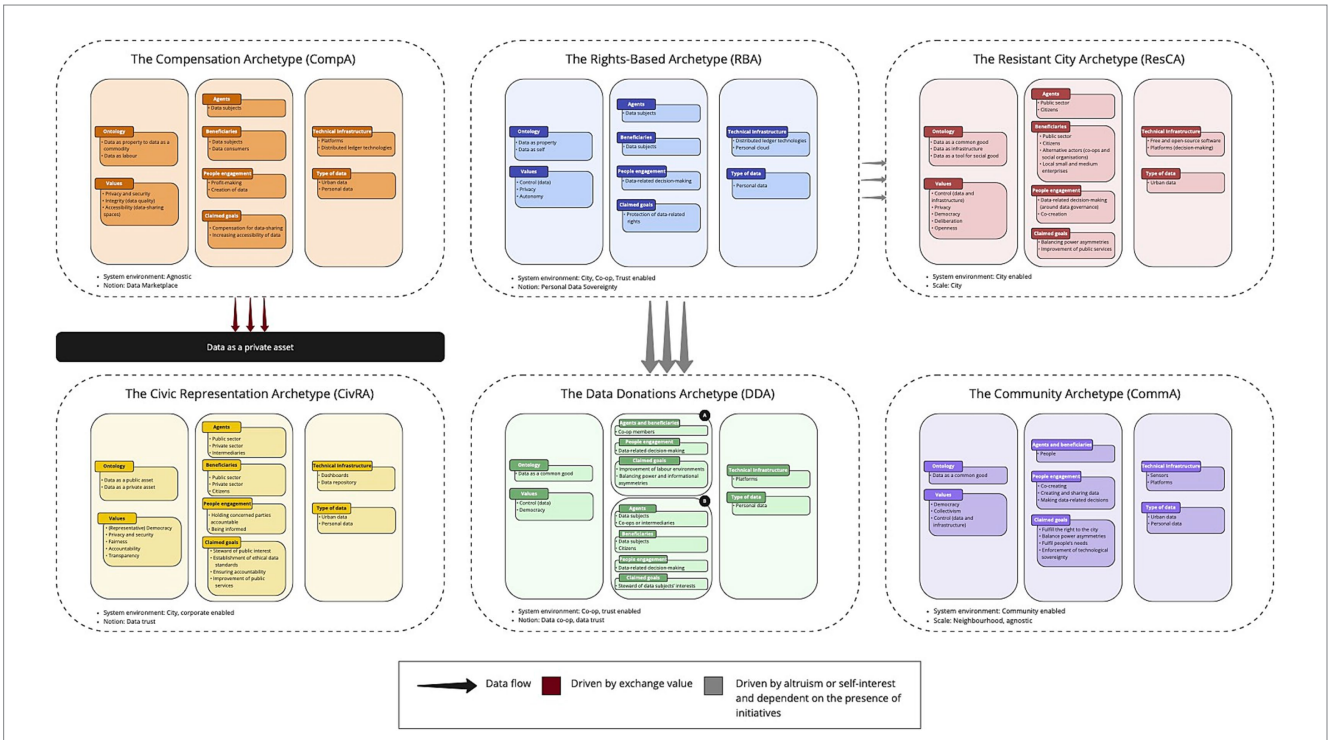

FIGURE 4
The six archetypes of PCDG in cities, extracted from reviewed passages.

TABLE 3 Domains and example papers corresponding to the six archetypes.

Archetype	Conception	Control	Sharing	Emergent benefits	Example passages
The Compensation Archetype (CompA)		X	X	Benefits are realised outside the scope of associated models, most likely as a private asset. The driver of data's flow to realise benefits is its exchange value.	Anthony (2023), Bornholdt et al. (2021a), and Mukhametov (2021)
The Rights-based Archetype (RBA)		X	X	Two conditions must be satisfied for data to leave the domain resulting in a possible realisation of benefits. (1) Sharing data is voluntary and therefore underpinned by altruism or self-interest. (2) The existence of initiatives that align with the data subject's interests or altruistic endeavours is also necessary for data to exit this domain. As observed in the literature, data from this archetype flows into ResCA and DDA, where benefits were realised.	Balan et al. (2023) and Tan and Rodriguez Müller (2020)
The Resistant City Archetype (ResCA)	X	X	X	X	City of Amsterdam (2021) and City of Barcelona (2015)
The Civic Representation Archetype (CivRA)	X	X	X	X	Artyushina (2020) and König (2021)
The Data Donations Archetype (DDA)		X	X	X	Calzada (2023) and Rinik (2020)
The Community archetype (CommA)	X	X	X	X	de Lange (2019) and de Rosnay and Stalder (2020)

city, a co-op, a trust, or private entities (e.g., Balan et al., 2023; Calzada, 2018; Calzada, 2021; City of Barcelona, 2015; Doned and Belli, 2020; Tan and Rodriguez Müller, 2020).

3.2.3 The resistant city archetype

Data is regarded as a common good, infrastructure, or a tool for social good. Central to it are control (over both data and digital infrastructures), privacy, democracy, and deliberation. The city council and citizens are the primary agents. However, benefits go beyond them and reach local SMEs and alternative organisations. Its goal is to balance power asymmetries to counter current power structures by promoting SMEs and alternative organisations, enforcing technological sovereignty with the adoption of free and open source software, and diminishing private entities' control over access to citizens' data. The archetype integrates platforms that increase access to decision-making spaces. It is driven and enabled by the city council (e.g., Calzada, 2018; City of Amsterdam, 2021; City of Barcelona, 2015; de Rosnay and Stalder, 2020; van Zoonen, 2020).

3.2.4 The civic representation archetype

Data is seen as an asset, either public or private. The archetype is accompanied by values including (representative) democracy, privacy, security, fairness, accountability, and transparency. The public sector, private sector, and intermediaries representing people are seen as active DG agents whilst benefits also include the public sector, the private sector, and citizens. Models corresponding to this archetype aim to act as stewards of public interest, promoting the establishment of ethical data standards, accountability, and the improvement of services. Though people are not directly involved in the DG model, they are informed about data-related schemes and able to hold concerned parties accountable. Technical infrastructures include dashboards and data repositories. This archetype could be enabled by the city or corporations (e.g., Artyushina, 2020; König, 2021).

3.2.5 The data donations archetype

This archetype relies on voluntary data-sharing, often complementing ResCA, and views data as a common good. The central values are control and democracy. The Actors layer in this archetype typically takes one of two forms. The first (DDA.A in Figure 4) centres around members of a cooperative in an environment enabled by the co-op. Here, co-op members are actively involved in making data-related decisions, with corresponding models designed to enhance labour environments by providing information that optimises working conditions and returns. The second form (DDA.B in Figure 4) applies to both data cooperatives and data trusts, where data subjects, alongside intermediaries or cooperatives, play an active role in DG. Data subjects are engaged in decisions predominantly about data sharing, and the models associated with this archetype serve as stewards of their interests. The benefits of this archetype may extend beyond the data subjects themselves, contributing to the realisation of broad social benefits, such as health research. The type of data governed is often personal data. Additionally, it incorporates platforms (e.g., Calzada, 2020, 2021, 2023; Rinik, 2020).

3.2.6 The community archetype

This archetype is underpinned by values of democracy, collectivism, and control over both data and infrastructure, viewing data as a common good. People, regarded as both agents and beneficiaries, are the enablers of this archetype. They also participate in creating data, co-creation, and making data-related decisions. The primary objectives of models concomitant to this archetype include fulfilling the right to the city, balancing power asymmetries, addressing

specific needs that likely prompted the initiative, and enforcing technological sovereignty. Technical infrastructure might encompass sensors or even platforms. The type of data includes urban and personal data, with initiatives often conducted at the neighbourhood level or being scale-agnostic, particularly in cases involving platforms (e.g., de Lange, 2019; de Rosnay and Stalder, 2020).

4 Discussion

PCDG is a multifaceted concept that can materialise in various ways. The findings indicate that PCDG in the literature is attributed to one or more of the following four characteristics: (1) a set of values that are either inherently people-centred, such as inclusion and privacy, or that contribute to the people-centredness of the process or goals, such as openness and transparency; (2) the inclusion of people as agents, beneficiaries, or enablers of DG; (3) the incorporation of mechanisms for people engagement in DG; or (4) the alignment of the model's claimed goals with people-centredness. Table 2 highlights the three most common themes in each studied category, providing a glimpse into potential PCDG aspects and mechanisms. The 6 archetypes shown in Figure 4 are constructs extracted from the collective of reviewed passages aiming to conceptualise representations of DG. They are not intended to inform discrete implementations of DG models in cities: multiple constructs may have a nested relationship or complement each other (e.g., Calzati and van Loenen, 2023a; City of Barcelona, 2015; Fischli, 2022), or some models could incorporate elements of these archetypes rather than adopting them in their entirety (e.g., Foth et al., 2021). The results of this study do not imply completeness but are part of an evolving PCDG framework that should be complemented by further aspects and constructs. Nevertheless, they contribute to discussions about desirable urban futures by unpacking the notion of PCDG as it exists in the literature, providing a foundation upon which interpretations can be problematised and normative work can be based. The aim of this work includes a reassessment of PCDG. To achieve this, the remainder of this section critically examines the archetypes, identifying both problematic and constructive components. Finally, insights from this critique are consolidated to inform a reassessment of PCDG.

Both CompA and RBA represent models that adopt individual-centric approaches, focusing primarily on the data subject. The first pitfall of such models is their exclusion of mechanisms pertaining to the conception of data. They focus on how data can be controlled, owned, or sold by the data subject rather than why and how it is collected (Doned and Belli, 2020; Lehtiniemi, 2017). Addressing the conception of data requires collective mechanisms rooted in democracy and civic participation, which go beyond an individual's capacity to regulate their own data flows. Instead, they involve collective decisions about which issues should be datafied (de Lange, 2019) and investments in data collection schemes (Muldoon, 2022). Indeed, in many cases pertaining to CompA, the data subject decides whether or not to collect data (e.g., Wang et al., 2014). However, the scope of this decision-making is typically limited to a simple "yes" or "no," as the specifics of what to datafy and expected benefits are usually predetermined by potential data consumers.

Furthermore, emergent benefits are realised only when data exits the associated models' domains. For example, while CompA aims to promote economic fairness by allowing the data subject to intervene in the extractivist data regime (Lehtiniemi and Haapoja, 2020), a fundamental issue undermines the viability of compensation as a people-centred solution: compensating for data turns it into a private asset, primarily serving the interests and goals of the entity that comes to own it and separating people from the realisation of the emergent benefits of data. In RBA, the motivation for data sharing must be carefully considered if the emerging benefits are to be realised by data subjects and the general public. Altruistic endeavours or self-interest, coupled with the capacity to engage in the activity of sharing, often drive data's flow outside the model's domain to realise these benefits. The latter requires not only an intrinsic willingness but also the presence of external initiatives that align with the values and goals of the data subjects.

In CivRA, data subjects are represented by an intermediary, which is tasked with governing initiatives by both the private and public sectors and stewarding the 'public interest'. Although models associated with this archetype are an improvement to the status quo, they might not ensure the incorporation of people's perspectives and needs, nor guarantee that benefits are realised by them, for three main reasons. First, the archetype is recognised as the most conservative amongst the 6 archetypes in terms of people's participation and control. It functions by representing citizens and their interests without their direct involvement, contrasting sharply with others that facilitate data-related decision-making by data subjects or collective deliberation. The preference for representation in CivRA over deliberation is based on the assumption that deliberative processes are impractical (König, 2021; Ryfe, 2005). However, this approach to democracy often aims to preserve the core of the system rather than challenge it (Blaug, 2002). In contrast, deliberative processes are viewed as more legitimate in integrating people's needs and insights into decision-making (Blaug, 2002; de Hoop et al., 2022), thereby fostering an environment in which the emergence of ideas that could potentially challenge existing systems is possible.

Second, weak participation coupled with an arrangement of agents including the public and private sectors along with citizen representatives might reproduce a microcosm of the current governance landscape. This arrangement, especially when (1) the trust itself is developed and enabled by private entities, (2) initiatives involve Big Tech, or (3) initiatives are underpinned by Public-Private Partnerships, might fail to balance power dynamics or reduce asymmetries (e.g., Artyushina, 2020; Sidewalk Labs, 2018). These dynamics might be further reinforced by the vagueness and problematic application of the term 'public interest'. For example, Short (2023) highlighted that the 'common good' or 'community' values are seldom considered by American agencies in analysing the 'public interest'. Instead, an outcome is often considered to align with the 'public interest' if it is justified by "studied, economic arguments" (e.g., cost–benefit analysis) (Short, 2023, p. 759). Moreover, the prevailing interpretation of 'public interest' tends to adopt a majoritarian view, which can leave minority and marginalised communities unprotected (Feasby, 2020). This is especially problematic since vulnerable groups are already disproportionately impacted by the datafication of the city (Kennedy et al., 2021; Tracey and Garcia, 2024).

As seen in ResCA, DDA, and CommA (Table 3), it is expected that the domains of models associated with data as a common good encompass the realisation of emergent benefits. This concept extends beyond segmenting access of data between a group and outsiders, materialising in the realisation of data "for the common good" (City

of Barcelona, 2015, p. 27) and the eventual "production of a common good" (de Lange, 2019).

ResCA positions the public sector as a defender of people's right to the city, working to balance power asymmetries between corporations and citizens. While a traditional concept of openness, operationalised through open data initiatives, likely exists in cities adopting such a model, ResCA promotes a form of openness that demands action from private entities. This is enforced by the public sector through mechanisms like procurement agreements, public tenders, or licensing terms that stipulate interoperability and mandate the sharing of citizens' data (City of Barcelona, 2015). The aim of ResCA is to transfer control of data and digital infrastructures back to the people and to the city itself (City of Barcelona, 2015; City of Amsterdam, 2021). It does not accommodate traditional corporate practices, particularly because it aims to counteract these forces.

DDA benefits from strategies and policies in cities that support alternative economic actors and social organisations. In return, it enriches the city by promoting fairer labour environments (DDA.A) or offering personalised options for managing personal data streams that leverage contributions of data subjects for the greater good (DDA.B). However, this model is viewed as complementary rather than standalone due to several limitations: (1) it lacks mechanisms for the initial conception of data; (2) it relies on public sector support to counteract competitive pressures from corporations and to encourage data donations from individuals; (3) although it has the potential to contribute to systemic change and advance the common good, it primarily serves the immediate interests of co-op members or data donors; and (4) it does not address other forms of urban data that are not identifiable.

CommA is driven by people from the conception of data through to the realisation of its emergent benefits. It presupposes the development of a shared understanding of what constitutes the common good and how it can be achieved through the collection and use of data (de Lange, 2019). Although this model serves as a form of resistance to the status quo by enabling the community to meet its own needs and shape its narrative, it often offers an alternative to corporate practices without actively disrupting them on a larger scale. Effective forms of societal change at the city-level require both: building alternatives and abating existing hegemonic practices (Hebinck et al., 2022).

The three aforementioned models (ResCA, DDA, CommA) realise data as a common good through different configurations of their Normative, Actors, and Technical layers. However, they share three key commonalities. First, the power dynamics underpinning each of these socio-technical systems favour people: the public sector positions itself as a defender of the people against the hegemonic model by focusing on public-community partnerships (ResCA); intermediaries act solely as fiduciaries to ensure the benefit of those who co-produced the data (DDA) or those impacted by it (DDA.A); or people serve as enablers, agents, and beneficiaries within the DG system (CommA). Second, these models play a role in balancing power asymmetries imposed on cities by the hegemonic ownership model by (1) countering practices that inhibit people's control over datafication (ResCA) and (2) developing alternatives to the status quo (ResCA, DDA, and CommA). Third, radical forms of people's engagement in DG are demonstrated in these models, including co-creation and deliberation. These forms connect people directly to decision-making spaces around key aspects of the system such as its ontology (e.g., defining what the common good entails), goals, and beneficiaries.

4.1 Re-assessing PCDG

There are four key points to consider when assessing PCDG. The first concerns the domain covered by the model or integrated models (e.g., RBA connected to DDA). If these do not include the realisation of the emergent benefits of data, then, they do not ultimately aim to fulfil people-centred ends. An example of this is CompA, where values of privacy and control, along with the compensation of people for data sharing, serve as people-centred means. These means legitimise the separation of people from the emergent benefits of data they co-produce, which are often realised for private interests. Another stage of the domain that is often disregarded is the conception of data (e.g., CompA, RBA, and DDA), which plays a role in shaping the emergent benefits. While the extraction of meaning from data originally designed for other purposes is possible, crucial gaps remain (Lazer et al., 2021; Sadowski et al., 2021). Therefore decisions regarding the purpose of datafication, what to datafy, and how, can better orient the model towards intended people-centred ends.

The second involves the power dynamics embedded in PCDG models. While the domain might include or exclude specific stages of DG, power dynamics determine the extent to which people's needs and perspectives are incorporated into these stages and reflected in the resultant benefits. These require the examination of interactions between the context, agents, beneficiaries, claimed goals, and people engagement. As seen earlier, although CivRAencompasses the four stages of the domain (conception through to the realisation of benefits), the extent to which people's perspectives and needs are truly incorporated into DG and their reception of emergent benefits remains questionable due to the relative powerlessness of people demonstrated in the Actors layer of the model, which might reproduce a microcosm of the status quo.

The third involves participation and is directly linked to the second, since different forms of participation influence power dynamics in distinct ways. Radical forms of participation (such as those linked to CommA) that connect people to decision-making spaces involve people in major aspects of the model, such as defining what the ontology entails (de Lange, 2019), the underlying values (de Rosnay and Stalder, 2020), and claimed goals (Calzada, 2021). It materialises in various forms such as deliberative sessions or co-creation (City of Barcelona, 2015; van Zoonen, 2020). This contrasts the more conservative involvement of people in CivRA.

The fourth is concerned with the extent to which the model plays a role in balancing the power asymmetries emerging from the landscape in which it is situated. A model that aims to meaningfully incorporate people in DG cannot be developed in isolation, but must instead be informed by the status quo, which is underpinned by significant power imbalances that disadvantage people. The cognisance of the status quo and the intention to change it begin with the entities enabling the model, are embedded in its goals, and are operationalised through the development of mechanisms that disrupt prevailing practices (as seen in ResCA) and alternatives that

explicitly realise the common good (as seen in ResCA, DDA, and CommA).

If the aforementioned points are not addressed, what is perceived as PCDG could be a result of scaffolding models with people-centred elements to legitimise and perpetuate the extraction of data from cities and people, while preserving the core that continues to serve private interests. Accordingly, the authors suggest a PCDG framework that aligns the orientation of the emergent benefits of data with people's needs and priorities by (1) ensuring coverage of all stages of DG from the conception of data to the realisation of its emergent benefits, (2) addressing power dynamics within the model to ensure people's perspectives and needs are fully incorporated and reflected into these stages, (3) incorporating high-level participation that connects people to data-related decision-making, and (4) proactively balancing power asymmetries embedded in the broader landscape.

5 Conclusion

This study unpacked and reassessed PCDG in cities through a systematic scoping review. It extended the discussion of PCDG beyond initially identified indicators, such as participation and instrumental aspects. It emphasised the importance of connecting people to the emergent benefits of data, the power dynamics within the model, the extent to which participation facilitates decision-making, and the model's role in balancing power asymmetries within the broader landscape. The conclusions of the paper thus argue for (1) moving away from compensation models, which separate people from the emergent benefits of data and legitimise its use as a private asset; (2) exercising caution around rights-based models as standalone solutions, suggesting their integration within broader initiatives that treat data as a common good and encompass both the conception of data and the realisation of its benefits; and (3) a shift in focus from pursuing a vaguely defined and often majoritarian 'public interest' to embracing the 'common good', which is defined by the people and provides a consistent normative framework throughout the DG model.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

JBN: Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. AC-L: Conceptualization, Writing – review & editing. DS: Supervision, Writing – review & editing. MA: Supervision, Writing – review & editing. LB: Supervision, Writing – review & editing. SG: Funding acquisition, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work is funded by a Monash Data Futures Institute postgraduate scholarship and the Monash Faculty of Information Technology.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsc.2024.1518618/full#supplementary-material

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