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SHORT ARTICLE



# Understanding urban infrastructure via big data: the case of Belo Horizonte

Aksel Ersoy <sup>a</sup> and Klaus Chaves Alberto<sup>b</sup>

## ABSTRACT

One major impact of the global economic crisis is the way it has deepened inequalities around the world. Infrastructure remains essential within this debate as it provides wider health, economic and environmental benefits for society beyond the conventional calculations of cash returns. With the potential exploration of big data, cities now face challenges as well as opportunities to use a series of static and dynamic datasets. Big data methods are offering new opportunities to design decision-making models for urban planning and management. The combination of social media, census, sensors and traditional data gives a new perspective to solve modern urban challenges through a holistic and inclusive approach. Nevertheless, the BOLD methods are relatively new and have not been applied in the context of urban infrastructure. This paper explores whether BOLD methods can help one reconceptualize urban infrastructure not only with technical and operational characteristics but also with social values in the context of the Global South. To demonstrate, Belo Horizonte, Brazil, is used as a case study.

## ARTICLE HISTORY

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## KEYWORDS

infrastructure; Belo Horizonte; big data; interdependency

## INTRODUCTION

The issues of global environmental change and sustainability have now been on the agendas of research institutions, government departments and civil society organizations for a number of years. While the implications of the transnational and global characteristics of environmental problems continue to be integral to policy-making, government and governance, increasing attention is being directed at the necessity and scope for local action. Local authorities have framed the issue in terms of the so-called ‘triple bottom line’ in which sustainable development incorporates development that is economically, environmentally and socially acceptable (Elkington, 1994). Adopting more sustainable practices makes one think about creating value not only in financial terms but also in ecological and social terms (Cramer, 2002). In this context, urban infrastructure represents a fundamental challenge because the reconfiguration of urban infrastructure systems highlights the importance of interaction between social and technical systems as well as the relationship between urban actors and their practices.

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It has been argued that urban infrastructure systems can be defined as the framework that connects and integrates social, cultural, financial, natural, technological and human values in the context of urban systems (Pandit et al., 2017). They not only enable the flow of people, energy, water, materials and money into, within and out of cities but also contribute to the urban landscape. This framework also echoes with earlier studies in which urban processes are characterized by interconnecting infrastructural landscapes. In this sense, urban infrastructure is the ‘connective tissue that knits people, places, social institutions and natural environment into coherent urban relations’ (Graham & Marvin, 2001, p. 43). Adopting a holistic understanding of urban infrastructure would enable one to think of cities more systematically in the era of uncertainty. Moreover, it has been realized that the increasing interconnected nature of infrastructure networks has created opportunities for reshaping the decision-making process, enabling new sites of experimentation and stimulating inclusive urban infrastructure (Ersoy, 2017).

Big data has recently become one of the themes to demonstrate how governments operate and interact with citizens.<sup>1</sup> It combines a diversity of data sets to ‘explore new applications and transform current practices and processes in various fields, including policymaking, service provisioning, inspection, and enforcement’ (Janssen & Kuk, 2016, p. 4). Such discussions are especially relevant today as the combination of human and non-human elements of urban living are implicated in the ongoing making and remaking of contemporary cities (Thrift, 2014). Big data offers new possibilities for collecting and evaluating data faster and thus acquiring real-time information. Glaeser, Sari, and William (2015) argue that digital exhaust – the trail of data left online through everyone’s day-to-day use of the internet – can help one inform about the making of social structures and networks in the society. A different approach to imagining how citizens might reshape their cities is to recognize how city routines and rhythms are held together by different interfaces. Those interfaces can be used between imagination and action, from the ongoing experimentation, ‘making do’ and improvisation with the diverse material, social and technological elements that come to constitute the changing city.

Big data has a particular role within the discussions of urban infrastructure as it can provide one with massive amounts of information, although much of this is unstructured and at different levels. The analysis of big data can provide opportunities for a more extensive quantification of urban living that has been difficult to attain using surveys and questionnaires alone. It can help governments and public agencies think about their policies and programmes for targeting sustainable development, economic growth, better quality of life for their citizens and creating happiness (Ballas, 2013). The question addressed in this paper is not whether big data is good or bad, but how it can make one aware of the interconnected nature of urban infrastructure. The paper uses Belo Horizonte in Brazil as a case study.

## EMERGENCE OF BIG DATA IN BELO HORIZONTE

Belo Horizonte, the capital of the state of Minas Gerais, has approximately 2.5 million inhabitants and is one of the main Brazilian metropolitan regions. To meet the challenges of urban management, the city has been developing various initiatives for the organization, provision and management of data to improve the quality of life of its inhabitants. One of the first initiatives to make data available was the creation, already in the 1990s, of 81 georeferenced social indicators for the intra-municipal units. These indicators were based on the data provided by the Demographic Census of the Brazilian Institute of Geography and Statistics (IBGE in its Portuguese abbreviation) and the data provided by the various municipal agencies that service the population. In this context, the urban quality of life index (UQLI) and the social vulnerability index (SVI) were created. While the UQLI seeks to measure physical aspects of the urban space, such as the provision of services and resources and the population’s access to them, the SVI is essentially a population index that seeks to characterize the population of a location

(Nahas, 2001). These indices were used to guide the distribution of public municipal resources, especially regarding the decisions of the participatory planning committees of the city, and they still serve as support for the development of studies in various academic fields.

More recently, the use of big data enabled other advances in the provision of data. In 2013, the Office of Strategic Priorities of the government of Minas Gerais launched the DataViva<sup>2</sup> platform with funding from the Research Support Foundation of the state of Minas Gerais (Fapemig in its Portuguese abbreviation) and in partnership with the Macro Connections Laboratory of the Massachusetts Institute of Technology (MIT). This platform makes strategic official data available (on exports, economic activity, location, education and occupations) not only for Belo Horizonte but also for more than 5000 other Brazilian municipalities. The Product Space visualization is an example designed on the basis of the economic development model created by Ricardo Hausmann (Harvard) and Cesar Hidalgo (MIT). This network formalizes the idea of relatedness between products traded in Brazil. The free visualization of these data allows for an intuitive, fast and, especially, flexible reading of the data. Eleven applications are used to this end, which together provide more than 1 billion data visualizations possibilities. This open and transparent relationship with the data establishes a dialogue between researchers, companies and governments that favours the innovation environment (Barrance, Gome, & Freitas, 2014).

The integrated management of real-time information is also one of the focuses of the state of Minas Gerais. In 2014, the Integrated Operations Centre of Belo Horizonte (COP-BH in its Portuguese abbreviation) was created mainly for the need for strategic coordination in decision-making during the reception of the Football World Cup of 2014 in Brazil. This initiative explores the potentialities of big data to strengthen public security, just as had already been done in other Brazilian capitals, including in the city of Rio de Janeiro, where the Operations Centre at City Hall in Rio was created (Alberto & Ersoy, 2016). The COP-BH has an integrated control room that monitors approximately 1600 cameras scattered strategically throughout the capital, through which 14 institutions act simultaneously and in an integrated way. This coordinated action enables a significant reduction in the response time to various situations that are taking place in the municipality. Its main purpose, therefore, is to allow public power to act in the prevention and prediction of 'problems related to public security, public order, mobility, urban services, civil defence and health care emergencies, among others'.<sup>3</sup>

## UNDERSTANDING THE INTERCONNECTED NATURE OF URBAN INFRASTRUCTURE VIA 'BRICOLAGE OF DATA'

Through the city's vast academic (62 higher education institutions established in the city) and professional structure (the city has the highest density of information technology companies per capita in Brazil),<sup>4</sup> the current municipal government in Belo Horizonte seeks to focus its administrative actions to bring them closer to the smart city concept. In this context, the Belo Horizonte Smart City programme is defined as one of its strategic lines of action. This programme seeks to boost the interaction of the city's technology ecosystem to facilitate the access of citizens to essential services. In its presentation, the city defines its intention to use:

context sensitive information and communication technologies [IoT in its Portuguese abbreviation], urban management and social action guided by data in Belo Horizonte's urban area to serve as the foundation for the integrated management between the various areas of administration and to ensure that the public services have access to more qualified information to improve their quality and efficiency.<sup>5</sup>

In the case of the COP-BH, the system enables public agencies (such as Belo Horizonte Public Transit, the Civil Defence, the Municipal Guard, the Office of Urban Sanitation and the Mobile Emergency Services) to be prepared to take actions in emergencies. In 2017, Belo Horizonte

experienced a heavy rain that left the city in a state of alert as the risks of floods, tree falls and landslides increased with the intensity and volume of rainfall. During the storm, the COP-BH distributed the demands and informed the institutions, in real time, alerting various occurrences. With the follow-up and support of the COP-BH, civil defence teams inspected locations at risk of collapse, urban cleaning workers collected debris and rubbish accumulation and cleared the pathways. The maintenance agents worked on the identification of holes and performed the recovery of streets and avenues. With the coordinated and integrated work, the city was able to return to its routine functioning.<sup>6</sup> More importantly, the COP-BH stimulated thoughts about the current state of the urban infrastructure and how different sectors and institutions should be interrelated towards promoting efficient infrastructure development and informing public policy.

Similarly, various other actions were defined to achieve the Belo Horizonte Smart City programme, ranging from initiatives in the physical infrastructure of the city through the deployment of monitoring cameras and the creation of free wireless internet hotspots – including in areas of social vulnerability. The Integrated Public City Transport Management, Monitoring and Information System (SITBus), for instance, is made up of onboard sensors, infrastructure at stations and an electronic ticketing system. It can provide data in real time via a web browser as well as providing aggregated information about various aspects of the system's operation such as accomplished trips, punctuality per bus stop, punctuality per vehicle, etc. These are provided on a daily basis apart from the real-time information that can be accessed online through a dedicated website. Another action front is making official data of the city available through a project called Dados Abertos (Open Data). The application PBH APP was created to facilitate the requests of public services and to make their monitoring transparent. Through this app, the units responsible for the implementation of the services are immediately engaged to perform services or respond to the actions related to these services. In this app, the user can also 'locate public equipment on a map of the city of Belo Horizonte and record his satisfaction with the provided service'.<sup>7</sup>

This rather eclectic tampering with data creates a piece of 'bricolage' where both soft and hard infrastructure can be interconnected. Also bringing together various data sets in a more structured enables one not only to think about urban infrastructure more holistically but also to see connections between a variety of different sectors and experimentation. The main point within this framework of 'bricolage of data' in relation to urban infrastructure is that it breaks down urban infrastructure into its subcomponents. For any complex projects to be successful in the context of smart city development, it is important to recognize that failure of one component can lead to overall failure of efforts as in the case of emergency evacuation.

## CONCLUSIONS

This case study has summarized how the interconnected nature of urban infrastructure can be valued with the help of big data. The engagement with data provides a key role in the collaborative development of urban planning and hence urban infrastructure. This case study can aid urban planning and policy development in a data-rich society. The citizens can make connections with the data in a more visible way and acquire more insights about the ubiquitous presence of digital and data technologies in the city. This also helps one to diagnose the patterns of interactions and outcomes among hard and soft infrastructure such as resource use (and overuse), the implementation of policy, the distribution of infrastructure and wealth, conflict or directional change (Mahoney, 2000). Moreover, this enables a shift from 'outside-in' thinking towards 'inside-out' thinking in which communities can build up to their capacity and deliverables as resourcefulness.

Research on urban infrastructure and big data remains crucial for creating alternative paths to sustainable futures. Although the limitations of big data have been widely recognized in the academic literature, we would argue that big data offers important opportunities for unpacking urban infrastructure. Clearly, big data is not a panacea for all urban ills and further research is needed to evaluate the opportunities and challenges that lie ahead. There is a need to reflect on the usefulness of big data and urban development approaches in relation to the value of urban infrastructure. This case study can inform future policy in a way that will enrich the lives and well-being of all those living in cities. There is an abundance of data available for each city and it is crucial to see how big data can provide a holistic understanding of cities and how they function. In the context of urban infrastructure, the big data discussions are valuable as the current state of conceptualizing urban infrastructure is predominantly based on economic values rather than on how it brings together different sectors or services.

One productive way of framing these discussions is by referring to J. K. Gibson-Graham (Gibson-Graham, 2008), who highlights the social relations shaping – and shaped by – different forms of economic activity. Gibson-Graham argues for many diverse forms of economic activity in which people engage become unvisitable if only a focus is made on economic value. Similarly, urban infrastructure is one way of illustrating what is usually regarded as the scaffolding of the city, but a small set of activities by which citizens produce, exchange and distribute values in the society. It opens up new conversations around how our common knowledge about the creation of value, not only just in financial terms but also in social as well as ecological terms. Reconceptualizing infrastructure that contributes to wider benefits helps one to recognize the wider outcomes and ascertain a set of mechanisms to public policy-making.

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## DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

## NOTES

1. See <http://www.centre-for-bold-cities.nl/about-us/>.
2. See <http://legacy.dataviva.info/>.
3. See <https://prefeitura.pbh.gov.br/projetosestrategicos/gestaointegradaeinteligente/>.
4. See <https://prefeitura.pbh.gov.br/cidade-inteligente/>.
5. See <https://prefeitura.pbh.gov.br/projetosestrategicos/bhcidadeinteligente/>.
6. See <https://prefeitura.pbh.gov.br/noticias/cop-bh-integra-orgaos-publicos-em-aco-es-para-periodo-chuvoso/>.
7. See <https://prefeitura.pbh.gov.br/pbhapp/>.

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