Knowledge-based urban development as a strategy to promote smart and sustainable cities

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Abstract

Introduction: In the knowledge era, rapid technological progress, especially in information and communication technologies, is seen as the main ally to respond to the increasing urban environmental and socioeconomic crises. In this context, smart and sustainable cities are those that apply technology and innovation to improve the quality of life of their citizens and the efficiency of services, aiming at sustainable urban development. In practice, however, several challenges are posed to cities that seek to become smart and sustainable. To bring together the intelligence and sustainability dimensions, cities need locally-designed solutions, as well as integrated and balanced strategic urban planning. A strategic framework that can respond to these requirements is Knowledge-Based Urban Development (KBUD), which articulates four knowledge-based development domains (economic, social, spatial and institutional) for a long-term process of urban transformation, in the context of the new knowledge economy and global competitiveness.

Methodology: Through a literature review, this article aims to present and discuss the main conceptual and application aspects of KBUD as a strategic approach to the promotion of smart and sustainable cities.

Results and discussion: The results indicate that KBUD can contribute by offering a multidimensional and integrated approach to strategic urban planning that includes the implementation of urban technologies, developed by endogenous innovation processes, for a truly smart and sustainable urban development.

Keywords: Smart and sustainable cities. Knowledge-based urban development. Sustainable urban development. Knowledge economy. Knowledge-based development.

O desenvolvimento urbano baseado no conhecimento como estratégia para promoção de cidades inteligentes e sustentáveis

Resumo

Introdução: Na era do conhecimento, o rápido progresso tecnológico, especialmente no campo das tecnologias de informação e comunicação, é visto como o principal aliado para responder às crescentes crises ambientais e socioeconômicas urbanas. Nesse contexto, as cidades inteligentes e sustentáveis são aquelas que empregam tecnologia e inovação para melhorar a qualidade de vida de seus cidadãos e a eficiência dos serviços, buscando o desenvolvimento urbano sustentável. Na

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prática, entretanto, diversos desafios se impõem às cidades que buscam tornar-se inteligentes e sustentáveis. Para agregar as dimensões de inteligência e sustentabilidade, as cidades precisam de soluções desenhadas localmente e planejamento urbano estratégico integrado e equilibrado. Um modelo estratégico aderente a esses requisitos é o Desenvolvimento Urbano Baseado no Conhecimento (DUBC), que articula quatro domínios de desenvolvimento baseado no conhecimento (econômico, social, espacial e institucional) para um processo de transformação urbana de longo prazo, no contexto da nova economia do conhecimento e da competitividade global.

Metodologia: Por meio de revisão de literatura, este artigo tem como objetivo apresentar e discutir os principais aspectos conceituais e de aplicação do DUBC como uma abordagem estratégica para a promoção de cidades inteligentes e sustentáveis.

Resultados e discussão: Os resultados indicam que o DUBC pode contribuir ao oferecer uma abordagem multidimensional e integrada para o planejamento urbano estratégico que inclui a implementação de tecnologias urbanas, desenvolvidas por processos endógenos de inovação e voltadas a um desenvolvimento urbano verdadeiramente inteligente e sustentável.

Palavras-chave: Cidades inteligentes e sustentáveis. Desenvolvimento urbano baseado no conhecimento. Desenvolvimento urbano sustentável. Economia do conhecimento. Desenvolvimento baseado no conhecimento.

El desarrollo urbano basado en el conocimiento como estrategia para promover ciudades inteligentes y sostenibles

Resumen

Introducción: En la era del conocimiento, el rápido progreso tecnológico, especialmente en el campo de las tecnologías de la información y la comunicación, se considera el principal aliado para responder a las crecientes crisis ambientales y socioeconómicas urbanas. En este contexto, las ciudades inteligentes y sostenibles son aquellas que emplean la tecnología y la innovación para mejorar la calidad de vida de sus ciudadanos y la eficiencia de los servicios, buscando un desarrollo urbano sostenible. En la práctica, sin embargo, se imponen varios desafíos a las ciudades que buscan volverse inteligentes y sostenibles. Para agregar las dimensiones de inteligencia y sustentabilidad, las ciudades necesitan soluciones diseñadas localmente y una planificación urbana estratégica integrada y equilibrada. Un modelo estratégico que se adhiere a estos requisitos es el Desarrollo Urbano Basado en el Conocimiento (DUBC), que articula cuatro dominios de desarrollo basado en el conocimiento (económico, social, espacial e institucional) para un proceso de transformación urbana a largo plazo, en el contexto de la nueva economía del conocimiento y competitividad global.

Metodología: A través de una revisión de la literatura, este artículo tiene como objetivo presentar y discutir los principales aspectos conceptuales y de aplicación de DUBC como un enfoque estratégico para la promoción de ciudades inteligentes y sostenibles.

Resultados y discusión: Los resultados indican que el DUBC puede contribuir ofreciendo un enfoque multidimensional e integrado de la planificación urbana estratégica que incluya la implementación de tecnologías urbanas, desarrolladas por procesos de innovación endógenos y orientadas a un desarrollo urbano verdaderamente inteligente y sostenible.

Palabras claves: Ciudades inteligentes y sostenibles; Desarrollo urbano basado en el conocimiento; Desarrollo urbano sostenible; Economía del conocimiento; Desarrollo basado en el conocimiento.

Introduction

The new millennium has been marked by what is referred to as a new evolutionary cycle of civilisation: the transition from an industrial, material-production era to a knowledge-production era (Carrillo, 2004). Significant changes in the productive arrangements have been triggering this transition, in which intangible forms of capital, also known as intellectual capital or knowledge capital, play an essential role in the development of the economy – the

knowledge economy, and the society – the knowledge society, imprinting new patterns of human activity and human living (Carrillo, 2004, 2014). In the knowledge economy, also referred to as new economy (Leite & Awad, 2012), education, science, technology and innovation are levers to economic growth, and knowledge-based activities are a requirement for development – a knowledge-based development (KBD) (Fachinelli, D'Arrigo & Breunig, 2018).

A new city model also emerges from this context, intertwined with the new economy basis (Leite & Awad, 2012). For decades, urban centres have been under intensive pressure to accommodate the needs of the rapidly growing population and industrial activities of the Fordist production system (Knight, 1995; Leite & Awad, 2012). The resulting social and environmental externalities out of these processes (e.g., climate change, depletion of natural resources, increased income inequality, difficult access to housing and urban infrastructures) made it clear that the development models needed to be reviewed and that sustainability should be at the centre of the debate (Yigitcanlar & Kamruzzaman, 2015). Therefore, in the knowledge era, cities are idealised to encourage the production and circulation of knowledge in an economically secure, socially just, ecologically sustained and well-governed human setting (Yigitcanlar, 2011).

As societies become increasingly knowledge-based, the rapid technological progress, especially in the fields of information and communication technology (ICT), starts to be seen as the main ally to respond to the increasing environmental and urban socioeconomic crises (Yigitcanlar & Kamruzzaman, 2018; Yigitcanlar, Kamruzzaman, Foth, Sabatini-Marques, da Costa & Ioppolo, 2019). Indeed, the growing availability and popularisation of new technologies have made their use possible not only for human communication but also for solving complex urban problems and for city governance (Cortese, Coutinho, Vasconcellos & Buckeridge, 2019). The concept of 'smart cities' emerges from this view, commonly gravitating around technology application and innovation to solving urban development challenges (Trindade, Hinnig, da Costa, Sabatini-Marques, Bastos & Yigitcanlar, 2017).

Among the most recent conceptual approaches, however, there is a consensus that, by itself, the application of technology to the urban environment is not enough to make a city smart (Ahvenniemi, Huovila, Pinto-Seppä & Airaksinen, 2017; Yigitcanlar & Kamruzzaman, 2018; Yigitcanlar et al., 2019). With more than half of the world population living in cities in the very first years of the millennium, sustainable development has become a fundamental urban issue (Bugliarello, 2006; Phillis, Kouikoglou & Verdugo, 2017; Vojnovic, 2014). Therefore, in order to be truly smart, a city must also be sustainable (Ahvenniemi et al., 2017; Yigitcanlar et al., 2019). A smart city would be the one which seeks to achieve its sustainability goals with the support of modern technologies (Chang, Sabatini-Marques, da Costa, Selig & Yigitcanlar, 2018), also investing in the development of social, environmental

and human capital to generate sustainable urban development (Caragliu, Del Bo & Nijkamp, 2011). For some authors, the term 'smart and sustainable cities' is more appropriate to translate the urban model to be sought in the 21st century (Ahvenniemi et al., 2017; Chang et al., 2018; Dhingra & Chattopadhyay, 2016; Ivaldi, Penco, Isola & Musso, 2020; Yigitcanlar & Kamruzzaman, 2018).

According to Yigitcanlar and Kamruzzaman (2018), to bring together the smart and sustainable dimensions, cities need locally designed solutions and integrated strategic urban planning that include implementing urban technologies focused on truly smart and sustainable development. Considering that the knowledge economy and society are defining the urban experience on the 21st century, the path to making cities smart and sustainable also goes through the assimilation of knowledge as the main driving factor of contemporary urban development (Carrillo, Yigitcanlar, García & Lönnqvist, 2014).

An adhering strategic model to these requirements is Knowledge-based Urban Development (KBUD). Having emerged in the urban planning agenda during the very last years of the 20th century (Yigitcanlar, 2011), KBUD is an approach that highlights the central role of endogenous knowledge, associated in the economic, social, spatial and institutional domains, as a driver to the development of cities (Carrillo et al., 2014). Over the last two decades, KBUD became a prevalent policy for cities and regions that seek to increase their competitiveness, update infrastructures, attract and maintain investment and talent and improve the quality of urban life (Yigitcanlar & Lönnqvist, 2013; Yigitcanlar, Edvardsson, Johannesson, Kamruzzaman, Ioppolo & Pancholi, 2017).

Considering the above, it is relevant to explore the relation between KBUD and smart and sustainable cities. This article focuses on the topic based on the question: how can KBUD strategic approach contribute to promoting smart and sustainable cities? The objective is to present and discuss the main conceptual and application aspects of KBUD as a strategic approach, analysing its adherence to the premises of smart and sustainable city projects.

The literature review was adopted as the methodological procedure (Creswell, 2010) to collect theoretical and state-of-the-art references of KBUD and its relation to the furthering of smart and sustainable cities. Firstly, combinations of keywords were defined considering research objectives and preliminary readings of academic papers on the topics of interest. Scopus database was selected as the source for academic articles' research due to the broad coverage, impact and quality of journals indexed in it, especially in the Social Sciences domain (Harzing & Alakangas, 2016; Mongeon & Paul-Hus, 2016). The research strategy included the use of the terms "knowledge-based development", "knowledge-based urban development", "knowledge economy" associated with "smart AND sustainable cities".

Aiming at a broad perspective, the initial selection included journal articles and journal

reviews, books and book chapters, editorials, conference papers and conference reviews. Documents such as letters, technical reports, notes and errata were left out. The next criterium applied concerned the subject area – in general, documents on Exact and Biomedical Sciences were excluded. The remaining documents had their titles and their abstracts 'eye-balled' for an evaluation of their adherence to the research themes. Subsequently, a CVS file containing the list of documents was exported and manipulated in Excel. A column containing the journals' impact factor (Scimago Journal Ranking) was added when available. After that, the entries were sorted on a priority order that combined citation count (highest to lowest), the impact factor (highest to lowest) and date (newest to oldest). Then, the documents on the resulted ordered list started to be read.

As the documents (mostly journal articles) were being read, notes on literature they referred to were collected, which provided the second map of relevant literature that needed to be considered. On this second stage, Scopus and Google Scholar databases were used for specific research. Qualitative summaries were produced as the documents were read. The main findings from the literature review are presented next.

KBUD origin and conceptual aspects

For over two centuries, traditional input factors of the production function – i.e., labour, land and capital, all of material base, were sufficiently adequate for explaining the growth of economies based on agriculture, extraction and industrial manufacturing (Carrillo, 2014). Human capital was either embedded in labour or in a capital category (Edvardsson, Yigitcanlar & Pancholi, 2016). However, by the second half of the 20th century, analysts and economists started to realise that the growth rates of several economies could not be explained in terms of traditional economic factors anymore and that knowledge was sufficiently relevant to be acknowledged as a fourth production factor (Cooke & Leydesdorff, 2006; Edvardsson et al., 2016). By the turn of the millennium, it has become clear that non-tangible forms of capital, also known as intellectual capital or knowledge capital, were playing a central role in the development and competitiveness, especially in innovation-driven economies (Carrillo, 2014; Cooke & Leydesdorff, 2006; Edvardsson et al., 2016). Thus, in the knowledge economy, the improvement and increased integration of knowledge-based production factors generate development for national, regional and local systems – a knowledge-based development (KBD) (Carrillo, 2014).

Initially applied with a focus on economic management and industrial innovation, KBD rapidly caught the attention of researchers in the fields of Economic Geography and Urban and Regional Planning (Yigitcanlar, Lönnqvist & Salonius, 2014). In the mid-1990s, Knight (1995) already attributed an essential role to knowledge in the development of sustainable

cities, emphasising that new policy and planning approaches were needed to address KBD, defined by him as the transformation of knowledge resources into local development.

During the 2000s, the connection among cities, as places where knowledge is created, applied and marketed, and the concept of KBD became stronger, as the 'knowledge cities' became a popular theme in academic research (see Bugliarello, 2004; Carrillo, 2004; Dvir & Pasher, 2004; Ergazakis, Metaxiotis & Psarras, 2004; Yigitcanlar, O'Connor & Westerman, 2008; Yigitcanlar, Velibeyoglu & Martinez-Fernandez, 2008). Soon, it became clear that the knowledge-based perspective needed to be embedded in the urban planning and development theoretical framework more systematically. That was when the concept of Knowledge-Based Urban Development (KBUD) was coined as a new planning and development policy approach for cities and regions in the context of the new knowledge economy era and global competitiveness (Yigitcanlar, 2011, 2014a; Yigitcanlar et al., 2014).

Ever since, different associations have been made concerning what KBUD consists of. One of the most popular approaches comes from the idea that the KBUD aims at the implementation of geographic unities of technology production and innovation, constituting scientific, technological, academic, cultural and innovation-intensive clusters in urban spaces that operate as engines of economic productivity (Carrillo et al., 2014; Leite & Awad, 2012). Formations such as technological parks, innovation districts, science and technology corridors and research and development (R&D) poles compose this concept. International examples include California's Silicon Valley, London's East End and Barcelona's @22 (Carrillo et al., 2014). The Innovation Route in Florianópolis, the Curitiba Software Park, the São Carlos High Technology Foundation (ParqTec) and the Development Company of Campinas High Technology Pole, among others, are examples in Brazil (Leite & Awad, 2012).

Another perspective frequently associated with KBUD refers to the creative class concept, introduced by Richard Florida (2002). In this perspective, KBUD seeks to develop cities that attract and concentrate highly educated and skill-trained workers in fields such as Management and Entrepreneurship, Arts, Biological and Applied Social Sciences, Architecture, Engineering, and others (Carrillo et al., 2014; Leite & Awad, 2012).

Nevertheless, these perspectives of KBUD are somewhat limited. Whereas they constitute relevant aspects of it, KBUD is not limited to the development of technology clusters, or to policies aimed at attracting knowledge workers, or even to the implementation of ICT infrastructure. KBUD is a multidimensional transformation strategy that seeks to comprehend and develop the city from a collective and integrated social value perspective, where all aspects relevant to a viable and balanced urban life, including the environmental, economic and social dimensions of sustainability, are given due consideration (Carrillo et al., 2014).

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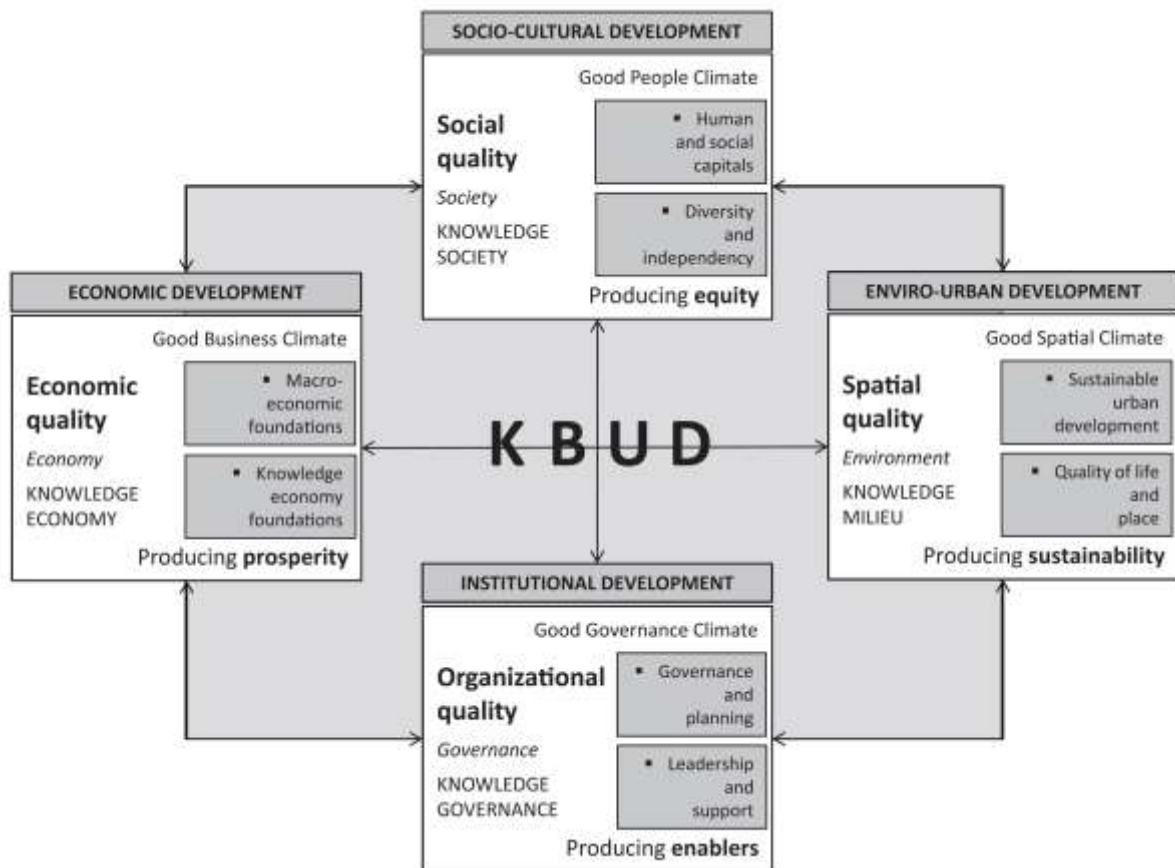**9**(1), p. 1-19, e18740, 2020

From this perspective, Yigitcanlar (2011) presents KBUD as a new development paradigm in the knowledge era which aims to bring economic prosperity, environmental sustainability, a just socio-spatial order and good governance to the cities, producing a city purposefully designed to stimulate the production and circulation of knowledge. In this sense, KBUD considers the multidimensionality of knowledge in the cities, including development initiatives such as social innovation and social entrepreneurship, frugal innovation, happiness economics, sharing economy and collaborative consumption (Carrillo et al., 2014). On a KBUD strategy, planning requires the understanding of the unique characteristics, the identity differences, the diverse socioeconomic and socio-spatial forms and, mostly, the existing knowledge assets of a city or region (Edvardsson et al., 2016; Yigitcanlar et al., 2014; Yigitcanlar, O'Connor & Westerman, 2008; Yigitcanlar, Velibeyoglu & Martinez-Fernandez, 2008).

Knowledge assets are, on a broader sense, all the knowledge factors and capabilities of local development-related stakeholders, such as citizens' skills and competences, cooperation relationships and mechanisms, or existing instruments and structures, that support knowledge creation within a city (Edvardsson et al., 2016; Lönnqvist, Käpylä, Salonius, & Yigitcanlar, 2014). Other urban knowledge assets found in the literature include knowledge and creative workers, universities, ICT systems, housing and property markets, among others (Edvardsson et al., 2016). For Lönnqvist et al. (2014), in a KBUD approach, knowledge assets have a fundamental role as local development drivers. Nevertheless, the relevance of each type of knowledge asset can vary from city to city. The development strategies and objectives outlined by each city will define which knowledge assets are critical to obtaining the desired results (Lönnqvist et al., 2014). Special attention must be paid to the local historical, cultural, aesthetic and ecological values that give the city its distinction and can leverage its strategic objectives (Knight, 1995).

Carrillo (2002, 2004) proposed the C*apital System* taxonomy as a generic framework for identifying, developing and evaluating a city's multiple forms of capital assets, both tangible and intangible, and thus building a systematic KBUD approach. In its turn, KBUD's conceptual framework, as developed by Yigitcanlar and Lönnqvist (2013) – Figure 1 – connects four knowledge-based development domains: economic, sociocultural, spatial and institutional, that must operate with integration and balance in order to achieve a knowledge-based development (Yigitcanlar, 2014b; Yigitcanlar & Lönnqvist, 2013; Yigitcanlar et al., 2014).

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Figure 1 – Conceptual framework of KBUD

Source: Yigitcanlar & Lönnqvist (2013, p.359).

The *economic development perspective* emphasises endogenous knowledge assets as the centre of economic activities, using locally developed research, technology and brainpower to create high value-added products and generate economic prosperity (Yigitcanlar, 2009, 2011).

The *sociocultural development perspective emphasises* the diversity, independence, and development of the citizens' capacities and skills. The goal of the knowledge society must be social equity through the development of the community's human and social capitals (Yigitcanlar & Lönnqvist, 2013; Yigitcanlar et al., 2014).

The *spatial development perspective* emphasises the importance of conserving and integrating both natural and built environments, aiming at ecologically correct and sustainable urban development, that offers quality of life to all residents (Yigitcanlar & Lönnqvist, 2013; Yigitcanlar, 2014b).

The *institutional development perspective* emphasises a set of policies, functions, responsibilities and processes that act as KBUD enablers through strategic planning, institutional leadership and collaboration. It aims to democratise and humanise knowledge, institutionalise interdisciplinary collective learning processes and engage the several actors and agents in the urban development governance process (Yigitcanlar, 2011, 2014a;

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Yigitcanlar & Lönnqvist, 2013; Yigitcanlar et al., 2014).

Likewise, sustainability and organisational capacity are critical dimensions that must be in the heart of a KBUD process (Yigitcanlar, 2011, 2014b). Cities interested in applying KBUD must start by forming a KBUD strategy and adapting their planning mechanisms to it so that the city's main characteristics and circumstances are considered in the formulation process (Yigitcanlar, 2014a; Yigitcanlar et al., 2014). Furthermore, literature shows that the development of long-term planning is one of KBUD best practices (Edvardsson et al., 2016; Yigitcanlar, 2009, 2011, 2014a; Yigitcanlar & Lönnqvist, 2013; Yigitcanlar et al., 2014).

Besides, essential for the success of a KBUD process is the ability of city managers and policymakers in establishing and cultivating collaboration through partnership models. In increasingly knowledge-based societies, innovation must be visualised not only as the development of new products and processes but also as the creation or reconfiguration in a more productive combination of the institutional arrangements that improves the innovative process (Etzkowitz & Zhou, 2017). In this sense, the triple-helix model, in which the collaborative interaction of university, industry and government generates new innovation strategies and practices is highly convergent with KBUD (Yigitcanlar et al., 2017). The triple-helix operates as a platform for continuous dynamics of new knowledge transformation and transfer, which flow from university, industry and government through collaborative processes, and by the creation of new organisational formats such as incubators, technology parks and venture capital firms (Etzkowitz & Zhou, 2017).

KBUD approach places a central position to universities, seen as critical assets that act as knowledge hubs, deeply embedded in systems of innovation and knowledge training, generation, exchange, circulation and commercialisation (Edvardsson et al., 2016). For Etzkowitz and Zhou (2017), the university is the fundamental institution in any KBUD strategy. Unlike companies' R&D centres or government's labs, that need to make significant investments to attract human capital and keep ideas flowing, universities have an active and continuous stream of students, professors and researchers that enables the generation of new ideas and innovation projects (Etzkowitz & Zhou, 2017). Furthermore, universities attract scientists and creative people and can also play a governance role by improving the administrative capacity and effectiveness of the city or region (Yigitcanlar et al., 2017). Likewise, government plays a fundamental role in the partnership, by providing infrastructure (Fachinelli et al., 2018) and nurturing a knowledge incubation environment (e.g., offering incentives and physical structure or investing in quality of life) (Yigitcanlar, Velibeyoglu & Martinez-Fernandez, 2008).

However, exploiting city's knowledge assets and developing partnerships is not enough for successful KBUD. In practice, KBUD's effectiveness strongly depends on the community support to policies, as well as solid financial foundations, usually public funding

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and incentives (Yigitcanlar, 2009, 2011; Yigitcanlar et al., 2017). Implementing these policies requires competent organisations, organisational skills, and expert teams, in association with city administrations, planners, policymakers and citizens, equipped with powerful decision and policy support tools and systems to make informed decisions (Yigitcanlar, 2009, 2011, 2014b; Yigitcanlar et al., 2017). In this sense, a KBUD strategy can be facilitated, for instance, by the availability of information, especially in the contemporary context of open data, internet of things and big data (Fachinelli, D'Arrigo & Giacomello, 2015).

However, there is no generic recipe for articulating a KBUD strategy, as each city's key characteristics and circumstances must be considered in the formulation process (Yigitcanlar et al., 2014). At the practical level, KBUD strategies are developed through different planning and implementation contexts. Therefore, assessing and comparing KBUD's global best practices can also contribute to the development of more appropriate methods and processes for local KBUD planning, policymaking and implementation (Yigitcanlar, 2014b). Comparative assessments and benchmarking can inform strategic planning and urban development policymaking by helping cities analyse achievements and improvement opportunities. Yigitcanlar (2014b) highlights that, for cities seeking prosperous development through KBUD, keeping track of the global benchmarks is a prerequisite for a broad strategic vision. Comparative assessments can also help cities set future performance goals and then monitor and evaluate their progress against their competitors. In recent years, comparative analyses and benchmarks of cities that have applied and succeeded in their KBUD have become increasingly popular within the sphere of urban policymaking, and different models and evaluation frameworks can be found in the literature (see Edvardsson et al., 2016).

In addition, the community's involvement in the monitoring and evaluation of the implemented strategy is essential, given that citizen's participation and engagement in urban development processes are constituent pillars of KBUD. Thus, a KBUD strategy is only effective if implemented through transparent and inclusive governance processes composed of a set of policies, functions, responsibilities and processes that aim to better manage the city and guide it towards achieving its knowledge-based sustainable development goals (Carrillo et al., 2014).

KBUD studies and initiatives in Brazil

In Brazil, KBUD applied research and initiatives have evidenced the model's adherence to the national context, as well. Without the intention of presenting an exhaustive roll, since this was not an objective of the proposed literature review, some examples are highlighted to demonstrate the applicability of KBUD approach to Brazilian urban realities.

Fachinelli, Carrillo and D'Arisbo (2014) applied the capital system taxonomy to evaluate the creative economy model adherence to further the knowledge-based development of the city of Bento Gonçalves Rio Grande do Sul state. The study revealed that the strength of the local cultural heritage, originated by Italian immigration, is a valuable knowledge asset with high potential to create sustainable development for the city.

Spinosa, Krama and Hardt (2018) explored the relations between KBUD and innovation ecosystems in the urban environment by applying a conceptual model developed specifically for this purpose in four Brazilian cities. The analysed cities were Recife (Pernambuco State) and Porto Digital innovation and technology pole; Rio de Janeiro (Rio de Janeiro State) and Federal University of Rio de Janeiro's Technology Park; Porto Alegre (Rio Grande do Sul State) and TECNOPUC, associated to the Pontifical Catholic University of Rio Grande do Sul; and São Leopoldo (Rio Grande do Sul State) and the TECNOSINOS Technology Park, associated to the Vale dos Sinos University (UNISINOS). The results indicated that KBUD perspectives could positively influence the results and impacts pursued by the Innovation Ecosystem in the analysed sites.

Yigitcanlar, Sabatini-Marques, Lorenzi, Bernardinetti, Schreiner, Fachinelli and Wittmann (2018) carried out a qualitative analysis, through the lenses of KBUD, of the main development domains in Florianópolis, Santa Catarina state capital, in its trajectory to become an internationally recognised smart and innovative city. The results revealed that the city achieved relevant advances in terms of KBUD, establishing itself as a promising national innovation hub and, thus, diversifying, through knowledge-based activities, the city's economy so far focused on tourism and public services. However, the study also revealed that in order to become a smart and sustainable city Florianópolis still needs to overcome some challenges in terms of environmental conservation, public security, urban mobility and urban infrastructure. Even so, the study concluded that knowledge-based activities contributed and are promising for Florianópolis' development (Sabatini-Marques, Yigitcanlar, Schreiner, Wittmann, Sotto & Inkinen, 2020).

KBUD for smart and sustainable cities

The smart city notion has its origins associated with the *Smart Growth* movement of the late 1990s. The movement came up as a response to the population growth and urban sprawl context in the United States, associated with environmental and social externalities, such as traffic congestion, pollution and increasing social inequality (Neirotti, De Marco, Cagliano, Mangano & Scorrano, 2014; Yigitcanlar et al., 2019). Later on, the smart city concept evolved to be strongly associated with the implementation and application of ICT to cities' infrastructure (Cortese et al., 2019), in a process that was later leveraged by the

speech of then IBM president, Samuel J. Palmisano, in 2008 (Yigitcanlar et al., 2019).

In the academic field, so far there is no consensus established on what is or what makes a smart city, and different definitions can be found in the literature (Albino, Berardi & Dangelico, 2015; Ivaldi et al., 2020; Nam & Pardo, 2011; Yigitcanlar et al., 2019). However, some scholars agree in associating the notion of 'smart city' to the sustainability goals (Ahvenniemi et al. 2017; Yigitcanlar et al., 2019). A study by Yigitcanlar et al. (2019) analysed the relation between 'smart cities' and urban sustainability in academic literature and concluded that, in order to be smart, cities also need to be sustainable. A 'smart and sustainable city' (Ahvenniemi et al., 2017; Chang et al., 2018; Dhingra & Chattopadhyay, 2016; Yigitcanlar & Kamruzzaman, 2018) uses innovation and technology to improving its citizens' quality of life and services efficiency, aiming at sustainable urban development (Ivaldi et al., 2020).

In practice, however, such results may be more challenging to obtain than the theory points out. A study conducted by Yigitcanlar and Kamruzzaman (2018) with 15 cities in the United Kingdom did not find evidence that there is a positive correlation between the adoption of smart technology and sustainability results, such as the reduction of CO_2 emission over time. The authors also pointed out that so far, there is little empirical evidence that smart cities contribute to cities' sustainability agenda (Yigitcanlar & Kamruzzaman, 2018).

This is partly due to the fact that smart and sustainable urban development goes beyond technological aspects (Yigitcanlar, 2016; Yigitcanlar & Kamruzzaman, 2018; Yigitcanlar et al., 2019). Distinctly, it must be conceived and operationalised over the three main dimensions of sustainable development (triple bottom line), taking environmental quality, economic prosperity and social justice as foundations. In recent years, governance has also been regarded as a necessary dimension to achieve the three firsts, compounding what is called the quadruple bottom line approach for sustainability (Yigitcanlar & Kamruzzaman, 2015). In the same perspective, Maiello, Battaglia, Daddi and Frey (2011) emphasise that the cities' sustainability depends on a transdisciplinary vision of urban governance, which takes the policy process as a knowledge generation process. In this sense, KBUD's multidimensional approach, as presented in Figure 1, offers an overarching framework to combine and strategically operate the economic, social, spatial and governance dimensions, contributing to the integration of the smart city and the sustainable city views. Furthermore, for Chang et al. (2018), KBUD, as a development strategy, has shown to be adequate to promote smart and sustainable cities, for it can operate as a city's knowledge management element, broadly articulating the four development domains.

The beforementioned study by Yigitcanlar et al. (2019) also shed light over specific limitations of smart cities to achieve sustainability. One of them corresponds to the heavy

technocentricity in many of the approaches, which prioritise technological solutions, usually high-cost ones, and neglect more simple and sustainable alternatives. Some smart cities projects end up distorting the very notion of smartness, excluding from it sustainability aspects without which development cannot be achieved (Dhingra & Chattopadhyay, 2016; Yigitcanlar et al., 2019). Differently, KBUD's vision recognises the multidimensionality of knowledge in the cities, also valuing common knowledge (Carrillo et al., 2014). If taken as a strategic guideline, KBUD's approach can contribute to keeping the balance of sustainability's social value in smart cities' initiatives.

Another limitation pointed out by the researchers is due to the practice complexity of smart cities. Cities are complex systems, formed by several other subsystems (economic, social, environmental, technical, administrative) that are equally complex and, thus, imply various planning and management challenges for their administrators (Neirotti et al., 2014). Therefore, the practice complexity of smart cities is evident and needs to be considered in the policy formulation, implementation, and monitoring processes that aim at furthering smart and sustainable cities (Yigitcanlar et al., 2019). KBUD seeks to answer this challenge by promoting organisational capacity, institutional development and the engagement not only of the government but also of several actors and agents of the governance process of urban development.

A third limitation identified by Yigitcanlar et al. (2019) concerns a lack of sound smart city conceptualisations, which gives place to *ad-hoc* ones, easily distorted in practice. Even though in theory the notion of 'smart' does not make sense when disassociated of the notion of 'sustainable', in practice, smart city initiatives often reinforce the neoliberal economic model, applying solutions that favour a small group of privileged people, neglecting the needs of a significant part the population and even reinforcing inequalities and producing negative environmental externalities (Carrillo et al., 2014; Yigitcanlar et al., 2019). This contradiction between theory and practice is mainly due to the inherent dichotomy between the notions of smart/artificial versus sustainable/natural – a contradiction that has long dominated the discussions on sustainable urban development (Costa, 2000; Maiello et al., 2011). Yigitcanlar et al. (2019) point out the occurrence of this contradiction in the researched literature, manifested in the opposition of ideas such as 'short-termism' vs. 'long-term gains'; 'elitist' vs. 'inclusive'; 'profit-driven' vs. 'equilibrium-driven'; 'materialism' vs. 'dematerialism', among others.

Distinctly, KBUD is based on long-term endogenous development processes, which emphasise regional and local cultural and human resources instead of the exploitation of natural resources and locational advantages driven by external interests (Knight, 1995). In this sense, KBUD offers a more self-sufficient economic, social and environmental system. Carrillo (2014) sees a substantial convergence between KBUD and sustainable

development, insofar cost transfers of socio-environmental degradation to future generations threatens a central dimension of collective urban capital. In this sense, achieving sustainability goals is a necessary condition to achieve KBUD goals (Carrillo, 2014). KBUD's paradigm allows overcoming the apparent contradiction between the notions of smart/artificial/material versus sustainable/natural/intangible, for it involves a transformation process from an urban economic culture based on consumption, accumulation and industrial production to an emerging culture based on collective value balance (Carrillo et al., 2014).

Yigitcanlar (2016) emphasises that an integrated and balanced approach is necessary for 21st-century cities. The opportunities provided by technology applications must be seen as a means to further all urban development domains: economic, social, environmental and institutional. In this sense, in order to be genuinely successful, smart and sustainable cities need:

a) In terms of *economic development*, to develop technologies according to their problems and development needs, also contributing to the establishment of an innovative local economy (Yigitcanlar, 2016). In this sense, KBUD can contribute to promoting smart and sustainable cities by stimulating local-based R&D and innovation processes and leveraging the endogenous knowledge assets as key production factors to generate high value-added products (Yigitcanlar, 2009, 2011). Moreover, a recent study carried out by Ivaldi et al. (2020) with 116 Italian cities concluded that the development of the knowledge-based economy could elevate a city's smartness and sustainability level;

b) In terms of *sociocultural development*, to connect the city with inclusive smart urban technologies that contribute to achieving socioeconomic equality (Yigitcanlar, 2016). In this respect, KBUD's vision, which considers the multidimensionality of knowledge within the city and advocates for the training and development of citizens' skills, stimulating their independence and valuing their diversity, offers a clear perspective of social value to equity-driven application of technologies (Carrillo et al., 2014; Yigitcanlar & Lönnqvist, 2013; Yigitcanlar et al., 2014);

c) In terms of *spatial development*, to apply the sustainable urban development principles, adopting technologies that truly minimise the urban footprint and reduce emissions, contributing to the cities' ecological sustainability (Yigitcanlar, 2016). In this point, by recognising the potential of initiatives such as frugal innovation, sharing economy and collaborative consumption, KBUD nurtures the development of smart and sustainable alternatives for cities' environmental issues (Carrillo et al., 2014);

d) In terms of *institutional development*, to equip the city with dynamic mechanisms that contribute to improve long-term planning and day-to-day operational challenges

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management (Yigitcanlar, 2016). In the KBUD approach, shared governance and innovation through partnership and collaboration are fundamental elements that democratise and institutionalise collective learning about city management processes (Yigitcanlar, 2011, 2014a; Yigitcanlar & Lönnqvist, 2013; Yigitcanlar et al., 2014).

Therefore, in the knowledge era, the main challenge of smart and sustainable development for cities is to create new types of opportunities and promote equitable well-being through solid strategic planning, transforming innovation and technology into local economic development that is also environmentally friendly and socially just. Technological advances are not, by themselves, a panacea for all of the urban development ills and only with a holistic view can cities become truly smart and sustainable (Yigitcanlar et al., 2019). In this context, KBUD provides an integrated approach for the transition of smart and sustainable cities through the attraction, development and retention of intellectual and human capitals, and fostering knowledge and innovation dynamics that further economic, environmental, social and institutional transformation (Chang et al., 2018).

Conclusion

Smart and sustainable cities are currently seen as the urban model of the future. However, the transition from current levels to such a model demands that cities adopt a comprehensive, solid and integrated strategy. The bibliographic review reported here revealed that there is a convergence between the KBUD strategic model and smart and sustainable cities. While the latter is the goal of current urban development projects, KBUD offers the means to achieve it, operating as a planning platform, which provides the strategic basis for the application of smart solutions at the practical level, without losing sight of sustainability goals.

Whether so far there is little empirical evidence that the so-called smart initiatives are also bringing sustainability to cities (Yigitcanlar & Kamruzzaman, 2018), this is partly due to the fact that many smart city projects have failed to overcome the instrumental view focused on technology implementations, which lacks a systemic approach that considers all relevant aspects of the life in the city, and that includes governance processes capable of integrating all city actors and all dimensions of sustainability. In turn, KBUD constitutes a multidimensional system that can certainly include instrumental smart city initiatives, but also offers an integrated approach to transform the territory in economic, environmental, social and institutional terms. While, for example, a smart city seeks to apply innovation to solve urban problems, with KBUD, a smart and sustainable city aims at establishing an innovative local economy that generates development and sustainability.

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Also, a differential in KBUD is the importance of the institutional governance processes, frequently neglected in smart city initiatives. The fundamental concern with the institutionalisation of interdisciplinary collective learning processes, which contribute to the community's involvement and participation in the formulation and monitoring of implemented strategies, is a KBUD's essential element that could contribute to the application of smart city initiatives.

Thus, through a literature review, this article presented a theoretical view on KBUD's concepts and applications as a strategic approach for the furthering of smart and sustainable cities. It concludes that KBUD can constitute an integrated system for the strategic urban planning of smart and sustainable cities, including the implementation of urban technologies developed by endogenous processes of innovation and oriented towards truly smart and sustainable urban development.

The study makes a contribution by presenting perspectives for the development of smart and sustainable cities in the context of the knowledge economy and society. However, the authors recognise the study's limitation in considering only the conceptual aspects contained in the literature. Future research may focus on empirical investigations about the practical application of KBUD's principles and guidelines on smart and sustainable city projects, for which the review presented here may provide initial reflections.

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