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# Exploring the relevance of ‘smart city’ approaches to low-income communities in Medellín, Colombia

Harry Smith · Gabriela M. Medero · Stephanie Crane De Narváez · Wilmar Castro Mera

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**Abstract** Smart city approaches have tended to be top-down, techno-centric/corporate and expensive approaches which are promoted by large, global companies. Smart city narratives focus on their expected capacity to improve citizens’ quality of life. However, can technology-driven and municipally-led smart city initiatives address the issues faced by poor and vulnerable communities in urban and peri-urban areas? This paper explores key aspects of the implementation of smart city approaches in the Global South taking as a case study the Colombian city of Medellín, which has been recognized internationally for its social innovation and is considered a smart city by the Inter-American Development Bank. The paper draws on a local, national and international literature review; interviews with key local stakeholders involved in smart city initiatives; and an international workshop on smart cities and community data management organized by the authors in Medellín and bringing together three perspectives: academia, government and community. The paper provides a reflection on the concept of smart city, data management and citizen participation in smart city initiatives in Medellín, contrasting each of these with the

literature. Our research found gaps between broader conceptualisations and community-oriented intentions in smart city initiatives in Medellín, as well as very low uptake and reported impact of such initiatives. We conclude that a redefinition of smart city approaches that may respond to the needs of the population while improving liveability is still urgently needed, and we set out a series of questions for an international research agenda on low-income community-oriented smart city research.

**Keywords** Smart cities · Community data · Community management · Low-income · Global South

## Introduction

Smart city initiatives favoured by municipal governments tend to be top-down, techno-centric/corporate and expensive approaches which are promoted by large, global companies that produce the systems and equipment these approaches require. In rapidly growing cities in the Global South, the benefits provided by smart city initiatives to the large proportions of the population living in poor, unplanned and unregulated neighbourhoods are questionable. Though there is a debate in the smart city literature over technology-oriented versus people-oriented approaches, this tends to focus on the underlying ethos of smart city

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**Table 1** Types of interviewed organization

Sector	Interviewee	Focus
Academia	Universidad Pontificia Bolivariana (UPB), GIDATI Research Group	App development, digital content, artificial intelligence, data science and ICT
	Universidad Nacional de Colombia, Architecture Faculty: Escuela del Hábitat	Habitat-related research
	InTIColombia Research Group, Vive Lab Bogotá Project	Innovation and co-creation lab
NGO	Makaia	Strengthening of social capacities through cooperation, technology and innovation
	Low Carbon City	Collective solutions to address climate change
Citizen Collectives	Un/Loquer	Collaborative and experimental work around technology, with a special focus on community empowerment
Public– Private	Ruta N	Business innovation centre
Private	Medellín Chamber of Commerce, Sustainable Habitat Cluster	Provision of business services
	Corporación Colombia Digital	Digital transformation and technology appropriation
Public	Investment and Cooperation Agency (ACI) (Public agency)	Cooperation, investment, internationalization
	Medellín and Aburrá Valley Early Warning System (SIATA)	Risk management, monitoring of environmental conditions, citizen science and local technology development
	Medellín Network of Public Libraries	Science and culture

initiatives rather than on their effectiveness in helping address inequalities in cities—whether in the Global South or the Global North. Furthermore, there is ample evidence in the literature on urban technologies of their potential to increase inequalities and processes of socio-spatial urban fragmentation (e.g. Graham & Marvin, 2001). Therefore it is essential to assess the real-world impacts of the rapid deployment of new urban technologies and systems, as distinct from the idealized narratives produced by companies and municipal governments. The capacity of the smart city systems in place appears to be limited in scope, reach, and relevance.

The challenges are therefore: (1) to assess the wider technological and societal impacts of smart city initiatives, including assessment of the effectiveness of adopted technologies as well as their impact on inequalities and social inclusion/participation; and (2) to redefine smart city approaches in a way that responds to the needs of the population, improving urban resilience and liveability. In this regard, addressing the former challenge requires an evaluation of the purposes and impacts of smart city initiatives in

relation to poor, peripheral and vulnerable communities. This paper contends that addressing the latter requires enabling and supporting community-led data collection and management on the one hand, and the development of processes whereby top-down and bottom-up data generation and management can be used in complementary ways and provide a basis for joint decision-making on the other hand.

This paper explores these challenges using as a case study the city of Medellín, Colombia, which promotes itself as a smart city, achieving prominence amongst Global South cities in this regard though comparative international studies such as Amar-Flórez (2016). Medellín is a significant case study because, particularly in Latin America, it has become an exemplar of urban management initiatives such as ‘social urbanism’, which are widely considered to have transformed the city and which have won it international accolades such as the Urban Land Institute’s award to the most innovative city in the world in 2013 (Garcia Ferrari et al., 2018). Medellín’s high profile in international urban management circles on the one hand—e.g. forming part of a range of networks such as 100

Resilient Cities and being reported in the press as the world's smartest city (e.g. Bintrim, 2015; Freedman, 2019)—and its extremely high levels of inequality on the other, make it a critical case study to address the following questions: To what extent are smart city approaches effectively being adopted beyond the rhetoric? And to what extent do smart city initiatives address inequalities and support social inclusion?

The paper first reviews the literature on (1) key ways in which smart cities have been conceptualised, (2) issues of data management, which is central to smart city approaches, and (3) citizen participation and co-creation in smart cities. The paper then sets out the methodology employed to undertake the research. After introducing the context of Medellín and providing a brief overview of how its smart city approach has evolved, the paper then (1) maps how key players in smart urbanism in Medellín relate to such conceptualizations, (2) explores the successes and limitations of data management for smart urbanism in Medellín, and (3) assesses the level of citizen participation in key so-called 'smart city' initiatives in Medellín. The paper concludes with a proposed new research agenda for smart city research that supports communities in benefitting from (and influencing) smart city thinking.

### **A review of key literature on conceptualizations, data management and citizen participation in smart city discourse**

#### Conceptualizations of the smart city

The concept of smart city has been promoted since the end of the twentieth century by various actors and institutions (Matus & Ramírez, 2016), mainly by technology companies (Bouskela et al., 2016; Dirks & Keeling, 2009; Dirks et al., 2010; Duque, 2016), and later by public administrations and academia (Hollands, 2008; Caragliu et al., 2011; Van and Leiba 2019). Since the concept of smart city is both theoretical and practical, there is no consensus on a definition (Chourabi et al., 2012; Odendaal, 2003), nor a framework to apply it as a universal approach (Albino et al., 2015).

Though the earliest references to the concept are from large technology companies, linking it to business models such as IBM's, multilateral agencies such as the World Bank, the United Nations and the

European Union also see their interests reflected in these initiatives and promote them (Duque, 2016). These organizations tend to approach the notion of smart cities from the perspective of how it can help address current issues and realize opportunities in terms of the technological efficiency they purport to represent (Bouskela et al., 2016).

Academics have taken a more critical approach, going beyond the supposed benefits of technology. Hollands (2008, 2015) notes that smart city labelling not only distracts from the negative effects of high-tech and networked data structures on cities, and that there may be differences between rhetoric and reality when smart cities are labelled as such, but also that it can alienate and exclude many of the city's residents. As opposed to the corporate technology-oriented approach to smart cities, a range of academic authors have proposed a people-oriented approach that focuses more on social and human capital and, for example, the potential of participatory governance as part of a smart city approach (Albino et al., 2015; Eremia et al., 2016; Greenfield, 2017; Hollands, 2008, 2015). This approach would seem particularly appropriate in the Global South, avoiding costly hi-tech solutions and making use of grassroots' potential. Among the many mainstream conceptualizations of the smart city, three relatively recent definitions and one set of success factors that go beyond a technological focus are worth noting. The three selected definitions are taken from authors who based these on wide literature reviews and who took different approaches that underpin their construction of such definitions.

The International Telecommunications Union—ITU (2015, Recommendation ITU-T Y.4900) defines a smart sustainable city as 'an innovative city that uses information and communication technologies (ICTs) and other means to improve the quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects'. This is an institutional view focused on the implementation of multilateral international organizations' agendas, based on an analysis of more than 100 definitions and linking the United Nations concept of sustainable development with ICTs as a means to improve the quality of life, efficiency in urban services and competitiveness. In this definition ICT is still central, and it seems to attempt to straddle corporate

views of smart cities and an institutionalised language around sustainable development.

Bouskela et al., (2016, p. 16) state that ‘A smart city places people at the centre of development, incorporates ICT in urban management and uses these elements as tools to stimulate the formation of an efficient government that includes collaborative planning processes and citizen participation. By promoting integrated and sustainable development, Smart Cities become more innovative, competitive, attractive and resilient, thus improving lives’ [translated from Spanish by the authors]. This definition advocates people-centred development, with ICT being the means for efficient urban management of comprehensive and sustainable development, in which social and human capital benefit from city governance, planning and infrastructure. It thus bridges the technology- and people-focused approaches.

In their review of the literature on the domains of a Smart City, Neirotti et al., (2014, p. 26) concluded that ‘an SC should be able to optimise the use and exploitation of both tangible (e.g. transport infrastructures, energy distribution networks, natural resources) and intangible assets (e.g. human capital, intellectual capital of companies, and organisational capital in public administration bodies)’. They focus on tangible and intangible societal assets as a prerequisite for a smart city, distinguishing between hard (technological) and soft (welfare-related) domains, with the latter not requiring technological deployments but the creation of appropriate social and institutional conditions that lead to greater well-being (Neirotti et al., 2014).

Chourabi et al. (2012) identify a series of dimensions related to territorial and spatial aspects, economic development, development stakeholders’ agendas, ICT infrastructure, quality of life and active participation. They argue that these dimensions are factors that contribute to successful smart cities if they are integrated into how public and private sector organizations operate, if an appropriate culture is promoted among public sector officials and citizens in general, and if they improve quality of life and economic development—this latter condition being the most important.

What the prevailing definitions have in common is that they see ICTs as means to solve problems and generate opportunities given their efficiency, generating a data-based urban planning, which tends to a

computational understanding of the city as interconnected and integrated systems and infrastructure, reducing urban life to logical rules and procedures and calculators (Kitchin, 2016). This data-based urban planning is aligned with innovation, entrepreneurship and the market, a situation that requires investment, configuring dynamics of supply and demand in a logic where citizens and quality improvement are placed at the centre of the discourse of life. However, in reality smart urbanism is still ‘rooted in pragmatic, instrumental and paternalistic discourses and practices instead of social rights, political citizenship and the common good’ (Cardullo & Kitchin, 2018, p. 1)—i.e. it is still focused on a technology-oriented approach rather than a people-oriented approach. This has prompted calls for ‘smart urban governance’, moving away from ‘the technocratic way of governing cities often found in smart cities’ (Jiang et al., 2020).

#### Data management in the smart city

According to these conceptualizations, smart cities are fuelled by data, but ‘before a city can deploy applications, it has to be able to generate, capture, and analyze enormous volumes of data in complex infrastructure systems and settings that are often teeming with millions of people’ (McKinsey Global Institute, 2018, 77). For this to materialize, cities must have a strong technology base, which is comprised of (1) fixed and mobile sensors and devices; (2) communication networks such as broadband and mobile networks, free public Wi-Fi, and low-power wide-area networks (LPWAN) that support the Internet of Things; and (3) open data portals that provide standardized, shareable formats of data, and deliver the necessary information to ‘train’ analytics and AI systems (McKinsey Global Institute, 2018). These networked information systems enable data collection, storage and analysis at city level in the *digital city* model of the smart city (Cocchia, 2014).

Defining this combination of physical and digital infrastructures as essential to produce smarter solutions within the application areas of the smart city (Degbelo et al., 2016), or as an integral part of the city’s infrastructure which can be considered as a means to integrate and coordinate the city’s subsystems in order to make cities more smart, liveable and sustainable (Batty, 2013), suits the narrative of the large corporations that provide, and in some cases

manage, these infrastructures. A key issue is how and in what areas do these digital infrastructures aid communication and knowledge management in a way that, together with innovation, creativity and the capacity to create knowledge at the institutional level, generates smart territories and cities (Komninos, 2006).

As part of our research and international literature review, we reviewed how data is produced, managed and used within a range of initiatives in the cities of Singapore, Barcelona, Cape Town, Buenos Aires, Rio de Janeiro and Jakarta, which represent different geographic and socioeconomic contexts and display a range of technological bases,<sup>1</sup> according to a 2018 study conducted by McKinsey Global Institute. These case studies show that ICT, networks and data are harnessed to develop solutions to problems that are context-specific and that affect the quality of life of large segments of the population. Through the use of IoT technology and data analytics, these investments in infrastructure and technology are aimed towards the improvement of a range of issues including mobility and transport, public services, environmental issues and hazards, safety and citizen security, health, energy and governance, among others—all contributing to economic development. The case studies acknowledge data management as a way to make government more transparent, participative and effective; the importance of digital inclusion, digital democracy and equitable access to ICT and its benefits; the value of public data that is openly accessible and used to help in the co-creation of solutions through participatory platforms; and the concerns around data sovereignty, ethics and privacy. However, they also show that data-driven smart city initiatives tend to adopt a top-down perspective led by local governments, are bound by the vision and priorities of each political cycle, and can face resistance from institutions and public officials. Important challenges highlighted by the case studies are the difficulties in providing systematic real-time open data and the widespread scarcity of community-led data management initiatives.

<sup>1</sup> The selected cities were given a score based on their technological base: Singapore was given 25.0 points, Barcelona 20.8, Cape Town 10.7, Buenos Aires 10.5, Rio de Janeiro 8.8 and Jakarta 8.1. Medellín was given a score of 9.2 (McKinsey Global Institute 2018).

The questions that need to be addressed in order to explore the effective adoption of data-fuelled smart city approaches are therefore: How is data managed and used in smart cities? What types of data are used? Who has access to and/or uses the data? These are critical questions that need to be analyzed in order to understand the drivers of smart city infrastructures, how the use of technology and data is increasing (or not) citizens' quality of life, and what underlying complexities underpin these initiatives—these were explored in our fieldwork in Medellín.

#### Citizen participation and co-creation: community data management

Another key question driving our research was to what extent do smart city initiatives address inequalities and support social inclusion? And as an integral part of this, to what extent are poor, peripheral and vulnerable communities involved?

Although citizen participation is commonly valued as a critical component in urban management, it may lose legitimacy when the role of the community is less about inclusion and more about imposition and manipulation (Till, 2005). Arnstein's (1969) seminal hierarchy of participation<sup>2</sup> suggests manipulation is often embedded in participatory processes. Therefore, in order to truly enable participation, traditional and top-down systems of governance should be either replaced or at least complemented by the deployment of context-specific knowledge and experience from local actors and communities within a specific socio-cultural context (Shotter, 1993). In this regard, we need to understand the processes and dynamics behind community-led urban management through self-produced data usage, as well as evaluate how effective they are at addressing issues such as socio-spatial and environmental vulnerability and resilience, or quality of life.

The capacity of poor, marginal communities to mobilize around common goals and priorities, and find innovative solutions to complex problems through the

<sup>2</sup> The levels of participation and community engagement were famously described by Arnstein (1969) as 'a ladder of citizen participation'—ranging from manipulation and therapy (non-participation); through informing, consultation and placation (tokenism); to partnership, delegated power and citizen control (citizen power).

use of information and communication technologies is undermined by what has been labelled in the literature as the ‘digital divide’. The term refers to the gap between segments of the population that have access to new forms of information technology and those who do not (Van Dijk, 2006). Consequently, individuals or groups that are subject to this exclusion—whether due to geographical location (urban vs. rural), education, socio-economic status, or in a broader sense the differences between more or less developed countries—will ultimately also be excluded from the benefits that ICT is heralded to bring (Selwyn, 2004). Although the concept of the ‘digital divide’ has been questioned for its ambiguity (Van Dijk, 2006) and for presenting various pitfalls in the use of the metaphor,<sup>3</sup> it is an important issue to consider in relation to community-led urban management initiatives and the complex obstacles these face in a networked and technology-driven world.

There is a gap in the academic literature and in the prevalent discourse of the smart city in relation to community-led data management in the context of Colombia. This is a relatively unexplored theme within that of the application of smart city strategies in urban and peri-urban contexts, especially relating to poor and vulnerable communities in the Global South, including the case of Medellín.

In the broader international literature, however, several research strands run in parallel to or stem from the smart city discourse while adopting a people-centred approach, such as the Human Smart City (Duarte de Oliveira, 2016), Living Labs and Open Innovation (Dutilleul et al., 2010; Paskaleva, 2011), and ICT for Development/ICT4D (Sciadas, 2003; Van Reijswoud, 2009). These research strands provide a basis to evaluate how communities can themselves use information technologies in order to address real-life needs with context-specific solutions, using local knowledge and community assets.

Amartya Sen’s Capability Approach (CA) is a response to views of development based solely on

<sup>3</sup> Van Dijk questions the ‘digital divide’ in the sense that the metaphor suggests (1) there is a divide between two distinct groups, (2) the gap is complex and difficult to bridge, (3) the divide is about absolute inequalities between those included and those excluded, (4) the divide is static instead of constantly shifting, and (5) physical access to digital technology will solve particular economic and social problems, revealing both a technological and normative biases (Van Dijk 2006).

income or utility, recognizing the need to view human development more holistically and encompassing individual needs. CA is relevant to a more participatory smart city in the sense that it has been associated with the practice of ICT4D (Andersson et al., 2012; Tshivhase & Turpin, 2016), Community Informatics (Stillman & Denison, 2014), Design for Development (Oosterlaken, 2009) and Computer Ethics (Johnstone, 2007), among others, as a social theory capable of offering a specific framework to orient different types of practices towards a more holistic and human-centred approach.

The focus on capabilities is of growing importance in the field of development in general and in ICT4D in particular (Thapa & Sæbø, 2014). Several authors promote this approach because it not only considers the economic benefits of disseminating ICTs in low-income communities in their efforts to boost their development, but also has an integral vision of development (Hatakka, 2011; Robeyns, 2006; Thapa & Sæbø, 2014; Tshivhase & Turpin, 2016; Zheng, 2009; Zheng & Walsham, 2008). ICT4D recognizes that technology by itself cannot contribute to human development. What ultimately makes a difference in people’s lives is the specific use of technology and the extent to which it helps communities and individuals achieve their development goals (Hamel, 2010).

This literature review highlights that further work is needed in research and in practice to develop more effective and better defined methodologies to enable community data management and citizen-centred development through the articulation of capacity building, technological appropriation and effective citizen participation.

## Methodology

At the core of the methodological approach taken in this study was a comparison of top-down and large-scale application of technology and data use with community-centric and -led initiatives to improve sustainability and liveability in cities, using Medellín as a case study. Key components of the methodology were:

1. Fieldwork: Organizations with key smart city initiatives that were ongoing in the city of Medellín at the time of the research were identified

and mapped during the preceding desktop exercise (a local-level literature review of 44 items from academic and the public and private sectors within the national Colombia and Medellín contexts). This was the basis for data collection and interviews with relevant government agencies, community organizations and NGOs in Medellín. Three types of criteria were used to select organizations and potential interviewees: (a) cross-sector coverage—we aimed to include actors in the community, private, public, NGO and academic sectors who had knowledge and/or experience in either implementation of or research on digital technologies, appropriate technologies, smart cities, etc.; (b) range of approaches—we aimed to include actors with different perspectives on smart cities, including from top-down to bottom-up; and (c) reflection of the local government's agenda—we wanted to ensure that a reasonable proportion of the selected initiatives and respondents allowed us to explore the implementation and equity of the official local government smart city agenda. Twelve semi-structured interviews were undertaken, with the interview topic guide being adapted to the type of interviewee (Table 2), and covering the following themes:

- Characterisation of the interviewee's organization;
- Conceptualization and perspectives of the smart city;
- Data management and use, access and appropriation of information and technologies;
- Methodologies for co-creation and citizen participation relevant to smart cities;
- Impacts of the initiatives at the community, city and national level.

The interviews were analysed according to the above themes, within each of which responses were codified and analytical categories were identified using a grounded theory approach.

2. An international workshop on Smart Cities and Community Data Management held in Medellín in May 2019, which brought together different views in relation to smart cities within the Latin American contexts, especially in relation to vulnerable

communities. The workshop was a one-day event focused on seeking innovative solutions to social and economic problems within the context of the smart city approach in Colombia and Latin America, making appropriate use of information technologies. It was run as a working meeting with 14 participants from academia and grassroots organisations, in which: (a) the results of the literature review and the interview analysis were presented and discussed, thus helping the research team refine their findings; and (b) a set of three questions around the scope for bringing together top-down and bottom-up smart city initiatives, the use of data to benefit the whole of the population including the most vulnerable, and the elements of a proposed research agenda around inclusive smart cities were discussed. Notes of the workshop were taken and written up by the researchers, and circulated among the participants for validation. This workshop was preceded by a half-day event which consisted of presentations from a range of invited stakeholders presenting academic, institutional and community perspectives on smart city approaches and their relationship with vulnerable communities—which was open to students and staff at the Faculty of Architecture and other departments of the Universidad Nacional de Colombia Sede Medellín. This preceding more public event provided inputs and background for the next-day workshop that was part of the overall research methodology.

We next turn to the context of the smart city as developed in Medellín, as a basis to then analyze how participation and co-creation methodologies have been used there and how these practices have been framed within a smart city vision.

### **Medellín and the smart city: development and planning context**

The Metropolitan Area of the Aburrá Valley (AMVA), with Medellín at its centre, is the second most important and populous urban area in Colombia. According to the National Statistics Department DANE (2019), it has 2,372,330 million inhabitants, i.e. 5.4% of the national population, and its GDP constitutes 44% of the 14% of national GDP that the



Department of Antioquia contributes to the nation (Cámara de Comercio de Medellín para Antioquia, 2019).

The city's topography has influenced its growth, as well as the segregation patterns that have emerged (García Ferrari et al., 2018). Low-income self-built areas are clustered in the north-eastern, north-western and central-eastern peri-urban areas of the city, where they tend to be located on steep slopes of 30% and above (Development Planning Unit—DPU, 2005; Schnitter, 2007; Velásquez, 2011). This situation is compounded by the high population density, high levels of poverty and social vulnerability and exposure to landslide and flooding hazards (Alcaldía de Medellín, 2015). Addressing these spatial segregation patterns was at the heart of initiatives such as the presidential programme intervention in the early 1990s in order to address the high levels of violence and inequality, which rolled out the slum upgrading *Programa de Mejoramiento Integral de Barrios de Medellín* (PRIMED), and subsequently the 'social urbanism' interventions of the 2000s, which connected peripheral neighbourhoods to the city centre via cable cars and provided them with cultural/educational facilities and parks (see García Ferrari et al., 2018). These initiatives put Medellín on the international map of recognized good urban management practices, and gave the city the impetus to seek international recognition eventually as a resilient city, a smart city, etc. On the ground, however, these initiatives had led to localised improvements, with larger scale socio-spatial segregation between the centre and the periphery continuing.

In addition to the specific conditions on the city's hillsides, there are citywide issues around air quality (Guerrero, 2017) and security, the latter having improved, though homicide and extortion rates are still a concern (Medellín Como Vamos, 2018). The city's historic high inequality continues to be a key issue. According to UN-Habitat and CAF (2014), income inequality between 1991 and 2010 in Medellín increased by 20% as measured by its Gini coefficient. This situation has improved only slightly recently, as in 2010 the index was 0.55, and in 2017 it was 0.52.

These conditions, partly resulting from accelerated and unplanned urban growth, permeated the city during the 1990s (Serna, 2011), coinciding with the climax in local and national violence (Centro Nacional de Memoria Histórica-CNMH, 2017). The city addressed

this situation, starting a process of transition and emphasizing the need to move towards services as the basis of its economy, which was first promoted by the public sector and later became the focus for public–private initiatives around two types of proposal: changing the city model and increasing productivity.

The change in the city model includes both an 'outward city', focused on internationalization,<sup>4</sup> and an 'inward city' focused on innovation,<sup>5</sup> its spatial pattern and the configuration of business and institutional ecosystems for economic growth and social development. In relation to the 'outward city', Medellín was showcased as a case study by the Inter-American Development Bank (IDB) and the Korean Research Institute for Human Settlements (KRIHS), highlighting mobility, environment and security strategies, the steps taken towards becoming a high-tech centre that articulates these and other dimensions, as well as its citizen-focused strategies<sup>6</sup> (Amar-Flórez, 2016).

Within the 'inward city' model, the Intelligent and Sustainable Medellín Master Plan (MedIS 2030) is an instrument that aims to establish guidelines and direct the future of technological territorial development in a broad regional context.<sup>7</sup> It is clear that the intention is to complement the city's current spatial planning, which proposes slowing down urban expansion on the slopes and promotes inward growth. This requires incorporating a cross-sectorial technological component at different levels to foster and support the development of the city as a whole and in all its parts (Alcaldía de Medellín, Universidad Nacional de Colombia y Universidad de Antioquia, 2018).

The focus on productivity underpins the consolidation of seven strategic clusters in digital businesses, sustainable habitat, fashion and advanced manufacturing, coffee, sustainable energy, health and business

<sup>4</sup> International aid, attraction of foreign investment and tourism.

<sup>5</sup> Medellín Innovation District, Medellín-Ruta N Innovation and Business Center, Medellín LAB and Smart and Sustainable Cities.

<sup>6</sup> This study concludes that although the city lacks a clear methodology and an articulation between civil society, academia and the private sector, its progress is comparable with what was achieved by Barcelona.

<sup>7</sup> MedIS 2030 is structured under three objectives: economic development, carbon footprint reduction and quality of life improvement.

**Table 2** Key Smart City Initiatives in Medellín identified by the research. *Source:* Information taken from initiative websites, as listed in the table

Initiatives	Description	Organizations
MEData <a href="http://www.medata.gov.co">www.medata.gov.co</a>	The city of Medellín's open data strategy, which seeks the gathering, opening up and use of data as a tool for government, citizen action and decision-making	Medellín Mayor's Office
Mi Medellín <a href="http://www.mimedellin.org">www.mimedellin.org</a>	A platform for citizen co-creation. It allows development and application of new ideas from citizens, thus contributing to their transformation	Medellín Mayor's Office Ruta N Corporation
Medis 2030	This is a strategic planning and forecasting method to give direction to the technological spatial development of Medellín in its regional context with a horizon to 2030. It is related to the city's spatial plan (Plan de Ordenamiento Territorial) and articulates the various dimensions of spatial public policies, maximizing rural and urban links based on the implementation of highly innovative technology-based pilot projects, financed through strategic public-private partnerships and international aid	Medellín Mayor's Office National University of Colombia University of Antioquia
Sistema de Alerta Temprana de Medellín y el Valle de Aburrá (SIATA) <a href="http://www.siata.gov.co">www.siata.gov.co</a>	A regional strategy based on scientific knowledge, technological development and innovation, in order to identify and forecast natural and anthropic events that may alter environmental conditions in the region, or which may generate risks to the population. It is based on real-time monitoring and hydrological and meteorological modelling	Aburrá Valley Metropolitan Area (AMVA) Medellín Mayor's Office Public Enterprises of Medellín (EPM) ISAGEN
Consejo de Datos de Medellín	A collaborative committee formed by representatives from local government, private enterprise, start-ups, civic groups involved in technology, universities and international partners. Its objective is to create a communication channel among the interested parties in the municipalities that form the Aburrá Valley, in order to facilitate the continuous and sustainable redefinition and implementation of the participating organizations' data strategies	Ruta N Corporation
Datos Abiertos del Área Metropolitana del Valle de Aburrá (AMVA) <a href="http://datosabiertos.metropol.gov.co">datosabiertos.metropol.gov.co</a>	An institutional initiative that provides access to the data held by AMVA and its 10 constituent local governments, mainly in six areas: spatial planning, mobility and transport environment, economic and social development, security and coexistence, and administration	Aburrá Valley Metropolitan Area (AMVA)
Nodo Ká <a href="http://www.nodoka.co">www.nodoka.co</a>	Platform for the exchange of resources, knowledge and information in the social sector in Latin America and the Caribbean. It is based on fee-paying membership	Makaia

tourism. This makes the city think in terms of the region, generating new relationships based on knowledge and capabilities for the creation of new values in the goods and services provided by its productive sectors (ACI Medellín, 2019).

This shift benefited from a series of emerging national programmes focused on connectivity and the use and appropriation of information and communication technologies (ICT). This was capitalized on by the city in the Medellín Ciudad Digital<sup>8</sup> (Medellín Digital City) programme, making it a national and

international model and the main precedent for the Colombian Smart City, thus referenced as such by the Colombian National Ministry of Education (2013).

In this context, the key initiatives our research identified are based in state organizations, and most

<sup>8</sup> Currently, there are no impact studies of these types of programmes. However, recent academic literature does provide a critical assessment of the real appropriation of ICT (Rueda 2005; Barrera 2013; Quiroga-Parra, Torrent-Sellens and Murcia 2017).

are focused on open data (Table 2). However, when investigating the robustness of these datasets (amount of data and currency of the data) and whether they were in real time, they were found wanting, with the exception of the weather data reported by SIATA. This could be due to the initiatives having been established recently and to the organizations they are based in needing internal restructuring in order to generate open data according to established standards, which is apparently in process. An exception to state-led initiatives is Nodo Ká, a platform that emerged as part of the processes of development capacity maximization that the NGO Makaia supports, which are based on co-operation, innovation and technology.

### Analysis of Medellín's smart city approach

#### Smart city conceptualizations in Medellín

Our interviews in the city of Medellín identified the following considerations in relation to the concept of 'smart city', as seen by key local stakeholders: the extension of the concept to that of 'smart territories' beyond the confines of the city; the gap between the discourse of smart cities and its real impact on these territories; the smart city as a macro solution to specific problems (mobility, security, technological appropriation, etc.); the smart city as a trend towards a digital city which uses technology to address challenges in citizens' lives and supports internationalization; and the need for smart citizens, although in practice the initiatives we identified tend to focus on technology rather than on citizens.

Smart city terminology has been in the Colombian political discourse for less than a decade, and it seems to have been adopted as a response to the felt need to connect to a global agenda or trend, but without a critical and ethical analysis of its implications. Kitchin (2016) highlights ethical issues related to privacy, datafication, data surveillance, geosurveillance, profile creation and social classification. Our interviewees referred to two aspects related to these ethical issues: the primacy of technology and the potential of cross-cutting data management and what this might mean for citizen privacy; and citizens and the new spaces for, and forms of, participation.

The analysis of smart city conceptualizations among Medellín interviewees shows that they do not

share a common definition. For public sector interviewees, the concept is linked to a planning process because it starts from strengthening different initiatives or projects and then integrating these in a single discourse. Different aspects of smart cities emerged in the public sector interviews depending on the specific process the interviewee was involved with. For example, for an agency promoting Medellín the concept was also seen as an internationalization strategy, making the city visible and energizing the economy to generate greater 'social development'. NGO and academic interviewees tended to have a more critical vision, with the citizen taking centre stage and technology being seen only as a tool among a set of possibilities. In other words, the interviewees focused their responses on the specific interests of their organizations and emphasized the importance of data production, although they did not express or establish the need for this to be in real time.

It is important to highlight that Colombia, a country saddled with a historic armed socio-political conflict which has impacted on all aspects of its development, offers a very specific context for the conceptualization of the smart city explored here. Within this context, Medellín, which was an urban expression of this conflict, has in the last twenty years undergone a transformation that has generated interest nationally and internationally in the strategies it has employed. Transport improvements in previously not very accessible and socially marginalized areas, as well as the inclusion of ICTs in the digital city strategy, are among the experiences that have been recognized nationally and internationally as having social impact, and which are addressed in the smart city discourse.

On the other hand, the smart city concept has evolved to become an overarching approach, with better quality of life, economic development, data generation and the use of technology being common aspects and objectives. This is reflected in the interviewee responses, with those outside local government—such as academia and NGOs—questioning the true role of citizens and their participation, the real impact of technological artefacts on the territory, and whether the smart city is simply a marketing label which homogenizes and ignores the socio-economic gaps in the city. While for academia and NGOs it is important to undertake an in-depth analysis of this type of urban process, for the local public sector the concept is associated with opportunity and a gap in the

market mediated by data, in which the city is structured as a system which provides efficient services and which resolves its problems based on innovation and citizen participation as co-creators. Nevertheless, it is also seen as a challenge due to the organizational structures of local government, which are rigid and vertical, and the internal implications of providing data from the local administration to the citizenry.

We also found, however, that urban technologies for local knowledge management are used as a problem-solving tool, as in the case of SIATA, BiblioLab, Un/locker and Makaia's initiatives, but such use is not clear among the other interviewees. In this regard, the appropriation of technology and its direct link to common problems such as air quality have contributed to conceptualizations of the smart city that are more relevant to what is happening in the city of Medellín. By contrast, at the national level of Colombia, the smart city is seen as a forward planning strategy within the new logic of development promoted by international organizations worldwide.

#### Data management in Medellín: An illustrative snapshot

Various initiatives in social, economic and environmental development have engaged with data management in Medellín, although such data management is still in a process of development and systematization. Our research did not aim to make a comprehensive and complete assessment of all smart city initiatives in the city of Medellín. Rather, based on a set of interviews with a selected sample of key actors in Medellín, we aimed to (1) understand the orientation and drivers behind the infrastructure that supports smart city approaches in Medellín to improve citizens' quality of life; (2) begin to distinguish which are the types of data that are considered important to carry this out and what they are being used for; and (3) visualize the gaps, challenges and possible opportunities existing in these processes.

Here we briefly outline how ICTs and data are being harnessed to different degrees in order to address context-specific issues that have been identified either within the city's Development Plans at an institutional level or by citizen groups and NGOs in Medellín, within the areas of environment, public policy, pedagogy and education, entrepreneurship, and

challenges and opportunities in open data and governance. These themes emerged through coding of the semi-structured interviews.

#### *Environmental hazards*

Some of the interviewed organizations have worked on quantitative data in environmental monitoring. At the municipal level, SIATA has implemented monitoring processes for air quality and flood and landslide risk throughout the city; in particular, they have more than 130 rain monitoring stations in the 1150 km<sup>2</sup> region of the Aburrá Valley, while at a national level there are only 300 stations for the whole country. This is possible largely because SIATA has developed an in-house operation where they design, build and maintain their own monitoring devices with the help of electronic specialists from the National Learning Service (*Servicio Nacional de Aprendizaje, SENA*), which helps lower operational and maintenance costs. Additionally, with regards to air quality, SIATA is currently working towards providing real-time data for Open AQ, a platform that monitors general air pollution levels, which is supported by the current administration of the Metropolitan Area of the Aburrá Valley (AMVA).

The Universidad Pontificia Bolivariana (UPB) has initiated a sensing project called 'Smart Campus', through which they collect information on the energy they produce internally with solar panels to be able to share energy production data and its impact on CO<sub>2</sub> levels. Through the '*My Resilient and Low Carbon Neighbourhood*' initiative, Low Carbon City has generated data and diagnostics on waste collection issues and mobility and traffic flow. Given its small scale and low resources, its data collection methodology does not have a high level of technological innovation, with a manual survey-based process to generate data in order to measure its final impacts. They are also testing another initiative using participatory mapping, where through a platform, citizens can report, for example, where they believe there is a tree deficit, among other things.

#### *Public policy*

In Medellín, data has been generated and used by the public sector mainly in two lines of work: security and environment. In the case of security, access to data is

restricted and there is no publicly available detailed knowledge of its flow. In the case of the environment, a wide generation of hydroclimatological data is evidenced, the most relevant being the data on air quality due to local problems that are accentuated by the geographical conditions of the deep and enclosed Aburrá Valley, with air quality becoming one of the city challenges addressed in the Medellín Intelligent and Sustainable Master Plan (MedIS 2030).

The air quality data collected, mostly in real time, has helped to establish pollution reduction measures such as the ‘day without a car’ and ‘*pico y placa*’ (which reduces private and public motor vehicle use during peak hours). However, due to the complexity of the problem, the data obtained has been the starting point for modelling as well as for the generation of short, medium and long-term public policies such as the Comprehensive Air Quality Management Plan for the Aburrá Valley 2017–2030 and the Operational Protocol to address issues relating to air pollution (Área Metropolitana del Valle de Aburra-AMVA, 2019).

#### *Pedagogy and education*

Bibliolabs has been working with Makaia on a project that involves environmental sensors. However, according to the interviewees, its interest lies not in the sensors per se, but in increasing citizen awareness of the different environmental issues that affect their territory. Bibliolabs seeks to work with community members to generate data that can promote a sense of community and integration, where data acquires a pedagogical and productive value.

Un/Loquer has developed a learning kit with a focus on teaching people in the community to build and assemble environmental sensors—which measure levels of particulate matter, temperature, etc.—as a learning and empowerment process. Un/Loquer’s objective is to generate pedagogical tools that allow citizens to learn about electronics, open data and solving different kinds of problems.

SIATA pilot projects are accompanied by advanced social processes working with the community, including addressing the social and violence issues that prevent community work at times. All SIATA river basin monitoring processes have a component of community participation in the mapping of the territory, which in turn integrates the historical

memory of the community (what has happened, when it has happened, who has been affected).

In Medellín there are therefore interesting experiences attempting to link the monitoring of different environmental factors with social and pedagogical processes within the communities involved. These experiences raise the question of how can the social processes that accompany monitoring initiatives converge with a smart city vision that is more embedded in the territory and the communities that inhabit it. There is a gap in theory and practice in this regard, and we see this as an open question that requires further research.

#### *Entrepreneurship*

The Medellín Chamber of Commerce’s Sustainable Habitat Cluster (*Clúster de Hábitat Sostenible*) argues that the drive to ‘sensorize’ the city arises from the importance of data to generate new business models addressing the city challenges identified in the MedIS 2030 model. However, there is not enough infrastructure in Medellín to generate the required databases regarding mobility issues, waste management and public lighting, among other services. There is a business drive behind the MedIS 2030 model with an economic interest for the city to adopt new urban planning models, which, hand in hand with Big Data and sensors, may generate new markets around the problems of air quality, mobility and waste management. The Sustainable Habitat Cluster and Ruta N value the use of data particularly in its application to new collaborative business schemes, in partnership with the private sector.

#### *Open data governance: challenges and difficulties*

The city of Medellín has been working on open data issues through an Open Data Council, to gather the information collected by government institutions and other agencies in order to make them openly accessible through platforms such as MEData and Datos Abiertos del Área Metropolitana del Valle de Aburrá (Open Data of the Metropolitan Area of the Aburrá Valley). These institutional initiatives seek the provision of data produced by government agencies to (1) facilitate third-party access to information produced by government, (2) promote transparency and (3)

facilitate citizen participation (Alcaldía de Medellín, 2017).

The interviews revealed a series of difficulties that have hindered the effectiveness of these initiatives. Some organizations are providing almost real-time information, but most of the databases are disorganized, historical, do not have the semantics to be easily exported, or lack the functionality to develop applications or other practical purposes. The difficulties in accessing data openly and in real time need to be seen in the Colombian context of great social and economic inequalities and lack of a culture of technological appropriation at multiple levels, especially at the institutional level.

Local government departments operate in traditional ways and do not yet have an organizational structure to manage open data processes. This would require a restructuring of the public bodies of the city, since these were devised as traditional operational and political structures rather than from a technological point of view. This hinders the implementation of an alternative more centralized data management model. In addition, resistance to open data in government departments is also created by the perception that the data they produce is for internal use, which makes it difficult to develop a data management system in accordance with the standards of more advanced smart city strategies. The development of an open data platform called MEData by Ruta N confirmed that there are many gaps related to data use, inventory, anonymization and governance processes. This resistance is partly due to government agencies and the balances of power within these feeling threatened, and even more so if an alternative model that is more open towards citizenship is sought.

There is evidence of ongoing processes of data standardization and institutional modernization taking place in Medellín. For example, AMVA has given impetus to systematizing information and to proposing public policies within the framework of open data, on the premise that all the information needed for effective land and spatial management must be public and available to the community. In summary however, there is still a way to go for the data to be fully used internally by public sector agencies and externally by citizens, as seen in Fig. 1.

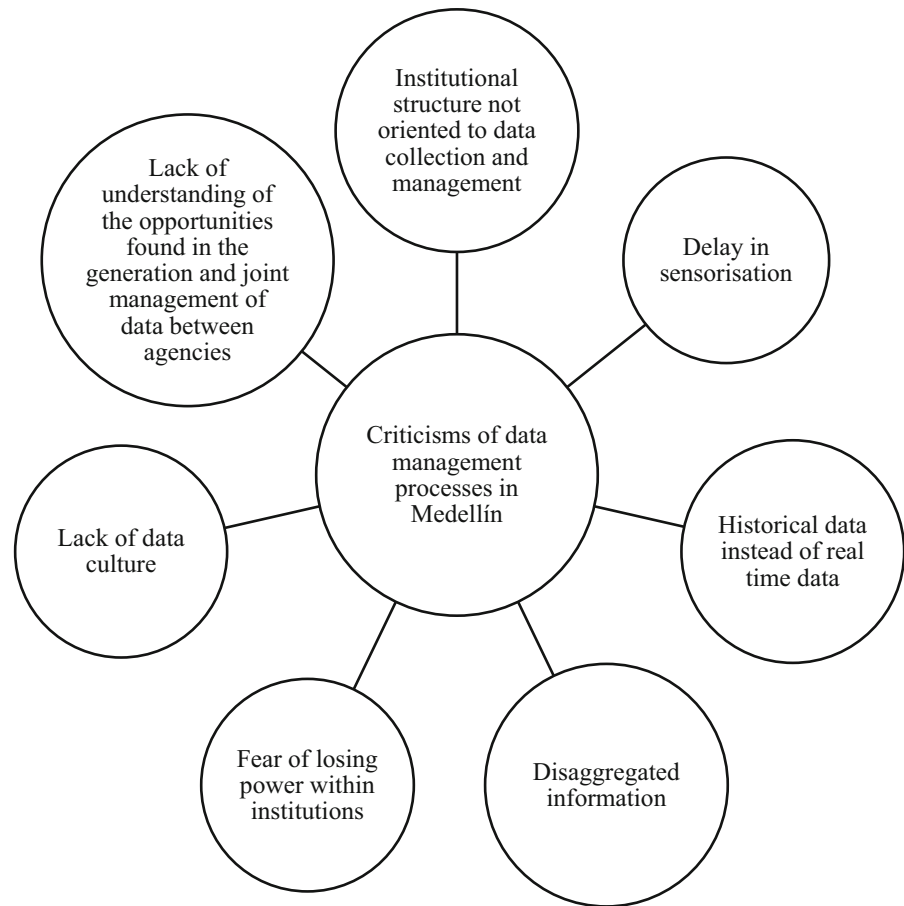
How is citizen participation framed within the smart city model in Medellín?

Our fieldwork in Medellín found that citizen participation is part of the way of working of a range of organizations, which claim they attach a high degree of importance to the inclusion of citizens in training, empowerment, awareness-raising and environmental activism. Examples of approaches from different perspectives found among interviewees in Medellín include, among others:

- Academic: as an object of research (with interviewees concluding that participation is low and the use of web platforms that allow feedback is almost nil).
- NGOs: claiming they promote more inclusive approaches that support co-production or capacity building for problem solving.
- Public sector institutions and agencies: proclaiming the need for participation that is cross-cutting, structural and at the level of organizations and cities.

Within smart city initiatives particularly related to the use of virtual tools that support or generate processes of co-creation and resolution of strategic city problems, participation is often limited to citizens who are acquainted with, and see opportunities in, the use of this type of tools, and have the knowledge and knowhow to use them. On the other hand, participation can be reinforced and diversified with technological tools, which may help communicate the problems of the city and specific territories. Our research suggests this could be seen as a way in which new forms of community in the smart city are being strengthened. In Medellín, there is a range of pre-existing forms of citizen participation (ranging from community-led Community Action Boards through to local government-initiated participatory budgeting and capacity-building workshops, among others), to which technological tools are now being added such as web platforms that create virtual spaces for participation around city issues, such as the Mi Medellín platform which reinforces citizen co-creation processes (see Table 2). As part of the 2016–2019 Development Plan, the Secretariat of Citizen Participation, alongside the University of Antioquia, developed a methodology to analyze and measure the quality of citizen participation (through the Index of Citizen Participation of

**Fig. 1** Criticisms of data management processes in Medellín



Medellín—IPCM and the Information System and Knowledge Management on Citizen Participation—SICG), and published their first report in 2017 focusing on youth and women’s participation in Medellín (Alcaldía de Medellín, 2017).

In the context of Medellín, the issue of the ‘digital divide’ discussed earlier is linked to the city’s large socioeconomic and knowledge gaps. This leads to questioning the effectiveness of the tools that various institutions have made available to the citizens (e.g. MEData, Mi Medellín), as well as the methodologies being used to generate co-creation processes between academia and community (e.g. SIATA, Makaia and Low Carbon city with regards to air quality, and Bibliolabs by generating spaces for technology experimentation workshops). However, through the interviews, we identified examples of work being undertaken aimed at closing gaps between smart city (or related) initiatives and the inclusion of citizens in these processes. In particular, Low Carbon City has

worked on small scale interventions based on awareness of inequality and the socio-economic and development gaps that exist; Makaia has identified development needs (not necessarily technological) with communities, and developed and delivered capacity-building, awareness-raising and self-learning processes to enable people in the community to engage with technology; Un/Loquer has built capacities in citizens so that they can solve any type of problem or need with the help of technology; and Bibliolabs has focused on the democratization of knowledge.

It should be noted that the level and scale of participation in smart city (and related) initiatives seems to be linked to the nature of the issue such initiatives address. Environmental initiatives which affect everyone and are in the media, such as those focused on air quality and climate change, are prioritized as city challenges within local government plans and strategies, attaining high levels of participation. However, participatory processes set up to

address problems that may affect only specific sectors of the population, such as environmental risk management (e.g. landslides and flooding), do not reach similar levels of citizen participation and are not seen as relevant by the general population. The issue of levels has two aspects: one is the breadth across the city, and the other is the intensity of citizen involvement or engagement. For example, citizens in general may be aware of air pollution data, but be much less involved in specific activities than someone who sees their neighbourhood and home affected by hazards such as landslides and floods. Although environmental issues are city challenges that the smart city model tries to address, the way in which environmental management is approached at the city level is different from how other social issues are addressed, such as manifestations of inequality, which although perhaps are not city-wide problems, do affect a substantial proportion of the population.

### Role of the citizen

Analyzing the role of the citizen and their degree of inclusion in certain processes helps understand the extent to which the top-down dynamics of smart cities may converge with different community-based initiatives. Arnstein's Ladder of Participation becomes relevant in this section, as defining the extent to which the citizen exercises an active role can determine the effectiveness of a smart city initiative that attempts to bring together top-down and bottom-up approaches. Figure 2 maps different types of roles as identified by our interviewees onto Arnstein's Ladder of Participation.

In Medellín there are considerable barriers that make it difficult for many citizens to take an active role in smart city processes, a key one being the high socio-economic inequality, which discriminates between those citizens who have access and ability to propose, create, innovate, learn and contribute, and those who do not—with a range of intermediate conditions. This highlights that participation in the smart city is a social problem, since the needs of a citizen will be determined by their particular socio-economic conditions, and their possible lack of skills and/or access will limit their ability to participate. In addition to this, their role as participants in the smart city is envisioned in different ways by different types of actors in smart city initiatives, from citizen and scientist citizen, to

user and client, each of which has different connotations for the role that the person has within a specific initiative, service or process.

And finally, even in the cases of certain institutional initiatives (e.g. the Mi Medellín portal) which purportedly offer citizens the opportunity to propose ideas that respond to a series of city challenges and that may contribute to the innovation and co-creation process, there are limitations to the role of the citizen. Not only is access to such opportunities hindered by the already mentioned access/knowledge gaps, but suggestions from those who can participate are merely that, suggestions that may or may not be carried out, a type of engagement that Arnstein's Ladder would classify as tokenistic and that may undermine the long-term willingness of citizens to engage through this type of tool.

### Citizen participation and its impact on social exclusion and inequality

Ascertaining to what extent and how the processes of participation and/or co-creation with communities have helped solve social problems, requires taking into account the origin of the initiatives, their sustainability over time and, of course, the nature of their impact. The interviews identified relevant initiatives which were focused on a variety of topics, but these were found to be isolated experiences, not sustained over time or still under development, and without clear impacts yet identified. Table 3 illustrates examples of programmes, projects, actions and applications developed with a social approach, as found in our exploration of smart city initiatives in Medellín.

Though we did not find evidenced impacts on social exclusion and inequality, the interviewees did refer to other impacts of participation (environmental, economic, political). In particular, SIATA highlighted the environmental impact of 'Scientist Citizens' through raised awareness and change of habits, although this has not been measured; Low Carbon City mentioned their working methodology with communities within their 'My Resilient and Low Carbon Neighbourhood initiative'; and finally, it was seen in the cases of MedIS 2030 and MiMedellín that citizen participation is an important tool to define and solve city challenges and generate socio-economic development, as well as participation across academic, business and social organizations.



Citizen Power	8. Citizen Control	
	7. Delegated Power	● Appropriating, creating, resisting and proposing solutions, entering into other conditions in the new world of technology (Digital Capital).
	6. Partnership	● Acquiring new knowledge and co-creating solutions through the use and re-configuration of technologies (Un/Loquer). ● As 'Scientific Citizens', in the monitoring and co-interpretation of data (SIATA).
Tokenism	5. Placation	
	4. Consultation	● As a proponent of ideas that respond to a series of city challenges and that contribute to the innovation and co-creation process (Ruta N).
	3. Informing	
Non-Participation	2. Therapy	
	1. Manipulation	

**Fig. 2** Mapping of citizen roles on Arnstein's Ladder of Participation. *Source:* The authors, based on Arnstein (1969)

### Community data management in Medellín

The use of ICT in Colombia has been linked to the hope that technological appropriation will facilitate data management and that this will narrow socio-economic gaps. In theory, this may be possible depending on how such appropriation takes place. However, for Hamann (2016, p. 28) 'smart cities run the risk of fostering inequality, due to privileged access to technology and education'. The answer to this lies in the access to, and use and appropriation of ICTs, which aren't straightforward. According to Álvarez et al. (2011), internet consumption or literacy are not figures that effectively measure the uptake of

ICTs. For this one needs to identify people's specific needs, with the objective of building different scales of appropriation, on a personal basis, that allows an assessment of ICT use socially.

However, as our interviews showed, such appropriation is still an ongoing process in Medellín and a thorough analysis of the impact of ICT and its associated participatory methodologies is still pending. In addition, there is an extremely limited number of studies on community-led, bottom-up data management in the context of Medellín in particular and Colombia in general (Smith et al. 2020a, b, 2021), which evidences a need for initiatives (in research and in practice) that can articulate community-led data

**Table 3** Examples of smart city programmes, projects, actions and applications with a social approach in Medellín

Bibliolabs	Urban agriculture and 3D printing project as a focus of community learning on issues with social and community impact: aiming to democratize technology and build alliances with strategic local actors
Makaia	Working and collaborating with technology-based companies to facilitate technological appropriation by social organizations and community groups (e.g. helping farmers learn how to use smartphone technology to boost their business). This work is based on the identification of needs of different community groups, focusing on development needs rather than on technologies themselves as a solution
SIATA	Monitoring system of hydrometeorological conditions of the city and early warnings. Directed towards environmental management and risk management. The first has had an emphasis on air quality and climate change. The second is related to the early warning of natural hazards, which cause the greatest losses in the informal areas of the city
SIATA	Participatory budgeting for the procurement of monitoring equipment and establishment of community alerts for the prevention of flood risk in Quebrada Doña María
ViveLab Bogotá	Development of applications with a focus on issues of armed conflict and gender vulnerability, among others

management and participatory co-creation methodologies with the wider discourse and application of smart city solutions, especially in such unequal societies as Colombia.

### A new agenda for low-income community-oriented smart city research

We have seen that the concept of smart cities is relatively ambiguous, with varying definitions and applications, which respond to a wide range of elements in the political, economic, environmental and social domains. Often these initiatives tend to be top-down, technocentric approaches promoted by the state or by corporate companies with vested interests in the development of smart city solutions to complex problems within cities with the help of ICTs, Big Data, IoT and virtual or digital tools. By reviewing the key ways in which smart cities have been conceptualized, we found that in many ways the case of Medellín echoes the ongoing currents of smart city agendas seen on a broader level, as a way to harness the use of ICTs to improve areas such as economic development, mobility, public transportation, environmental risk management, and data production and management, among others. However, the scope and focus of this vision is not yet clear. Having mapped how key actors and stakeholders in the academic, local government and community visions of smart city development in Medellín relate to such conceptualizations, what also emerged are certain concepts that differ from those

found in the literature, such as the term ‘smart territories’ or the focus on technological appropriation for capacity building within marginalized communities, which are context-specific to the case of Medellín.

Data management practices on the one hand reveal an attempt to address economic, social and environmental problems through the harnessing of smart city infrastructure and data, while also revealing challenges within traditional forms of governance and in the systematization of open data systems, as well as issues relating to the quality, relevance and transparency of the data itself. The case of Medellín is a clear exemplification of the challenges and opportunities that are present within these processes. The impulse behind smart city infrastructures (both large and small scale) that underpin data management in Medellín, according to the interviewees, is related to economic growth and business development, open data governance, environmental risk and hazard reduction, pedagogy and education driven by technological experimentation and capacity-building.

Participation and co-creation methodologies are seen as a key component in the work of various government institutions and organizations, where the inclusion of citizens within smart city initiatives is considered a way to capitalize on local knowledge and collectively address urban issues that affect large portions of the population. However, the varying and mostly low level and intensity of participation within these processes reflect the complex inequalities that are present and highlight that often citizen

participation and inclusion in the smart city are a social challenge.

While several organizations and local groups in Medellín are addressing the need to build capacities among citizens and to increase the level of technological appropriation within communities that lack the resources to benefit from smart city initiatives, there is still a large amount of work to be done in order to help bridge the socio-economic divides that keep large segments of the population exposed to lower levels of quality of life, less access to opportunities and higher exposure to environmental hazards and risks. As seen earlier, further work is needed in research and practice in order to develop methodologies to enable community development through the use of data and technology. Closing the gap in research and practice relating to community-led data management within the context of poor and vulnerable communities in the Global South should be a priority in this regard.

Our attempt to assess the technological and societal impacts and effectiveness of smart city initiatives, as well as the socio-economic context with regards to inequality, social inclusion and participation in the case of Medellín, shows that a redefinition of smart city approaches that may respond to the needs of the population while improving liveability is still urgently needed. We argue that addressing this challenge requires academia and practitioners to enable and support community-led data collection and management, as well as to develop new dynamics where top-down and bottom-up data generation and management can complement each other and foster joint-decision making. To help achieve this, key questions for an international research agenda that we have initiated with this paper are as follows:

1. Do municipality-led, technology-centred smart urbanism approaches aim to address the key issues faced by citizens in poor, peripheral and vulnerable urban communities? If so, in what ways, and to what extent are they successful? How are these groups and spaces framed in smart city discourses and practices?
2. If this is not the case, why not? Is this by design, or due to how smart urbanism frames urban management matters (and certain groups of population) generally? What does this tell us about smart cities as currently deployed (globally, and specifically in Latin America)? In other words, are smart

city approaches essentially elitist and corporate-driven, and unable to envisage the needs of peripheral groups and spaces? Or can they be fine-tuned to better address local needs as well as the diverse range of actors' capacities?

3. By contrast, how effective are community-based approaches to urban management at addressing essential issues, such as socio-spatial and environmental vulnerability and resilience, or quality of life? If community-based approaches can be more effective in terms of their results, what contributes to this greater effectiveness?
4. Is there any potential for complementarity and mutual learning between top-down, smart city approaches and community-based ones? Can we imagine developing hybrid models of smart urbanism that facilitate a dialogue between different levels of urban governance and participation?

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