CEG
Centro de Estudos Geográficos

Finisterra, *LVI*(117), 2021, pp. 3-27
ISSN: 0430-5027
doi: 10.18055/Finis23269
Artigo

BEYOND THE CONTROL ROOM:
THE SMART (SUSTAINABLE?) PATHWAY OF RIO DE JANEIRO IN TIMES OF CRISIS

Luiza Josuá Cabral[1]
Maria Conceição Ramos[1,2]
Luís Carvalho[1,3]

ABSTRACT – Rio de Janeiro has been a textbook example of the limitations of smart city development, epitomized by IBM´s control room developed in the heyday of the city´s Olympic agenda. Over the last years, the smart city discussion has expanded to include notions of sustainable development in the form of a "smart-sustainable" perspective to urban planning, observed by the increasing concern with socio-environmental aspects, beyond those of strictly economic and technological nature. This paper draws on 61 initiatives to analyse how the city´s smart ambitions have evolved in this respect, scrutinizing domains, stakeholders, and focus, namely under a new context of political turmoil and budget restrictions. While most initiatives suggest weak collaborative environments and tensions between smart and sustainability ambitions, there is evidence that stagnation co-exists with the blurring between top-down and bottom-up initiatives, opening new challenges to understand smart-sustainable city development in crisis-ridden and budget-scarce cities.

Keywords: Rio de Janeiro; smart city; Olympic Games; crisis; sustainability.

RESUMO – PARA ALÉM DA SALA DE CONTROLE: O CAMINHO DA CIDADE INTELIGENTE (SUSTENTÁVEL?) DO RIO DE JANEIRO EM TEMPOS DE CRISE. O Rio de Janeiro tem sido considerado na literatura como exemplo das limitações no desenvolvimento de cidades inteligentes, personificado pela sala de controle da IBM, desenvolvida no furor da agenda Olímpica da cidade. Nos últimos anos, a discussão sobre este tema passou a incluir noções de desenvolvimento sustentável na forma de uma perspectiva "inteligente-

Recebido: 02/02/2021. Aceite: 31/05/2021. Publicado: 01/08/2021.

[1] Faculdade de Economia, Universidade do Porto, Porto, Portugal.
[2] Centro de Estudos das Migrações e das Relações Interculturais (CEMRI), Universidade Aberta, Lisboa, Portugal.
[3] Centro de Estudos em Geografia e Ordenamento do Território (CEGOT), Universidade do Porto, Edifício das pós-graduações (Gab. 625), Faculdade de Economia, R. Dr. Roberto Frias, 4200-464, Porto, Portugal. E-mail: luizajc@outlook.com; cramos@fep.up.pt; lcarvalho@fep.up.pt

-sustentável" de desenvolvimento urbano, observada pelo aumento da preocupação com aspetos socioambientais para além daqueles de natureza estritamente económica e tecnológica. Este artigo baseia-se em 61 iniciativas em curso na cidade para analisar como as ambições da mesma evoluíram neste aspeto, examinando domínios, atores e foco num novo contexto de turbulência política e restrições orçamentais. Enquanto a maioria das iniciativas reflete ambientes colaborativos limitados e tensões entre ambições "smart" e de sustentabilidade, há evidência de que a estagnação provocada pela crise pode coexistir com a fusão entre iniciativas "de cima para baixo" e de "baixo para cima", abrindo espaço para novos desafios na forma de entender o desenvolvimento urbano, inteligente e sustentável, no contexto de cidades em situações de crise e escassez de recursos.

Palavras-chave: Rio de Janeiro; cidade inteligente; Jogos Olímpicos; crise; sustentabilidade.

RÉSUMÉ – AU-DELÀ DE LA SALLE DE CONTRÔLE: LE CHEMIN INTELLIGENT (DURABLE?) DE RIO DE JANEIRO EN TEMPS DE CRISE. Le Rio de Janeiro est un exemple des limitations du développement des villes intelligentes, personnifié par la salle de contrôle IBM développée dans la fureur de l'agenda Olympique de la ville. Dans les dernières années, la discussion sur cette thématique s'est élargie pour inclure la notion de développement durable conçu comme une stratégie "intelligente-durable" du développement urbain, observée par une attention croissante aux aspects socio-environnementaux en plus de ceux de nature strictement économique ou technologique. Cet article s'appuie sur 61 initiatives en cours dans la ville pour analyser l'évolution des ambitions de la ville en tant que ville intelligente, en examinant les domaines et les parties prenantes dans un nouveau contexte de turbulence politique et de contraintes budgétaires. Alors que la plupart des initiatives illustrent des environnements de collaboration faibles et des tensions entre les ambitions intelligentes et durables, il est prouvé que la stagnation causée par la crise peut coexister avec la fusion entre initiatives descendantes et ascendantes, laissant place à de nouveaux défis pour comprendre le développement urbain, intelligent et durable, dans le contexte des villes en situation critique et en manque de ressources.

Mots clés: Rio de Janeiro; ville inteligente; Jeux Olympiques; crise; durabilité.

RESUMEN – MÁS ALLÁ DE LA SALA DE CONTROL: EL CAMINO INTELIGENTE (¿SOSTENIBLE?) DE RÍO DE JANEIRO EN TIEMPOS DE CRISIS. Río de Janeiro es un ejemplo de las limitaciones del desarrollo de las ciudades inteligentes, personificado por la sala de control de IBM, desarrollada en el furor de la agenda olímpica de la ciudad. Durante los últimos años, la discusión sobre *smart city* se ha ampliado a incluir nociones de desarrollo sostenible en la forma de una perspectiva "inteligente-sostenible" de la planificación urbana, observada por la creciente preocupación por los aspectos socioambientales, y no solo estrictamente económicos y tecnológicos. Este artículo se basa en 61 iniciativas en curso, para analizar cómo han evolucionado las ambiciones de la ciudad, como ciudad inteligente, examinando dominios, partes interesadas y enfoque, centrándose en un nuevo contexto de cambio político y restricciones presupuestarias. Si bien la mayoría de las iniciativas ilustran entornos de colaboración débiles y tensiones entre ambiciones inteligentes y sostenibles, existe evidencia de que el estancamiento coexiste con la confusión entre iniciativas de arriba-hacia-abajo y de abajo-hacia--arriba, lo que da lugar a nuevos desafíos sobre cómo entender al desarrollo urbano inteligente y sostenible, en el contexto de ciudades en situaciones críticas y con escasez de recursos.

Palavras clave: Río de Janeiro; ciudad inteligente; Juegos Olímpicos; crisis; sostenibilidad.

I. INTRODUCTION

In the current Anthropocentric Era, humanity's haphazard "take-make-dispose" approach to the natural environment and the reliance on non-renewable fuels has led to an unprecedented climate crisis (Bolger & Doyon, 2019; Gills & Morgan, 2019; The Intergovernmental Panel on Climate Change [IPCC], 2014, 2019; Yigitcanlar *et al.*, 2019). The frequency of extreme weather events increased together with temperature rises, flooding, destruction of marine and land ecosystems, with the current coronavirus pandemic being just one of the many consequences of this state-of-affairs (Snowden, 2020). These events tend to be particularly severe in developing countries, where massive urban population densities, the absence of economic resources and deficient urban provisions are often aggravating factors (UN-Habitat, 2017; United Nations, 2018).

As the hurdles of coordinating climate action at the global level became evident (e.g., Turnheim *et al.*, 2018), the search for local response grew over the last decade-and-a-half, with cities striving to proactively deal with sustainability challenges on their own (e.g., Bibri & Krogstie, 2017; Broto & Bulkeley, 2013). One of the many signs of this new urban protagonist has been the rise of so-called smart city initiatives, comprising a wide range of actions and strategies seeking to increase the quality and efficiency of urban services and infrastructure (e.g., transport, energy, health, the built environment, waste collection), combined – to a larger or lesser extent – with social equity and urban economic growth ambitions (Ahvenniemi *et al.*, 2017; Anthopoulos, 2017; Caragliu *et al.*, 2011). In many ways, smart city ambitions resonate with previous urban planning concerns with sustainability (Campbell, 1996; Naess, 2001), but now drawing on the possibilities offered by modern information and telecommunication technologies and digitalization.

Smart city initiatives grew markedly in the aftermath of the 2008 financial crisis, namely in Western and Asian cities, and were framed as instrumental to revamp local economies while curbing climate change (Carvalho *et al.*, 2018). However, there is now wide consensus that this early "smart" agenda has been falling short of expectations, with several studies challenging the ways through which smart city ambitions and initiatives have been conceived and translated into urban policy and practice (Anthopoulos, 2017; Cardullo & Kitchin, 2019; Carvalho, 2015; Contreras & Platania, 2019; Cowley *et al.*, 2018; Hollands, 2008; Mora *et al.*, 2019). Rather than effectively dealing with pressing environmental and societal challenges, smart city initiatives have been frequently exposed as branding hoaxes (e.g., Yigitcanlar & Lee, 2014), private-led, top-down, and overly technocentric approaches that fail to engage with the reforms needed to steer sustainable urban development (Ahvenniemi *et al.*, 2017; Kitchin, 2015; Martin *et al.*, 2018; Yigitcanlar *et al.*, 2019). A textbook example of the previous, often mentioned in the smart city literature, is the Urban Operation Center and Control Room devised by the International Business Machines Corporation (IBM) for the city of Rio de Janeiro (Goodspeed, 2015; McNeill, 2015; Townsend, 2013).

The developments suggest that a divorce between smart and wider notions of sustainability has actually taken place (Ahvenniemi *et al.*, 2017). Yet, this assumption underes-

timates the fact that smart city initiatives are not a cohesive whole and their materialization still differ widely across and within cities, influenced by social, political, and cultural contexts (e.g., Karvonen *et al.*, 2019). Taking this into consideration, Mora *et al.* (2019) propose that smart city strategies can be seen as encompassing variegated constellations of domains, stakeholders and objectives, with their logics ranging from highly top-down and technocentric to more inclusive and holistic practices, along different types of dichotomies. Moreover, there is also a time dimension involved, with the scope and emphasis involved in "smart" changing over time, influenced by economic and political swings, funding opportunities, bottom-up emergence, and reflexive learning (e.g., Carvalho & Vale, 2019). Yet, up until now, most studies on the smart-sustainable phenomena have focused on in-depth assessments of single flagship initiatives within a city, or in evaluating "smart" urban strategy on an aggregate level. Studies that systematically scrutinize the actual balance between smart and sustainable traits across multiple urban initiatives – as well as their origins and consequences – are scarce and only recently started to focus on cities of the so-called Global South (Gaffney & Robertson, 2018; Shatkin, 2007).

This paper contributes to this literature by assessing a wide and more recent spectrum of smart-sustainable city initiatives in Rio de Janeiro. Looking beyond a single example such as IBM´s flagship (Goodspeed, 2015; McNeill, 2015; Townsend, 2013), it seeks to re-assess and widen the perspective on smart city development in Rio de Janeiro, whose academic interest has dwindled in the aftermath of the international sports events (World Cup and Olympic Games) that sparked early "smart" initiatives in the city (Di Bella, 2020; Gaffney & Robertson, 2018). To do so, and building on recent studies on smart city development in the Global South, in general, and Latin America, in particular (e.g., Irazábal & Jirón, 2020), it seeks to position smart-sustainable city development in Rio de Janeiro under the light of deep-rooted socio-spatial and environmental disparities, as well as in relation to post-Olympic political turmoil and constriction of funds, seeking to highlight how these structural and conjunctural features have been interacting within the "smart" frame of reference. To do so, 61 initiatives were extensively scrutinized under the light of the methodology proposed by Mora *et al.* (2019), seeking to provide insight into the contemporary domains, stakeholders and the overall focus of smart city agendas and practices that unfolded since Rio de Janeiro became an early textbook case in smart city development.

The remainder of the paper is structured as follows. Section 2 provides a synthetic overview of smart city notions and the tensions that emerged around translating smart--sustainable visions into practice. Section 3 contextualizes the research setting and elaborates on the methods followed to conduct the study. Section 4 presents the results, identifying domains, stakeholders, and initiators for the analyzed set of initiatives. While there is evidence of a persistently weak collaborative environment and several tensions between smart ambitions and sustainability realities, the emergence of new bottom-up hybrid initiatives opens new perspectives for the future of smart city development in Rio de Janeiro. Section 5 concludes, raising challenges for smart city research in crisis-ridden and resource-scarce cities.

II. SMART CITIES: A BRIEF OVERVIEW

1. Origin and concept

The concept of smart city as such has made its first appearance in the early 1990s (Angelidou, 2015; Yigitcanlar *et al.*, 2019). Gaffney & Robertson (2018) trace the origins of the term to the new paradigms that emerged in North America out of the tension created between the rise of suburbs and the decline of central business districts. Its roots are also often associated with smart growth and new urbanism movements from the same period, which proposed new models of urban planning to tame urban sprawl and related environmental externalities (Hollands, 2008; Kitchin, 2015; Yigitcanlar *et al.*, 2019). Likewise, the idea that technology plays a pivotal role in urban societies has a long history, being portrayed as a driver of city development as well as a universal solution to most, if not all, urban problems ever since the industrial revolution (Angelidou, 2015; Bibri & Krogstie, 2017; Lee *et al.*, 2014; Townsend, 2013).

From this perspective, "smart" is one of the many concepts in an already vast lineage of notions seeking to address the relationship between cities and technology, including – but not limited to – "wired cities" (Dutton *et al.*, 1987), "intelligent cities" (Komninos, 2013), "digital cities" (Ishida & Isbister, 2000) or "information cities" (Batty *et al.*, 2012). Similarly, concepts such as "sustainable city", "eco-city", "green city" and "resilient city" have emerged in literature, emphasizing the connection between cities, its citizens, and the natural and built environment (de Jong *et al.*, 2015; Register, 1987; Sodiq *et al.*, 2019). In the midst of this diversity and proliferation, and according to Yigitcanlar *et al.* (2018, p. 146), these variations can be seen as "a result of different interpretations of what an ideal city should be like, and which policies these cities utilize to sustain growth, and address socio-spatial inequalities of resources". While information and telecommunication technology, particularly at the face of recent digitalization trends, has asserted itself as a rather indissociable aspect of the smart city concept, there is still no consensus as to a categorical definition or understanding of smart city (Baraniewicz-Kotasińska, 2020), as well as the balance between technological and wider sustainability concerns (Hollands, 2008; Komninos, 2013; Mora *et al.*, 2019). An illustration of some of the most common definitions, derived from Yigitcanlar *et al.* (2018), is listed on table I.

The absence of a "correct", or at least most widely accepted definition of smart city, allows for a corresponding lack of accountability. Cities can proclaim to be (or plan to become) "smart" by one definition or another, according to their actor´s needs and desires, without providing any type of measurable urban development outcome (Hollands, 2008). The issue is further complicated by the abstractness of the main ultimate objectives related to smart city development – such as sustainability, quality of life, well-being – which are difficult to quantify and define as individual goals themselves (Gaffney & Robertson, 2018).

Table I – Some definitions of smart city.

Quadro I – Algumas definições de cidades inteligentes.

Nº	Reference	Definition	Themes
1	Caragliu *et al.* (2011)	"investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance." (p. 70)	Technology; economic growth; quality of life; community; governance; sustainability
2	Townsend (2013)	"places where information technology is combined with infrastructure, architecture, everyday objects, and even our bodies to address social, economic and environmental problems." (p. 70)	Technology; infrastructure; environment; social affairs
3	Lee *et al.* (2014)	"To sum up, a smart city aims to resolve various urban problems (public service unavailability or shortages, traffic, over-development, pressure on land, environmental or sanitation shortcomings and other forms of inequality) through ICT-based technology connected up as an urban infrastructure." (p. 82)	Technology; development; infrastructure
4	Söderström *et al.* (2014)	"In quite general terms, smart cities involve the creation of new relations between technology and society." (p. 308)	Technology; community
5	Angelidou (2015)	"Contrary to what many believe, a cohesive smart city strategy must capitalize both on technology (i.e., digital intelligence) and on knowledge (i.e., human intelligence) to achieve spatial development." (p. 104)	Technology; human capital; development
6	Kitchin (2015)	"technological version of a sequence of neoliberal-infused new urban visions, including competitive cities, creative cities, sustainable cities, resilient cities and green cities." (p. 133)	Technology; neoliberal
7	Shelton *et al.* (2015)	"While data is both the driving force behind smart city initiatives, as well as the means by which these initiatives are implemented, the ultimate goal of the policies is fostering economic development, with success judged accordingly." (p. 16)	Economic growth; technology
8	Bibri and Krogstie (2017)	"there are smart city strategies which focus on the efficiency and advancement of hard infrastructure and technology (transport, energy, communication, waste, water, etc.) through ICT, and strategies which focus on the soft infrastructure and people, i.e., social and human capital in terms of knowledge, participation, equity, safety, and so forth." (p. 191)	Technology; infrastructure; efficiency x equity; community
9	Cugurullo (2018)	"the smart-city movement relies on information technology to produce data on how the city operates, particularly in terms of energy (production, distribution and consumption) and transport, and uses it to decrease the costs and waste that urban living generates." (p. 74)	Technology; efficiency; energy; mobility; environment
10	Lara *et al.* (2016)	"a community that systematically promotes the overall wellbeing for all of its members, and flexible enough to proactively and sustainably become an increasingly better place to live, work and play." (p. 9)	Community; quality of life; sustainability

Source: own elaboration, derived from Yigitcanlar *et al.* (2018)

2. Tensions and shortcomings

Notwithstanding the many faces of the smart city – as well as its concrete translation into urban policy and planning – one of the argued main pitfalls of the smart city practice has been its technocratic and elitist perspective on urban development (Söderström *et al.*, 2014; Townsend, 2013; Yigitcanlar *et al.*, 2019).

Söderström *et al.* (2014) alerted to the biased storytelling of technology corporations, selling a narrative of technological city utopias, achievable only by utilizing their products and services. These approaches are closely linked to other important critical analyses of the smart city, which highlight the link between smart city and urban security agendas, government control and the digital mediation of the urban space through technology (e.g., Kitchin, 2014; Rodrigues *et al.*, 2020). Likewise, extensive criticism has fallen upon smart city's technocentricity when concerning social impacts and digital accessibility in regard to uneven access to innovations in contexts of pre-existing social disparities (Angelidou, 2015; Martin *et al.*, 2018). Shelton *et al.* (2015) observed that poorly devised smart city projects are likely to perpetuate social inequalities instead of solving them. When analyzing the case of Philadelphia, the authors found that the proposed solutions failed to address longstanding socio-spatial inequalities by focusing solely on education and digital literacy of marginalized residents, without taking into account mobility challenges faced by this new workforce in getting from the distant low--income neighborhoods to the districts where jobs were initially intended to be. Moreover, the high costs of new technology and its planned obsolescence have also been called into question. As argued by Yigitcanlar *et al.* (2019), particularly in the Global South, the innovative use of existing, more affordable technologies and retrofitting solutions can be just as effective – as well as more realistic in terms of public purchasing power – as the alternative of integrating an entire city with brand-new, high maintenance cost sensors and devices which will inevitably need to be replaced in progressively shorter timeframes as technology develops.

Another issue recurrently brought up by the literature in recent years is the apparent divorce between many smart city strategies and one of their allegedly main intended targets: sustainability (Ahvenniemi *et al.*, 2017; Martin *et al.*, 2018; Yigitcanlar & Kamruzzaman, 2018). By analyzing a set of smart city and urban assessment frameworks, Ahvenniemi *et al.* (2017, p. 241) concluded that although environmental sustainability is frequently reported as an essential target of smart cities, "environmental indicators are clearly underrepresented in the smart city frameworks". On the same note, Martin *et al.* (2018, p. 276) review of empirical studies conducted on European and North American cities found out that, in practice, smart city initiatives "reinforce the focus on delivering unsustainable forms of economic growth and consumerist cultures, while neglecting social equity and environmental protection".

In an effort to guarantee that smart city agendas align with wider sustainability-related objectives, some scholars have since then proposed the use of a new terminology, "smart sustainable" city, which has been getting more advocates over the years as social-

-economic and environmental concerns continue to emerge as bottlenecks in many smart cities' strategies around the world (Ahvenniemi *et al.*, 2017; Bibri & Krogstie, 2017; Kramers *et al.*, 2014). According to Bibri and Krogstie (2017, p. 193), the smart-sustainable city would be a relatively new phenomenon, described as "a city that is supported by a pervasive presence and massive use of advanced Information and Communication Technologies (ICT), which, in connection with various urban domains and systems and how these intricately interrelate, enables cities to become more sustainable and to provide citizens with a better quality of life". In many ways, this notion resembles the holistic perspective of smart city proposed by Caragliu *et al.* (2011), but by emphasizing the importance of sustainability as an encompassing concept, it calls attention to the aforementioned limitations. Yet, other scholars believe that contemporary perspectives on smart city development have deeper problems and envision a more radical shift in which citizens assume control on smart city development, drawing on notions of citizen emancipation and social justice as sustainability criteria (Cardullo *et al.*, 2019). Evidence of such a shift has started to be seen, at least partially, in cities that used to be examples of more conventional smart city development, such as Barcelona (e.g., Donadio, 2020).

From a governance perspective, a related discussion (Mora *et al.*, 2019) is whether and how smart-sustainable city development could be organized beyond early coalitions of local government and technology firms, namely towards "triple-helix" collaboration modes, involving the government, industry, and scientific community (Etzkowitz & Leydesdorff, 2000), as well as bringing in the often-overlooked civil society in so-called "quadruple-helix" models (Carayannis & Campbell, 2009). In fact, as urban matters grow in complexity and wickedness, the reinforcement of active citizenship could be not only a way to widen the types of smart city innovation but also to ensure its alignment and wider diffusion across society beyond narrow segments of pioneer users. Likewise, traditional centralized strategies devised and led by the government and/or industry players (top-down) have also been put into question by some scholars due to their tendency towards disconnection from societal expectations, subservience to market interests and the understanding of citizens as solely technology users (Cardullo *et al.*, 2019; Kitchin, 2015; Townsend, 2013). Hence, the emergence of community-driven (bottom-up) initiatives has been observed as counterbalance to ensure greater social inclusivity and empowerment within a smart-sustainable city environment (Lee *et al.*, 2014; Mora *et al.*, 2019).

The challenges, to different degrees, can be seen as transversal to most smart-sustainable city initiatives around the world. Yet, it has been recognized that tensions between smart and sustainable goals may be especially acute in large metropolises of the Global South, and require careful evaluation (Bhattacharya *et al.,* 2020). This more so as most Global South metropolises are characterized by rampant socioeconomic disparities, non--inclusive institutions, and fragile urban governance systems, prone to unbalanced and "boom-and-bust" economic growth (van Dijk, 2006). While the rate of technological uptake can be even higher in these settings (i.e., through leapfrogging) as new digital services and infrastructure are developing fast, environmental, and societal-related concerns in smart initiatives are often neglected (Prasad & Alizadeh, 2020). Despite the

influence of concepts from Europe and North America, the implementation of smart visons in the Global South often mutates along the road as a result of politicization and contestation, whether influenced by local practices and the need to tackle distinct socio--spatial "ordinary" realities (Guma & Monstadt, 2020), or by becoming instrumental to other industrial and political agendas (McDuie-Ra & Lai, 2019).

In the Latin American context, previous studies on the implementation of "digital cities" – a predecessor of the smart city movement – have highlighted their focus on digital education, inclusion, and access to public services, while recognizing that their follow--up struggled with low financial autonomy of local governments and multi-actor coordination deficits (Costa *et al.*, 2019). In recent years and in many Latin American metropolises, the small-scale, distributed character of digital cities initiatives has given rise to more ambitious – yet not necessarily more sustainable – flagship "smart" projects centered around coalitions of governmental and industrial elites, seeking political influence, capital gains and branding payoffs (Irazábal & Jirón, 2020). However, it has also been highlighted that those perhaps unsustainable flagships coexisted with, and sometimes evolved towards, "mixed and bottom-up approaches [that] serve to provincialise and often informalise the initiatives in manners that destabilize elitism and more equitably distribute costs and benefits" (Irazábal & Jirón, 2020, p. 507). All in all, Marchetti *et al.* (2019) argue that the use of technology should be seen with parsimony in Latin America, and mobilized to solve other problems – social, economic, and environmental – simultaneously. Yet, whether these phenomena and ambitions are unfolding, and how the balance between smart-sustainable dimensions has been evolving in practice in these cities – namely in relation to the political-economic dynamics of the urban context – remains to be better understood and more systematically assessed.

III. RESEARCH SETTING, FRAMEWORK, AND METHODOLOGY

1. Research setting

Building on the previous, the remainder of the paper will use of the notion of "smart-sustainable", taking an open perspective that allows to identify the multiple facets and domains taken by different smart strategies and initiatives in the city of Rio de Janeiro. Notwithstanding the early interest in the case of Rio de Janeiro to characterize smart city development in Latin America (e.g., Irazábal & Jirón, 2020) and its influence in the smart city literature (e.g., Goodspeed, 2015; Townsend, 2013), this critical case still lacks a wider and systematic assessment about how "smart-sustainable" its overall practices turned out to be, as well as on the actual constellations of actors involved and the socio-economic and political context in which these initiatives kept unfolding. This is particularly timely in a moment during which the Olympic agenda has faded out, and smart city agendas reconfigured in the face of recent economic and political turmoil, notably in the period in-between the end of the 2016 Olympic Games and the eruption of the 2020 SARS-Covid Pandemic, which is the focus of this analysis.

As of 2019, Rio de Janeiro – Brazil's second largest metropolis – had an estimated 13 million inhabitants and represented more than three quarters of the gross domestic product of the larger administrative region it is part of (the homonymous State of Rio de Janeiro; Instituto Brasileiro de Geografia e Estatística [IBGE], 2019). Its physical landscape – wedged between various mountains and the sea – has influenced its long-lasting economic engines, notably tourism and oil-related activities (Bretas *et al.*, 2020; Instituto Pereira Passos, 2019). Throughout the years, the reliance on the rich underwater oil reserves along the State´s coastline has translated into tax dependency from the royalties obtained from oil exploration and refining. In this sense, recent oil crises, price fluctuations, and royalties' disputes meant budgetary restrictions for various government projects – including investment in urban development initiatives associated with smart sustainable cities (e.g., infrastructure and transport, high-end technology, renewable energy, among others). Moreover, Rio de Janeiro is marked by a chronic struggle with socio-spatial inequalities, with have-nots and impoverished population pushed outwards and upwards for many decades, in a vast "slumification" process leading to the absence (or inefficiency) of access to basic public services such as water, sanitation, health, schooling, and transport in many parts of the city (do Lago, 2000; Mosciaro & Pereira, 2019).

While the actual urban legacy of the city´s Olympic agenda is still a matter of dispute (Neri, 2020), the economic optimism and policy alignment leading to the World Cup (in 2014) and Olympic (in 2016) years was followed by intertwined economic, fiscal, and political crises of large scale and scope. On a national level, the country was shaken by political and judicial turmoil involving accusations of corruption, money laundering and overpricing of public contracts, which culminated into the debatable impeachment of President Dilma Rousseff in 2016 (Nunes & Melo, 2017). At the State level, this situation has been aggravated by the oil royalties' debacle, leading to a fiscal recovery plan in 2017 and a series of austerity measures that restricted the transfer of funds from State to Municipalities and thus a near-stagnation of most of its urban development plans (Di Bella *et al.*, 2020). It is under this context of political mistrust, institutional fragmentation, and strict resource constraints – coupled with longstanding social inequality – that smart sustainable initiatives have been more recently unfolding in the city.

2. Research framework and methodology

In order to assess the contemporary spectrum of smart sustainable initiatives in Rio de Janeiro in the post-Olympic context, the conceptual and assessment framework of Mora *et al.* (2019) was used. In their original work, the authors conducted a multiple case study analysis of four European cities by categorizing their smart initiatives under a three-way system of domains, stakeholders, and objectives, then followed by an assessment along four dichotomies: 1) technology-based or holistic strategy; 2) double or triple/quadruple-helix model of collaboration; 3) top-down or bottom-up approach; and 4) mono-dimensional or integrated intervention logic. This study proposes an adaptation of

Mora *et al.* (2019) classification system and dichotomies, merging dichotomies 1 and 4 into a single category: segmented (technocentric or otherwise) vs holistic approach. As previously mentioned, technocentrism is not the only bias that surrounds the smart sustainable city paradigm, notably in cities like Rio de Janeiro. In this sense, unifying the first and fourth dichotomies ensures that technocentrism is not singled out as the only bias, allowing for an equivalent analysis of other biases that eventually occur. The other dichotomies, double or triple/quadruple-helix model of collaboration[i] and top-down or bottom-up approach remain mostly the same, and their meanings are described in the conceptual discussion above.

In line with Mora *et al.* (2019), Rio de Janeiro's initiatives and projects were also cataloged under two classification systems. The first classification system (table II) addresses the consolidated first dichotomy, that is, the urban domain(s) an initiative aims to address.

Table II – First Classification System (Domains).

Quadro II – Primeiro Sistema de Classificação (Domínios).

Specific domain	**Description**
1. Energy	Energy efficiency and sustainability (i.e., grids, storage, street lighting, renewables).
2. Air	Air quality measurement and control, and CO^2 reduction.
3. Water	Water distribution, quality and management.
4. Waste	Waste management, treatment systems and other solutions (i.e., recycling, upcycling).
5. Green & Public Spaces	Gardens, parks and other public spaces.
6. Mobility & Transport	Urban mobility with the use of accessible and sustainable public and other alternative transport systems.
7. Residential Buildings & Districts	Efficient, accessible, improved management of sustainable buildings and districts.
8. Public Health	Improved quality, accessibility, organization of public health services and structures.
9. Social Inclusion & Diversity	Improved social inclusion, diversity and reduction of social disparities.
10. Culture	Protection of cultural heritage and incentive to cultural productions.
11. Education	Improved educational programs, systems, renovation/construction of schools, universities, and research facilities.
12. Accessibility	Improved accessibility of products, services, structures, or environments for disabled or elderly people.
13. Public Safety & Security	Public protection of citizens, institutions and organizations against threats to their well-being (i.e., law enforcement, fire and emergency, natural and man-made disasters).
14. E-Government	Increased accessibility and convenience of public information and services to citizens and temporary residents.
15. Industrial Districts & Business Accelerators	Fostering of economic activities and employment and creation of industrial or business parks.
16. Digital Infrastructure & Solutions	Digital solutions (i.e., ICT, IoT, Big Data, *Industry 4.0*, Apps).
17. Other	Initiatives that do not belong to the previous categories entirely or in part.

Source: own elaboration based on Mora *et al.* (2019)

It has been expanded from the original 12 categories to 17 specific domains, by means of adding domains when they emerged from the data and were not clear in the original typology (e.g., green & public spaces, accessibility) and/or by singling out previous aggregated domains (e.g., separating "buildings" into housing and industrial use, as well as health from the broad "social inclusion" domain). This allowed for a more nuanced categorization and understanding of Rio de Janeiro's smart-sustainable city strategies and initiatives, as some of the challenges faced by Rio de Janeiro differ from the ones of the European cities previously analyzed.

The second classification system (table III) is related with the type of organizations that promoted each initiative.

Table III – Second Classification System (Organizations).
Quadro III – Primeiro Sistema de Classificação (Organizações).

Category	**Description**
A. Industry	Businesses involved in consultancy, services or goods providing and businesses associations.
B. Government	Local, regional or national governmental authorities, regulators and public companies or associations.
C. Civil Society	Communal organizations, other representatives of civil society and individuals[ii].
D. Scientific Community	Universities, independent researchers and other educational or research institutions.
E. Other	Organizations that do not belong to the previous categories.

Source: own elaboration based on Mora *et al.* (2019)

The identification of smart-sustainable-related initiatives started from an in-depth assessment of Rio de Janeiro's current urban development strategy, the non-statutory Strategic Plan (i.e., *Plano Estratégico* 2017-2020; Prefeitura do Rio de Janeiro, 2017), covering economic, social, governance, and environmental dimensions. The Plan's dimensions closely resemble Yigitcanlar and Teriman (2015) definition of sustainable urban development, that is, a quadruple bottom-line of economy, social, environment, and governance. However, in practice, there is a clear preponderance of Social and Environmental targets, which combined represent more than 75% of all initiatives and goals. In total, 22 initiatives – out of the 166 mentioned in the Plan – were individualized and cataloged, while the remaining ones either lacked enough information, were discontinued, or simply never came to fruition. Subsequently, desk research (during December 2019-April 2020) allowed for the detailed identification and assessment of 39 additional initiatives actually running in the city but not mentioned in the city plan. Additional initiative´s identification took place mainly through online search based on combinations of keywords such as "cidade inteligente" (smart city) and "tecnologias de informação e comunicação" (ICT), linked to "Rio de Janeiro", and based on the authors´ contextual understanding of the city. Ultimately, a total of 61 initiatives and projects where identified, catalogued, and coded within the specific domains. As mentioned, the initiatives under analysis were operative in Rio de Janeiro at the time of the research. Some had

1-2 years of existence or less; others were older, and a few had their origins dating back to the pre-Olympic euphoria years. Yet, in these latter cases, the initiative was re-assessed taking in consideration contemporary ambitions and stakeholder´s involvement. Naturally, this set of initiatives cannot claim to be fully compressive, and it leans towards initiatives with, at least, a certain degree of institutionalization. Moreover, it considers initiatives that operate mostly within the boundaries of the municipality of Rio de Janeiro. Notwithstanding these and desk research-related limitations (i.e., the reliance on secondary data only), the final set of initiatives expands previous analyses and allows for highlighting the salience of different types of domains and the coalition modes currently involved. Detailed information on the city's smart-sustainable initiatives and projects was retrieved from government, companies, and other stakeholders' websites, and triangulated with academic studies, reports, press releases and policy documents.

IV. RESULTS

1. First dichotomy: segmented vs. holistic approach

The conducted analyses suggest that most of Rio de Janeiro's initiatives focus on the digitalization of internal Informational Technology (IT) systems to improve the city´s core operations and allow for more accessible and convenient public information and services. This claim can be verified by the predominance of the domain "Digital Infrastructure & Solutions", with over a third of the initiatives within this category. Moreover, these initiatives are often multi-domain, and beyond e-Government (8/23), also encompass Mobility & Transport (6/23), Education, Public Safety & Security, and Energy targets (5/23; fig. 1 and Annex A).

Aside from sensors, cameras, and monitoring systems associated with the city's renowned IBM Control Room and Urban Operations Center (COR) and the more recent System of Urban Information (SIURB; an internal government system that manages and consolidates urban data), little evidence was found of other initiatives at the municipal level utilizing advanced digital technologies associated with e.g., the "internet of things", suggesting a slow advance of this type of agenda in the aftermath of the Olympic euphoria. In line with Gaffney and Robertson (2018), the evidence also suggests that the smart technology used in the COR has limited applications and covers a reduced geographical area, being potentially less effective or absent in outer neighborhoods, and focusing on observation, security-focus and emergency response instead of guiding planning decisions. Likewise, large urban rehabilitation flagship projects dating from the Olympic period (e.g., "Porto Maravilha" project), despite being dubbed under "smart" and targeting "modernization and inclusion", show little evidence of any distinct use of digital technology at its core, let alone any concrete social inclusion purpose.

Additionally, initiatives that involve specific domains of a primarily environmental nature (i.e., Air, Energy, Water, Waste, and Green & Public Spaces) are particularly underrepresented, as opposed to the abundance of technology-related and distinctly gover-

nance-inclined initiatives (fig. 1). This corroborates the previously mentioned critique about smart cities being found lacking where environmental targets are concerned, despite being self-portrayed as sustainable (Ahvenniemi *et al.*, 2017; Martin *et al.*, 2018; Yigitcanlar & Kamruzzaman, 2018). In Rio, a fragile urban planning tradition combined with recently heightened institutional disarray are a possible cause to this limitation. For example, the city´s Climate Action Plan (CAP) is mirred in politics (Prefeitura do Rio de Janeiro, 2018) and, between 2014-2019, Rio's municipality reduced the budget for flood control and drainage programs by more than 75% (Grandin, 2019), in a city where about 25% of its population live precariously atop hills or in makeshift households, hence naturally at a greater risk of suffering from landslides after heavy rain.

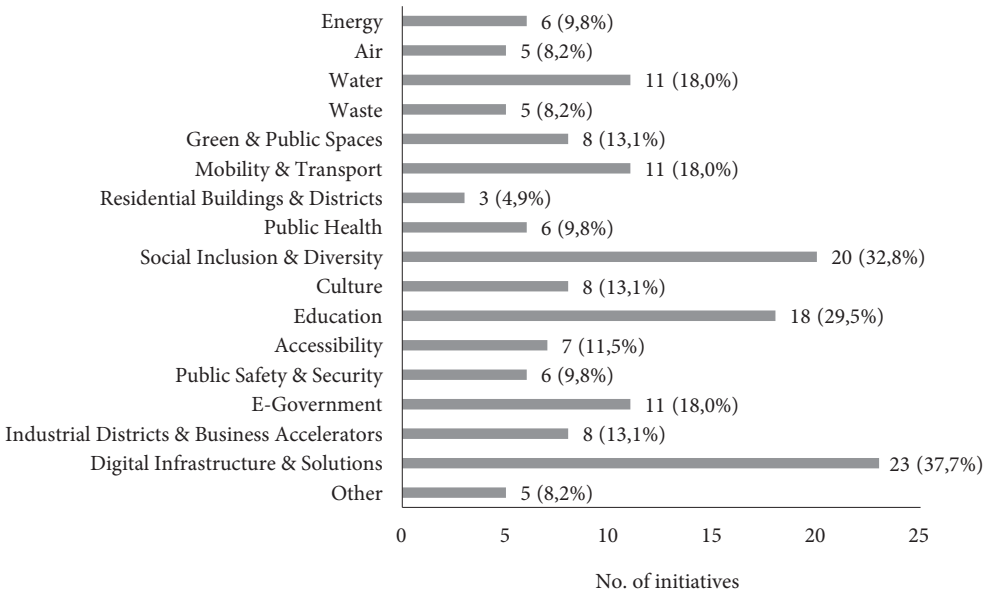

Fig. 1 – Initiatives analyzed in Rio de Janeiro, by specific domain (absolute number and percentage).

Fig. 1 – Iniciativas analisadas no Rio de Janeiro, por domínio específico (número absoluto e percentagem).

On the other hand, inherently social-related domains (e.g., Education; Culture; Social Inclusion and Diversity) are, on average, more evenly contemplated. It can be suggested that despite the challenges presented by the uncertain economic and political scenario, Rio de Janeiro's secular struggle with socio-spatial inequalities and poverty has influenced the city administration, ensuring that these concerns were at least included in the urban strategy and related initiatives. Examples of this are initiatives like the *"Naves do Conhecimento"* ("Knowledge Spaceships") – educational hubs located in some of the city's peripheries that promote more democratic and universal access to knowledge through digital technology –, or "*Projeto Ruas*" ("Streets Project"), an initiative connecting Rio's increasing homeless population to social services, health, and education.

It goes without saying that without further in-depth assessments, the concrete impact, and ultimate merits of the aforemetioned initiatives cannot be fully evaluated. Yet, the information collected suggests that several projects are still dissociated from a structured holistic vision with established long-term goals. Notwithstanding the presence of social--related ambitions in many initiatives *per se*, it is questionable whether initiatives in other domains would contribute to worsen social-goals. A prime example is the Port revitalization effort, which, despite the initial intention of improving housing and transportation situation for the local population, has been gradually pushing away residents from surrounding neighborhoods, due to increases in real-estate prices after the construction of luxurious office and residential buildings (Mosciaro & Pereira, 2019).

2. Second dichotomy: single-double vs. triple-quadruple models of collaboration

Regarding the second dichotomy, relating to the model of collaboration, the analyzed initiatives can be described as overall individualistic (table IV). Most of the initiatives are carried out by a single organization, most often the Government, with a few initiatives taken by two organizations and even less by three or four. A possible interpretation is that there is either a lack of interest and available funding from non--governmental agents (e.g., due to the economic downturn), a limited effort from the Government in coordinating and widening the number of stakeholders involved, or, more likely, a mixture of both.

Table IV – Initiatives by organization category (Rio de Janeiro).

Quadro IV – Iniciativas por categoria de organização (Rio de Janeiro).

No. Agents	No. Initiatives	A	B	C	D	E
		Industry	Government	Civil Society	Scientific Community	Other
1	41	4 (10%)	34 (83%)	3 (7%)	0	0
2	12	4 (33%)	11 (92%)	6 (50%)	2 (17%)	1 (8%)
3	5	5 (100%)	5 (100%)	4 (80%)	1 (20%)	0
4	3	2 (67%)	3 (100%)	3 (100%)	3 (100%)	1 (33%)
Total	61	15 (25%)	53 (87%)	16 (26%)	6 (10%)	2 (3%)

The involvement of the scientific community in the analyzed initiatives is particularly small. The standard triple helix collaborative model (i.e., government-industry-scientific community) is discarded in favor of a modest share in participation from the civil society. While citizen-driven participatory approaches are desirable to improve governance and ensure that citizens have a voice in decision-making processes, multiple authors defend the importance of universities and research centers as important drivers for innovation in smart agendas (Angelidou, 2017; Etzkowitz & Leydesdorff, 2000; Galvão *et al.*, 2017; Mora *et al.*, 2019). Civil Society plays an important role in iniatives such as the "*Diagnóstico Territorial Socio-participativo*" ("Participatory Territorial Assessment"), an online

platform that gathers data through participatory and investigative means and helps guide public policies, as well as the afforementioned "*Projeto Ruas*" (Annex A). Likewise, the Scientific Community engages in initiatives such as "*Mapa Solar*", an interactive and evolving map of Rio's solar power assets and distributed generation potential, or the "*Conexão Mata Atlântica*", a multilateral effort from universities, governments and citizens to restore, preserve and study Rio's main nature ecosystem, the Atlantic Forest. In this sense, it can be argued that both stakeholders' engagement occurs primarily in matters where there is an opportunity to address long-standing inequality issues under the communities' self-interests, or where technical expertise is pivotal (in the case of the scientific community).

The evidence from the analysed initiatives does not suggest a very different situation in relation to the early days of IBM-like, private-led involvement in the development of Rio´s COR and control room. Private participation is most noticeable in the high-end, large-scale flagship initiatives, taking the role of solution providers or engaging in public--private partnerships for infrastructure and service delivery. Exemplary initiatives include the concession for the deployment of a Bus Rapid Transit System ("*TransBrasil*"), housing and infrastructure development in the city's largest urban rehabilitation project ("*Porto Maravilha*") and the Public Lighting Renovation project – all of which have a strong governmental participation as well. In most of the analyzed initiatives, the Industry is highly dependant on the Government – for instance, by providing permits, establishing fees (i.e., for regulated services such as public transports), sharing costs, and providing a stable regulatory scenario. Therefore, Rio´s recent budget constraints and political turmoil easily reverberate into private partner involvement and their joint "smart" initiatives, most of them on hold or severely affected due to lack of funds, both from the public and private budgets (Rodrigues, 2019), suggesting that the resilience of smart agendas under dominat coalitions of local government and private providers may be limited.

3. Third dichotomy: top-down vs bottom-up approach

On the same note, the evidence collected shows a prominent role of the Government – notably the municipality – as top-down initiator. Even though there is evidence of civil society participation in about a quarter of the initiatives, the Government is still the leader and driving force behind most of them. Civil society is, in general, perceived more as a target – particularly in socially-oriented initiatives related to addressing inequality and educational gaps – rather than a self-organized force that promotes direct citizen involvement in decision making processes and devises its own initiatives and projects. That is the case with initiatives such as the "*1746*" and "*Carioca Digital*" initiatives, which are "one-stop--shop" online platforms that together centralize all services provided by the municipality to its citizens, or "*Saúde.rio*", a system and application that aims to consolidate all information related to the public health system and eventually allow for citizens to schedule medical appointments, small surgeries, and exams. In the instances where citizens were able to actively participate (e.g., "*Participa Rio*", an online citizen participation initiative), evidence

suggests that inputs were limited to what the system managed by public authorities considers relevant for debate. For example, at the time of this writing, only two initiatives were open for discussion in the portal (the city's master plan, and a reforesting program).

Yet, the top-down initiatives co-exist with others that were initiated from the bottom-up and managed to involve other stakeholders along the way. An example is "*Projeto Ruas*" (i.e., "Streets Project"), an initiative that originated from the civil society that operates primarily through volunteer work and donations to help Rio's homeless population with food, health, education and housing initiatives, issues which have only become more relevant as the economic condition worsened, resembling new views on smart city development advocated by Cardullo *et al.* (2019). Likewise, members from the Non-governmental organization "*Transporte Ativo*" ("Active Transport"), an association of cyclists, were responsible for the first comprehensive map of Rio's cycling pathways in 2011; this initiative has since then been adopted by the Municipality and evolved into the "*Mapa Cicloviário*" a digital and interactive map of the city's cycling pathways, integrated within the city's System of Urban Information (SIURB).

Despite the pervasive and enduring role of the public sector in creating conditions to advance the smart city agenda, the evidence suggests that clear cut divisions between public-private-not-for-profit and the boundaries between top-down and bottom-up are becoming more porous in a number of initiatives, co-evolving with one another.

V. DISCUSSION AND CONCLUSIONS

This article aimed to discuss how the balance between the smart-sustainable dimensions in smart city agendas has been evolving in practice in Rio de Janeiro, namely taking in consideration structural conditions and the recent turmoil associated with an economic and political crisis. It also sought to provide a more nuanced view on the evolution of smart city development as previous Olympic-driven coalitions weaken. Although the case of Rio has been primarily known in the smart city literature for its Urban Operations Center and Control Room – illustrating the dangers and limitations of tecno-centered, security-concerned, and algorithmic-driven urban management (Goodspeed, 2015; McNeill, 2015; Townsend, 2013) – the evidence collected suggests that the scope of smart-related intervention in the city is wider and expanded significantly, illustrating diversity in domains, scale, focus and initiators. This was revealed by an extensive analysis of 61 initiatives taking place in the city, making use of the classification method developed by Mora *et al.* (2019), now applied in the context of a city of the so-called Global South.

The systematic review of Rio de Janeiro's urban strategy and initiatives confirmed previous assumptions that smartness is not always synonym to what can be perceived as sustainable. The overall picture revealed by the analysis is one in which most initiatives and strategies are far from holistic and evolve weak collaborative environments, with the reduced participation from the citizens, suggesting that the persistence of technocratic and top-down perspectives endured. While social-oriented initiates are strongly represented –

inheriting from city´s longstanding context of rampant disparities – they do not guarantee *per se* citizen empowerment and deeper concerns about social justice, and environmental domains have been relatively neglected. Yet, even considering that other less institutionalized smart city initiatives were not captured in this analysis and could tell a more nuanced story, the evidence already suggests that the overall picture does co-exist with emergent forms of small-budget, bottom-up digital initiatives in domains which, over time, have been enlarging its network of constituents and co-evolving with more formalized city agendas. In this sense, although the tensions expected by the literature concerning the relation between smart and sustainable do take place in Rio de Janeiro as well, it would be premature to declare a complete and definite divorce between both.

The analysis provided insight into how smart city agendas and strategies evolved from the pre-Olympic euphoria into a new stage of political turmoil, confidence erosion and compression of funds. While several authors have stressed the need to analyze smart city initiatives in context (Karvonen *et al.*, 2019), few studies have actually analyzed how smart city initiatives react to sudden contextual changes. In this study, these issues started to be analyzed out of an extensive survey of initiatives, yet essentially relying on desk research. Further studies should follow more intensive and diachronic methodologies, for example, by in-depth analyzing and comparing timelines of smart city initiatives as their visions and ambitions mutate. Yet, it was already possible to observe that, as expected, several initiatives stagnated or even regressed over time, particularly when combined with the preexisting structural and institutional fragilities that characterize Rio de Janeiro. Namely as governmental and industry budgets become strained, it is both large flagships and less capital-intensive initiatives that are given precedence over long-term, costly yet fundamental investments in making transportation and sanitation infrastructure smarter and more sustainable. A question hence remains about if and how the new context will affect essential urban provisions in their road to "smartification", particularly as private investors might opt to take the less risky path of reducing investments and focusing on maintaining current services afloat. In terms of the need to diversify the perspectives and the actors involved in the construction of smart-sustainable cities, this situation could result in further fragmentation between public and private players and an (even) stronger unilateral perspective on smart city development, shaking the public-private coalitions that characterized previous stages of the smart city agenda.

However, at the same time, the collapse of larger projects does co-exist with the emergence of new examples of collaboration from the various actors in a wider set of domains, using digital technologies as instrumental to their aims. Despite the (direct and indirect) involvement of the public sector in many initiatives, this study suggest that a new lens is needed to frame and understand the role of the Government in the multiple articulations established with private and not-for-profit civil society initiatives as rigid divisions between actor´s roles may be blurring. As recently suggested by Irazábal & Jirón (2020), there is evidence that a new generation of "smart" action may be forming, in which the divide between bottom-up and top-down initiatives blurs as local governments make use of the drive of communities to strengthen their own strategies, while bottom-up

action contributes to "informalize", democratize, and permeate previously stalled projects. This suggests that stagnation, the death of collaboration and fragmentation are not the only possible outcomes of crises and instability in smart city development.

The findings open important research arenas to understand the mechanisms and conditions through which the previous interplays may occur, both for smart city development in general, and in the Global South, in particular. In the latter, instability, fragile institutions, and turmoil tend to be more frequent (van Dijk, 2006) and heighten some of the challenges involved. Moreover, urbanization in megacities of Global South cannot be directly linked to prosperity, but coexists with environmental degradation, poverty and access constrains, which are likely to be heightened in times of crisis. In the case of Rio de Janeiro, a large populational cohort is still grasping at ensuring access to basic utility services, with a considerable percentage of the population without access to services such as piped water and sewage treatment. In this sense, the smart-sustainable city agendas in the Global South face large challenges to ensure that citizens have access to basic provisions before "going digital", at the risk of alienating the already marginalized social and spatial peripheries. Hence, the relevance in understanding the aforementioned reconfigurations in smart-related investment strategies for large metropolises in the Global South.

In fact, although smart city agendas in developed economies emerged and gained traction as a reaction to the economic and financial crises of the early 2010s (e.g., Carvalho *et al.*, 2018), still very little is known about how such initiatives mutate when the urban economic and political context in which they unfold changes substantially (Donadio, 2020). This is more so in cities like Rio de Janeiro, in which the smart city agenda emerged in a context of economic optimism and political stability (Gaffney & Robertson, 2018). Future research should seek to better understand the impacts of crises – economic, political, social and, most recently, sanitary ones – in the development of consolidated and emerging smart-sustainable cities. Under which conditions can (different types of) crises lead to reformist and more transformative ideas instead of stagnation and minor tweaks? Can we see repeating patterns across cases? How do these patterns tie to Global South cities and their experience with instability and uncertainty, as opposed to Global North cities and their more stable institutional environments? How do the analyzed dichotomies may change, and which new types of collaboration are emerging? Answers to these questions would call for systematic and intensive case studies combined with cross-case extensive analyses and, ultimately, could provide more insight into how broader coalitions can contribute to shape smart sustainable cities in the future, namely in turbulent and resource-scarce urban settings.

ORCID ID

Luiza Josuá Cabral https://orcid.org/0000-0001-8622-2672
Maria Conceição Ramos https://orcid.org/0000-0003-4173-5428
Luís Carvalho https://orcid.org/0000-0002-7700-4558

AUTHORS CONTRIBUTIONS

Luiza Josuá Cabral: Conceptualization; Methodology; Formal analysis; Investigation; Writing – original draft preparation; Writing – review and editing. **Maria Conceição Ramos:** Conceptualization; Methodology; Writing – review and editing; Supervision. **Luís Carvalho:** Conceptualization; Methodology; Writing – original draft preparation; Writing – review and editing; Supervision.

REFERENCES

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and smart cities? *Cities, 60*, 234-245. https://doi.org/10.1016/j.cities.2016.09.009

Angelidou, M. (2015). Smart cities: A conjuncture of four forces. *Cities, 47*, 95-106. https://doi.org/10.1016/j.cities.2015.05.004

Angelidou, M. (2017). The Role of Smart City Characteristics in the Plans of Fifteen Cities. *Journal of Urban Technology, 24*(4), 3-28. https://doi.org/10.1080/10630732.2017.1348880

Anthopoulos, L. (2017). Smart utopia VS smart reality: Learning by experience from 10 smart city cases. *Cities, 63*, 128-148. https://doi.org/10.1016/j.cities.2016.10.005

Baraniewicz-Kotasińska, S. (2020). Smart city. Four approaches to the concept of understanding. *Urban Research & Practice*, Advance online publication. https://doi.org/10.1080/17535069.2020.1818817

Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M. … Portugali, Y. (2012). Smart cities of the future. *The European Physical Journal Special Topics, 214*(1), 481-518. https://doi.org/10.1140/epjst/e2012-01703-3

Bhattacharya, T. R., Bhattacharya, A., Mclellan, B., & Tezuka, T. (2020). Sustainable smart city development framework for developing countries. *Urban Research & Practice*, *13*(2), 180-212. https://doi.org/10.1080/17535069.2018.1537003

Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable Cities and Society, 31*, 183-212. https://doi.org/10.1016/j.scs.2017.02.016

Bolger, K., & Doyon, A. (2019). Circular cities: exploring local government strategies to facilitate a circular economy. *European planning studies*, *27*(11), 2184-2205. https://doi.org/10.1080/09654313.2019.1642854

Bretas, A. M., Laureano, F. G., Quintanilha, N., & Nazareth, P. (2020). Dependência das Rendas Petrolíferas nos Municípios do RJ [Dependence on Oil Rents in the Municipalities of RJ]. *Geo UERJ*, *36*, e48410. https://doi.org/10.12957/geouerj.2020.48410

Broto, V. C., & Bulkeley, H. (2013). A survey of urban climate change experiments in 100 cities. *Global environmental change*, *23*(1), 92-102. https://doi.org/10.1016/j.gloenvcha.2012.07.005

Campbell, S. (1996). Green cities, growing cities, just cities? Urban planning and the contradictions of sustainable development. *Journal of the American Planning Association, 62*(3), 296-312. https://doi.org/10.1080/01944369608975696

Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart Cities in Europe. *Journal of Urban Technology, 18*(2), 65-82. https://doi.org/10.1080/10630732.2011.601117

Carayannis, E., & Campbell, D. (2009). 'Mode 3' and 'Quadruple Helix': Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management, 46*(3-4), 201-234. https://doi.org/10.1504/IJTM.2009.023374

Cardullo, P., & Kitchin, R. (2019). Smart urbanism and smart citizenship: The neoliberal logic of 'citizen-focused' smart cities in Europe. *Environment and Planning C: Politics and Space, 37*(5), 813-830. https://doi.org/10.1177/0263774x18806508

Cardullo, P., Di Feliciantonio, C., & Kitchin, R. (2019). *The Right to the Smart City*. Emerald.

Carvalho, L. (2015). Smart cities from scratch? A socio-technical perspective. *Cambridge Journal of Regions, Economy and Society, 8*(1), 43-60. https://doi.org/10.1093/cjres/rsu010

Carvalho, L., van den Berg, L., Galal, H., & Teunisse, P. (Eds.). (2018). *Delivering Sustainable Competitiveness: Revisiting the organising capacity of cities*. Routledge.

Carvalho, L., & Vale, M. (2019). From participation to startup urbanisation? Re-situating open data in Lisbon. In A. Karvonen, F. Cugurullo, & F. Caprotti (Eds.), *Inside smart cities: Place, politics, and urban innovation* (pp. 211-226). Routledge.

Contreras, G., & Platania, F. (2019). Economic and policy uncertainty in climate change mitigation: The London Smart City case scenario. *Technological Forecasting and Social Change, 142*, 384-393. https://doi.org/10.1016/j.techfore.2018.07.018

Costa, A., Egler, T., & Casellas, A. (2019). Política urbana de inovação tecnológica: experiências de cidades digitais no Brasil [Urban policy of technological innovation: experiences of digital cities in Brazil]. *Finisterra – Revista Portuguesa de Geografia*, *LIV*(110), 93-113. https://doi.org/10.18055/Finis15347

Cowley, R., Joss, S., & Dayot, Y. (2018). The smart city and its publics: insights from across six UK cities. *Urban Research and Practice, 11*(1), 53-77. https://doi.org/10.1080/17535069.2017.1293150

Cugurullo, F. (2018). Exposing smart cities and eco-cities: Frankenstein urbanism and the sustainability challenges of the experimental city. *Environment and Planning a-Economy and Space, 50*(1), 73-92. https://doi.org/10.1177/0308518x17738535

de Jong, M., Joss, S., Schraven, D., Zhan, C., & Weijnen, M. (2015). Sustainable–smart–resilient–low carbon–eco–knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization. *Journal of Cleaner Production, 109*, 25-38. https://doi.org/10.1016/j.jclepro.2015.02.004

Di Bella, A. (2020). Global urbanism and mega events planning in Rio de Janeiro amid crisis and austerity. *International Planning Studies, 25*(1), 23-37. https://doi.org/10.1080/13563475.2019.1701423

Do Lago, L. C. (2000). *Desigualdades e segregação na metrópole: o Rio de Janeiro em tempo de crise* [Inequalities and segregation in the metropolis: Rio de Janeiro in times of crisis]. Letra Capital.

Donadio, T. (2020). Repensar a cidade inteligente ou voltar ao "antigo normal"?: Uma reflexão sobre o caso de Lisboa no contexto da Covid-19 [Rethink the smart city or go back to the "old normal"? A reflection on the case of Lisbon in the context of Covid-19]. *Finisterra – Revista Portuguesa de Geografia*, *LV*(115), 121-126. https://doi.org/10.18055/Finis20214

Dutton, W. H., Blumler, J. G., & Kraemer, K. L. (1987). *Wired cities: Shaping the future of communications*. G. K. Hall.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy*, *29*(2), 109-123. https://doi.org/10.1016/S0048-7333(99)00055-4

Gaffney, C., & Robertson, C. (2018). Smarter than Smart: Rio de Janeiro's Flawed Emergence as a Smart City. *Journal of Urban Technology, 25*(3), 47-64. https://doi.org/10.1080/10630732.2015.1102423

Galvão, A., Mascarenhas, C., Gouveia Rodrigues, R., Marques, C. S., & Leal, C. T. (2017). A quadruple helix model of entrepreneurship, innovation and stages of economic development. *Review of International Business and Strategy*, *27*(2), 261-282. https://doi.org/10.1108/RIBS-01-2017-0003

Gills, B., & Morgan, J. (2019). Global Climate Emergency: after COP24, climate science, urgency, and the threat to humanity. *Globalizations*, *17*(6), 885-902. https://doi.org/10.1080/14747731.2019.1669915

Goodspeed, R. (2015). Smart cities: moving beyond urban cybernetics to tackle wicked problems. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 79-92. https://doi.org/10.1093/cjres/rsu013

Grandin, F. (2019, February). Prefeitura do Rio reduziu em 77% as despesas com controle de enchentes nos últimos 5 anos [Rio City Hall reduced flood control expenses by 77% in the last 5 years]. G1. https://g1.globo.com/rj/rio-de-janeiro/noticia/2019/02/07/prefeitura-do-rio-reduziu-em-77-as-despesas-com-controle-de-enchentes-nos-ultimos-5-anos.ghtml

Guma, P. K., & Monstadt, J. (2020). Smart city making? The spread of ICT-driven plans and infrastructures in Nairobi. *Urban Geography*, 1-22. https://doi.org/10.1080/02723638.2020.1715050

Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive or entrepreneurial? *City, 12*(3), 303-320. https://doi.org/10.1080/13604810802479126

Instituto Brasileiro de Geografia e Estatística. (2019). *Estimativas de População* [Population Estimates]. IBGE. https://www.ibge.gov.br/estatisticas/sociais/populacao/9103-estimativas-de-populacao.html?=&t=o-que-e

Instituto Pereira Passos. (2019). *Data Rio – O Rio em síntese* [Rio Data – Rio in synthesis]. http://www.data.rio/pages/rio-em-sntese-2

Irazábal, C., & Jirón, P. (2020). Latin American smart cities: Between worlding infatuation and crawling provincialising. *Urban Studies*, *58*(3), 507-534. https://doi.org/10.1177/0042098020945201

Ishida, T., & Isbister, K. (2000). *Digital cities: technologies, experiences, and future perspectives*. Springer.

Karvonen, A., Cugurullo, F., & Caprotti, F. (2019). *Inside smart cities: Place, politics and urban innovation*. Routledge.

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal*, *79*(1), 1-14. https://doi.org/10.1007/s10708-013-9516-8

Kitchin, R. (2015). Making sense of smart cities: addressing present shortcomings. *Cambridge Journal of Regions Economy and Society, 8*(1), 131-136. https://doi.org/10.1093/cjres/rsu027

Komninos, N. (2013). *Intelligent cities: innovation, knowledge systems and digital spaces*. Routledge.

Kramers, A., Höjer, M., Lövehagen, N., & Wangel, J. (2014). Smart sustainable cities – Exploring ICT solutions for reduced energy use in cities. *Environmental Modelling & Software, 56*, 52-62. https://doi.org/10.1016/j.envsoft.2013.12.019

Lara, A. P., da Costa, E. M., Furlani, T. Z., & Yigitcanlar, T. (2016). Smartness that matters: Towards a comprehensive and human-centred characterisation of smart cities. *Journal of Open Innovation: Technology, Market, and Complexity, 2*(8), 1-13. https://doi.org/10.1186/s40852-016-0034-z

Lee, J. H., Hancock, M. G., & Hu, M. C. (2014). Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco. *Technological Forecasting and Social Change, 89*, 80-99. https://doi.org/10.1016/j.techfore.2013.08.033

Marchetti, D., Oliveira, R., & Figueira, A. R. (2019). Are global north smart city models capable to assess Latin American cities? A model and indicators for a new context. *Cities*, *92*, 197-207. https://doi.org/10.1016/j.cities.2019.04.001

Martin, C. J., Evans, J., & Karvonen, A. (2018). Smart and sustainable? Five tensions in the visions and practices of the smart-sustainable city in Europe and North America. *Technological Forecasting and Social Change, 133*, 269-278. https://doi.org/10.1016/j.techfore.2018.01.005

McDuie-Ra, D., & Lai, L. (2019). Smart cities, backward frontiers: digital urbanism in India's northeast. *Contemporary South Asia*, *27*(3), 358-372. https://doi.org/10.1080/09584935.2019.1647144

McNeill, D. (2015). Global firms and smart technologies: IBM and the reduction of cities. *Transactions of the Institute of British Geographers, 40*(4), 562-574. https://doi.org/10.1111/tran.12098

Mora, L., Deakin, M., & Reid, A. (2019). Strategic principles for smart city development: A multiple case study analysis of European best practices. *Technological Forecasting and Social Change, 142*, 70-97. https://doi.org/10.1016/j.techfore.2018.07.035

Mosciaro, M., & Pereira, A. (2019). Reinforcing uneven development: The financialisation of Brazilian urban redevelopment projects. *Urban Studies*, *56*(10), 2160-2178. https://doi.org/10.1177/0042098019829428

Naess, P. (2001). Urban planning and sustainable development. *European Planning Studies*, *9*(4), 503-524. https://doi.org/10.1080/713666490

Neri, M. (Ed.). (2020). *Evaluating the Local Impacts of the Rio Olympics*. Routledge. https://doi.org/10.4324/9781003044895

Nunes, F., & Melo, C. R. (2017). Impeachment, Political Crisis and Democracy in Brazil. *Revista de Ciencia Política (Santiago)*, *37*(2), 281-304. https://doi.org/10.4067/s0718-090x2017000200281

Prasad, D., & Alizadeh, T. (2020). What makes Indian cities smart? A policy analysis of smart cities mission. *Telematics and Informatics*, *55*, 101466. https://doi.org/10.1016/j.tele.2020.101466

Prefeitura do Rio de Janeiro. (2017). *Plano Estratégico da Cidade do Rio de Janeiro 2017-2020* [Strategic Plan of the City of Rio de Janeiro 2017-2020]. Rio Prefeitura.

Prefeitura do Rio de Janeiro. (2018, dezembro). *Rio inicia elaboração de Plano de Ação Climática para zerar emissão de carbono* [Rio starts preparing a Climate Action Plan to zero carbon emissions]. Rio Prefeitura. http://www.rio.rj.gov.br/web/guest/exibeconteudo?id=8843554

Register, R. (1987). *Ecocity Berkeley: building cities for a healthy future*. North Atlantic Books.

Rodrigues, N., Vale, M., & Costa, P. (2020). Urban experimentation and smart cities: a Foucauldian and autonomist approach. *Territory, Politics, Governance*, 1-19. https://doi.org/10.1080/21622671.2020.1777896

Rodrigues, R. (2019, December). *Entenda como a crise no Rio se espalha e já atropela obras na Niemeyer e do Transbrasil* [Understand how the crisis in Rio spreads and already runs over works at Nie-

meyer and Transbrasil]. O Globo. https://oglobo.globo.com/rio/entenda-como-crise-no-rio-se-espalha-ja-atropela-obras-na-niemeyer-do-transbrasil-24146925

Shatkin, G. (2007). Global cities of the South: Emerging perspectives on growth and inequality. *Cities, 24*(1), 1-15. https://doi.org/10.1016/j.cities.2006.10.002

Shelton, T., Zook, M., & Wiig, A. (2015). The 'actually existing smart city'. *Cambridge Journal of Regions Economy and Society, 8*(1), 13-25. https://doi.org/10.1093/cjres/rsu026

Snowden, F. (2020). *Epidemics and Society: From the Black Death to the Present. Society*. Yale University Press.

Söderström, O., Paasche, T., & Klauser, F. (2014). Smart cities as corporate storytelling. *City*, *18*(3), 307-320. https://doi.org/10.1080/13604813.2014.906716

Sodiq, A., Baloch, A. A. B., Khan, S. A., Sezer, N., Mahmoud, S., Jama, M., & Abdelaal, A. (2019). Towards modern sustainable cities: Review of sustainability principles and trends. *Journal of Cleaner Production, 227*, 972-1001. https://doi.org/10.1016/j.jclepro.2019.04.106

The Intergovernmental Panel on Climate Change. (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. IPCC.

The Intergovernmental Panel on Climate Change. (2019). Summary for Policymakers. In IPCC (Ed.), *Special Report on the Ocean and Cryosphere in a Changing Climate*. IPPC.

Townsend, A. (2013). *Smart cities: Big data, civic hackers, and the quest for a new utopia*. WW Norton & Company.

Turnheim, B., Kivimaa, P., & Berkhout, F. (2018). Beyond Experiments: Innovation in Climate Governance. In B. Turnheim, P. Kivimaa, & F. Berkhout (Eds.), *Innovating Climate Governance: Moving Beyond Experiments* (pp. 1-26). Cambridge University Press. https://doi.org/10.1017/9781108277679.002

UN Habitat. (2017). *Sustainable Urbanization in the Paris Agreement – Comparative Review of Nationally Determined Contributions for Urban Content*. UN HABITAT.

United Nations. (2018). *The World's cities in 2018.* United Nations Digital Library System.

van Dijk, M. P. (2006). *Managing Cities in Developing Countries: The Theory and Practice of Urban Management*. Edward Elgar Publishing.

World Bank. (2020). *Civil Society Overview*. World Bank. https://www.worldbank.org/en/about/partners/civil-society/overview

Yigitcanlar, T., & Kamruzzaman, M. (2018). Does smart city policy lead to sustainability of cities? *Land Use Policy, 73*, 49-58. https://doi.org/10.1016/j.landusepol.2018.01.034

Yigitcanlar, T., Kamruzzaman, M., Buys, L., Ioppolo, G., Sabatini-Marques, J., da Costa, E. M., & Yun, J. J. (2018). Understanding 'smart cities': Intertwining development drivers with desired outcomes in a multidimensional framework. *Cities, 81*, 145-160. https://doi.org/10.1016/j.cities.2018.04.003

Yigitcanlar, T., Kamruzzaman, M., Foth, M., Sabatini-Marques, J., da Costa, E., & Ioppolo, G. (2019). Can cities become smart without being sustainable? A systematic review of the literature. *Sustainable Cities and Society, 45*, 348-365. https://doi.org/10.1016/j.scs.2018.11.033

Yigitcanlar, T., & Lee, S. H. (2014). Korean ubiquitous-eco-city: A smart-sustainable urban form or a branding hoax? *Technological Forecasting and Social Change, 89*, 100-114. https://doi.org/10.1016/j.techfore.2013.08.034

Yigitcanlar, T., & Teriman, S. (2015). Rethinking sustainable urban development: towards an integrated planning and development process. *International Journal of Environmental Science and Technology, 12*(1), 341-352. https://doi.org/10.1007/s13762-013-0491-x

[i] The original framework by Mora *et al.* (2019) did not account for initiatives taken by a single organization, which has been the case with some initiatives analyzed in this study. To maintain the dichotomy and because an individual initiative is in fact a null degree of collaboration, the double-helix model of collaboration end of the scale has been expanded to include individual initiatives.

[ii] Civil society is defined by the World Bank (2020) as "the wide array of non-governmental and not for profit organizations that have a presence in public life, express the interests and values of their members and others, based on ethical, cultural, political, scientific, religious or philanthropic considerations".

ANNEX A – INITIATIVES UNDER ANALYSIS

#	Initiatives	Organizations					Domains															
		A	B	C	D	E	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1746		X																	X			
2	Academia Carioca		X								X			X									
3	Adote.Rio	X	X	X							X												
4	Armazenzinho		X													X	X					X	
5	Bike Itaú	X	X				X					X										X	
6	Bilhete Único Carioca / Rio Card +		X									X										X	
7	BRT TransBrasil	X	X									X											
8	Bus Rapid System -BRS		X									X											
9	Caravana da Ciência		X														X						
10	Carioca Digital		X																	X		X	
11	Carnaval Inclusivo			X											X	X		X					
12	Cartão Família Carioca		X												X		X						
13	Casa da Mulher Carioca		X												X		X				X		
14	Centro de Operações Rio (COR)		X									X							X			X	
15	Centro Integrado de Comando e Controle (CICC)		X																X			X	
16	Centros Municipais (Pessoa com Deficiência)		X															X					
17	Data.Rio		X																	X		X	
18	Desafio COR – Smart city, smart people	X	X	X					X			X									X		
19	Diagnóstico Socioterritorial Participativo		X	X											X					X		X	
20	Dicionário de Favelas			X	X										X	X	X						
21	EcoParque do Caju e Unidade de Biometanização	X	X		X		X			X													
22	Escola de Bamba		X	X											X	X	X						
23	Fazenda Urbana Via Parque	X															X						X
24	Forsoft	X															X					X	
25	Fórum de Desenvolvimento do Rio	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
26	Gestão Ambiental (Sistema Lagoa Rodrigo de Freitas)		X						X	X	X											X	
27	Giro	X										X										X	
28	Identidade Carioca		X																	X		X	
29	Jogos Estudantis do Rio de Janeiro	X	X	X																			X
30	labGov.RIO		X				X					X				X		X			X	X	

#	Initiatives	Organizations					Domains														
		A	B	C	D	E	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
31	Mapa Cicloviário		X	X								X											
32	Mapa Solar do Rio de Janeiro		X		X		X															X	
33	Minha Casa Minha Vida		X										X		X								
34	Mutirão Reflorestamento		X	X				X	X		X												
35	Naves do Conhecimento		X												X		X				X	X	
36	Orquestra nas Escolas		X	X											X		X						
37	Participa Rio		X	X																X		X	
38	Partiu Praia		X						X											X		X	
39	Portal da Transparência		X																	X			
40	Porto Maravilha	X	X	X	X			X	X		X	X	X		X	X	X	X			X		
41	Praia para Todos	X	X	X											X			X					
42	Programa Aconchego Família			X										X	X		X						X
43	Programa Cuidar da Cidade		X																	X			
44	Programa de despoluição da Baía de Guanabara		X						X		X												
45	Programa de Saneamento		X						X														
46	Programa Escolas Sustentáveis		X	X													X						
47	Programa Heróis do Tabuleiro		X	X											X		X						
48	Programa Hortas Cariocas		X	X										X	X		X				X		X
49	Programa Segurança Presente		X																X				
50	Programa Territórios Sociais		X			X									X		X						
51	Programa Zona Franca Social (ZFS)		X												X						X		
52	Projeto Conexão Mata Atlântica		X	X	X	X		X	X		X												
53	Projeto Recicla Orla	X								X													
54	Projeto Ruas			X										X	X	X	X					X	
55	Public Lighting Renovation	X	X				X	X											X			X	
56	Restaurante Popular		X												X								X
57	Rodando com Tampinhas		X	X						X					X			X				
58	Saúde.rio		X											X						X		X	
59	Sensores de Alagamento	X	X						X										X			X	
60	Sistema Municipal de Informações Urbanas		X																			X	
61	Sistema Novo Guandu		X						X														

Note: Organizations – A. Industry; B. Government; C. Civil Society; D. Scientific Community; E. Other.
Specific domains – 1. Energy; 2. Air; 3. Water; 4. Waste; 5. Green & Public Spaces; 6. Mobility & Transport; 7. Residential Buildings & Districts; 8. Public Health; 9. Social Inclusion & Diversity; 10. Culture; 11. Education; 12. Accessibility; 13. Public Safety & Security; 14. E-Government; 15. Industrial Districts & Business Accelerators; 16. Digital Infrastructure & Solutions; 17. Other.