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The Theoretical, Practical, and Technological Foundations of the 15-Minute City Model: Proximity and Its Environmental, Social and Economic Benefits for Sustainability

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Abstract: Conventional and emerging paradigms of urbanism require new responses under the current circumstances, especially in relation to the integration of sustainability dimensions and technology advances. The escalating rate of urbanization, coupled with the climate emergency, fundamentally indeed disrupt the challenges that urbanism research and practice deal with, calling for adopting more innovative approaches to urban planning and design. With cities contributing around 65% of Greenhouse Gas (GHG) emissions and experiencing an unprecedented growth of population, contemporary urban policy needs to be redefined and re-assessed accordingly. While numerous urban models, such as the Compact City, the Eco-City, the Sustainable City, and the Smart City, have emerged in response to the challenges of sustainability and urbanization, the 15-Minute City has recently gained a steep popularity. This paper explores the theoretical, practical, and technological foundations of the 15-Minute City, with a particular focus on the proximity dimension of mixed land-use and its environmental, social, and economic benefits of sustainability as supported by smart technologies. We argue that this evolving model of urbanism has the potential to gain more expansion and success in regard to building more sustainable, efficient, resilient, equitable, and inclusive cities in line with the global agendas of Sustainable Development Goal (SDG) 11, as it adds a strategic value to the amalgam of the prevailing and emerging paradigms of urbanism and their synergies with respect to increasing the benefits of sustainability while emphasizing its environmental dimension.

Keywords: 15-Minute City; compact city; eco-city; smart city; proximity; mixed-land use; urban computing and intelligence; sustainability; decarbonisation; urban planning and design

1. Introduction

Recent reports by the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) warn that the world is set to exceed the Paris Agreement targeted temperatures of below 2 °C (preferably 1.5 °C). The report highlights the likelihood that the temperatures might reach a high of 2.7 °C pre-industrial levels by the end of this century [1,2], as countries are far below their emissions targets. This underlines a new urgency to avert the already increasing climate change events, which are evident with the increasing frequency and intensity of events such as storm surges, unpredictable and erratic weather conditions that have prompted

flooding, increased desertification, prolonged and harsh drought, sea level rise, and so forth. These events have increased pressure on communities, prompting new challenges such as climate induced migrations, with over 30 million people reported to have migrated between 2018 and 2020 [3].

The anticipated temperature rise would be expected to impact and disrupt the quality of lives of urban communities, especially for those who reside in coastal regions and low-lying lands. This is critical, as over 55% of the global population is based in urban areas, and that this rate is expected to reach a high of over 68% by 2050 [4]. Further, urban areas have been reported to be the main engine of different economies (contributing over 70% of the global GDP) across the globe, and any disruption would have a cascading effect on almost all major sectors in global economies. It is also noteworthy that urban areas across the globe are responsible for more than 60% of global Greenhouse Gases (GHG).Urban areas are responsible for the increased consumption of resources such as energy, as 78% of world energy is consumed in sectors such as transport, construction, and manufacturing—industries that are based in cities [5]. Urbanization remains one of the greatest challenges facing contemporary and future cities. The natural resources available globally are predicted to increase by 90 billion tons by 2050, a considerable change when compared to the 40 billion tons available in 2010 [6]. This results in cities being at the forefront of climate change initiatives [7–9] and sociotechnical changes [10–12]. Furthermore, due to changing global consumption trends wherein most of the global population are seen to have high affinity for manufactured goods, urban areas have become a major source of pollution, which affects different parts of the environment [13]. Urban players will then have to play an important role in deep decarbonisation agendas, a subject of key importance at the COP26, which is calling for net zero commitments by 2050 [14].

Adding to decarbonisation agendas, urban players will further need to urgently consider the targets established in the Sustainable Development Goal (SDG) 11, which emphasize the need for inclusivity and equitability in urban areas [15]. While urban transitions will require climate financing, it is noted that the $100 billion pledged in the Paris Agreement by developed economies will unfortunately only actualise until roughly 2023 [16], therefore prompting the need for alternative urban climate financing strategies. In this case, models highlighting private sector participation, which yield high societal outcomes, may be favoured. One viable model, which incorporates a by-product of the Smart City pursuit, is that of the '15-Minute City', which was initially proposed in 2016 [17–19], but gained popularity during global lockdowns prompted by the COVID-19 pandemic [20]. The concept not only proposes a reduction in resource use, but also champions reductions in travel needs in urban areas by calling for higher population density and activities. This results in an urban milieu calling for a paradigm shift, where different urban nodes could be accessed by 15 min walks or via cycling. To support this model, it will be key that public services (post offices, banks, facilities, shops, etc.) and amenities (parks and recreation centres) be fairly distributed across the city and restructured in ways that allow for healthy human interactions, a necessity for fostering social cohesiveness [21,22]. This, in turn, would allow urban communities to achieve higher quality of life.

In light of the above, there is a dynamic interplay between urban form, resource consumption, and GHG emissions. The form of the contemporary city, coupled with urban growth, is perceived as a key source of environmental problems, directly affecting the natural environment and ecosystems as well as travel behaviour and thus air quality and global climate. Growing evidence from around the world indicates that GHG concentrations continue to accumulate at an alarming rate due to the current energy-dependent lifestyles and emerging social trends that are parts of urban ways of living. Urgent changes are thus needed in the design in the form of human settlements and in the behaviour of their dwellers in order to produce not only the environmental benefits of sustainability, but also its social and economic ones. As such, this article seeks to explore the 15-Minute City concept and its applicability in urban areas. In particular, it will help to clarify the theoretical, practical, and technological foundations of this model, especially in regard to proximity

dimensions and how these could influence mixed land use to yield environmental, social, and economic benefits. The discussion will further explore how proximity dimension has become critical as a result of unexpected global challenges, such as the outbreak of the COVID-19 pandemic, which has disrupted normalcy in many regions, thereby justifying the need for a planning and design model that prioritizes the human dimension. While the 15-Minute City concept has four main cornerstones (proximity, diversity, density, and digitalisation), this paper will emphasize the proximity dimensions while not reneging the other three dimensions. Therefore, this paper will explore the theoretical, practical, and technological foundations of the 15-Minute City, with a particular focus on the proximity dimension of mixed land use and its environmental, social, and economic benefits of sustainability as supported by smart technologies.

This paper is structured as follows: Section 2 provides background about the foundational aspects of the 15-Minute City. Section 3 addresses the link between the COVID-19 pandemic and the 15-Minute City, as well as other related models. Section 4 delves into the theoretical, practical, and technological origins and underpinnings of the 15-Minute City model. Section 5 provides an account of the 15-Minute City within the narrative of future smart and inclusive cities. Section 6 unpacks the 15-Minute City within the Global South. Section 7 focuses on a relevant discussion. This paper ends in Section 8 with conclusions and recommendations for future work.

2. Background

Proximity as conceptualized in the 15-Minute City model offers direct avenues to reduce emissions through decreased travel needs and short distances, as it has been noted that vehicular transportation is a major source of the 78% of emissions attributed to urban areas. Globally, it is noted that 14% of annual emissions are attributable to the transportation sector, of which 72% is from road vehicles [23]. More specifically, in regions such as the UK, for instance, reliance on cars for transportation is reported to prompt approximately 33% of the emissions to emanate from the transport sector alone, especially prior to the COVID-19 pandemic [24]. As such, the quest to adopt a planning model with the potential to reduce the emission load is no longer an option, but a necessary and positive approach. As for post-COVID-19, with the emissions from the urban centres reported to be rising [25], particularly from the economic recovery approaches being adopted by different economies, it will be important to take urgent action to reduce the car dependency syndrome in urban areas. For this challenge, the 15-Minute City model offers a practical pathway.

Another aspect of the 15-Minute City concept is the creation of decentralised production and consumption hubs within urban areas, wherein significant amounts of GHG emissions could be further eliminated [26]. Already it is noted that even in cities that have not adopted this planning model, the idea of "producing and shopping locally" has gained popularity as a result of people gaining more trust with local supplies during the height of the COVID-19 lockdowns [27]. For instance, it is noted that most supermarket chains in Swedish cities are favouring locally produced products [28]. In other regions, such as American cities, most e-commerce deliveries are observed to be sourced from small local hubs rather than the traditionally centralized locations, as these are often located at a far distance which requires car transportation. In the pursuit of environmental sustainability, the idea of sourcing, producing, and consuming local products can therefore help to build resilience as well as reduce emissions. Research on local food innovations during the pandemic showcases that over 29% of locals in different countries favoured locally produced products. This figure may climb even higher as urban residents continue to embrace the concept. For instance, in Paris, France, it was noted that 51% of randomly sampled residents were in support of locally sourced food and were willing to continue supporting innovations that promote decentralization [28].

Besides the proximity dimension, the 15-Minute City concept is also anchored on other three dimensions (density, diversity, and digitalization) which can be calibrated to respond to the net-zero agenda in an inclusive and equitable fashion [19,29]. For instance, with respect to density, the concept promotes the compact city model where people could be comfortably sustained by the available resources, thereby differing from the conventional urban planning concept where density is solely viewed in terms of built environment quotas. Indeed, as pointed out by Bibri [30], achieving the objectives of the compaction strategy is not only about increasing density per se or increasing density across different spatial scales (i.e., the ratio of dwelling units or people to land area), but is also about good planning to achieve an overall more compact urban form, thus allowing for the full effects of sustainability.

Diversity is conceptualized in two distinct ways: (1) mixed use of built environment in that there is healthy mix of residential, entertainment, and commercial elements, thus maximizing available spaces as well as fostering the proximity between services; and (2) social mix in terms of multi-culturality. To this end, by utilizing mixed use neighbourhoods, it is possible to welcome different cultures transacting for both social and economic gains, which will lead to increasing social coherence. Mixed land use entails a variety and proximity of compatible land uses, resulting in the formation of cross-sectional residential, commercial, institutional, and cultural infrastructures associated with living, working, and service and amenity provision. However, diversity involves building densities, housing for various income groups, various housing types, job–housing balances, household sizes and structures, and cultural plurality, therefore representing the sociocultural context of the compact city. The availability of different housing types and forms help to achieve social mix (i.e., the presence of residents from different backgrounds and income levels in the same neighbourhood) [31].

The digitalisation dimension makes it possible for the other three dimensions of the 15-Minute City model to be realised, especially through integrating smart technologies into different processes and practices. For instance, with digital solutions such as the use of smart sensors, it would be possible to monitor the usability of different public spaces such as parks, bicycle lanes, walking paths, and so one. This would allow the adoption of the most optimal strategies as a way to maximize user experiences. For instance, in the case of Smart Cities, technology has made it possible for establishing and implementing car-free zones, thereby increasing human-scale benefits, such as reduced car accidents, decreased noise pollution, and healthy lifestyles as underpinned in the February 2020 Stockholm Declaration. This approach also has notable environmental benefits, especially in facilitating the reduction of emission loads in cities [32] by advocating and promoting the adoption of alternative mobility options. However, the car-free zones approach should also be aligned with other planning objectives to avoid a scenario like that of Rome, Italy, wherein there are both many green spaces and serious traffic challenges. Data gathered can be utilized to increase performance and efficiency at the urban, district, community, and individual levels [33]. This would allow cities to adopt sustainable practices such as energy efficient buildings [34], renewable energies, and waste management, among others. This unveils opportunities for decentralised solutions with the possibility to be developed locally, thereby empowering local communities in the process and aligning with the narrative around the need to contextualise climate solutions to make them emerge locally where possible. Additionally, a shift in green and digital policies is noted to also increase economic resilience, and as potent strategies to raise capital [35], which can be utilized in urban regeneration objectives.

Furthermore, it is important to combine both urban design strategies and applied technology solutions for achieving the desired outcomes of sustainability. This is at the core of the emerging models for urban development, namely:

- The '15-Minute City' [20];
- The 'data-driven smart compact city' [36];
- The 'smart eco-city' (e.g., [37,38]);

- The 'data-driven smart eco-city' and the 'integrated sustainable district' [39];
- The 'data-driven city' [40]; and
- The data-driven smart city [41,42].

Of importance to note is that these models emphasize both urban design strategies and applied technology solutions at varying degrees, as well as emphasizing their role in enhancing particularly the environmental and social aspects of sustainability. In addition, these models have many overlaps among them in their ideas, concepts, visions, practices, and polices. Therefore, they tend to integrate these from each other to form new loosely or completely integrated models, or to strengthen a particular dimension of sustainability. In doing this, they are adding to missing aspects of sustainability and/or improving others. The main differentiator is the 'branding' component, whereby one model can be integrated more than the other. The 15-Minute city is a clear illustration, wherein its steep success has been documented, as will be showcased in the next section.

3. The COVID-19 Pandemic and the Emergence of the 15-Minute City and Related Models

Though COVID-19 has accelerated the digital transformation of urban society by encouraging the creation of new digital approaches to urban development, the digitalisation process of cities has been central to sustainable urbanism since the mid-2010s. Digitalisation is part of the endeavour that numerous sustainable city models have prioritized, especially by focusing on enhancing their infrastructures and services through innovative approaches to planning for better environmental outcomes, among others (e.g., [36,43,44]). Figure 1 below displays that the 15-Minute City concept has gained significant popularity, especially in the post-pandemic era. Furthermore, it is estimated that the concept is yet to peak, thereby its increased popularity in the immediate and sustained future.
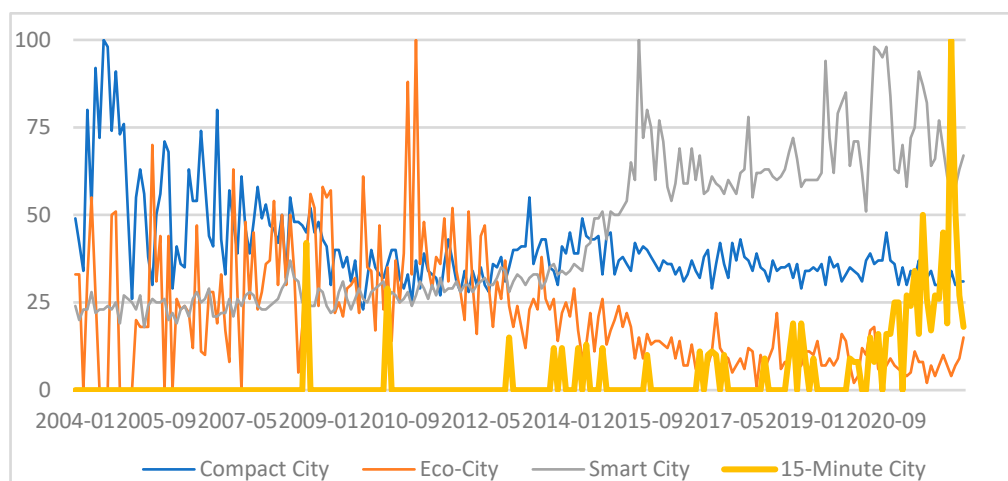

Figure 1. Google Trend Analysis showcasing the popularity of the 15-Minute City against the Compact City, Eco-City, and Smart City models. Sourced from Google Trends and analysed by the authors [45].

This is increasingly driven by sustainability-oriented innovations associated with smart cities with respect to the environment [46]. The endeavour is also in response to the SGD 11 of the United Nations' 2030 Agenda, which emphasises the role of advanced ICT in protecting the environment, optimizing resource efficiency, and improving infrastructure [47]. This, in turn, highlights the multifaceted potential of smart cities and their convergence with sustainability goals pertaining to environmental regeneration and conversation [48,49].

In relation to the three dimensions of the 15-Minute City, recent reviews on the synergic potential of the integration of compact urbanism and smart urbanism reveal that data-driven technology hold great potential for advancing compact urbanism processes and practices with respect to environmental sustainability [50,51]. This pertains to the link between this advanced technology and the compact city as regards enhancing urban planning and design approaches, as well as monitoring and optimizing operational functioning.

Concerning the eco-city, Bibri [52] utilizes case study research to analyse and discuss both the role and relevance of integrating density, mixed land use, and low-energy buildings to the sustainability of eco-districts, as well as the new conceptions of the spatial scaling of urban form in the context of data-driven smart eco-cities. The author found that combining those compact and ecological design strategies improves the performance of eco-districts with respect to the three dimensions of sustainability, as well as paving the way for their balanced integration for producing synergistic effects. Moreover, the author highlights the innovative potential and enabling role of urban computing and intelligence in transforming the spatial scaling of data-driven smart eco-cities through generating the kind of designs that increase the effects of sustainability as outcomes of processes. The energy dimension in cities is paramount to environmental sustainability and must be actively ensured at larger scales, as advocated by Qiu, et al. [53].

Urban computing and intelligence are increasingly gaining momentum in academic circles and policy debates as an advanced solution to the integration of advanced technologies and their novel applications for tackling many of the contemporary complex problems and challenges associated with urbanisation and sustainability. As an integrated and holistic approach, it allows for generating well-informed decisions concerning service provision and infrastructure operation and feedback loops between urban environments, human activities, and physical movements. It is an integral part of the infrastructure of the 15-Minute City, as illustrated and discussed in more detail by Allam, Bibri, Jones, Chabaud and Moreno [18] and Allam, Nieuwenhuijsen, Chabaud and Moreno [26]. As "*a process of acquisition, integration and analysis of big and heterogeneous data generated by a diversity of sources in urban spaces . . . to tackle the major issues that cities face, e.g., air pollution, energy consumption, and traffic congestion. Urban computing . . . creates win-win-win solutions that improve urban environment, human life quality, and city operation systems . . . [and] also helps us understand the nature of urban phenomena and even predict the future of cities*" [54].

4. The Theoretical, Practical, and Technological Origins and Underpinnings of the 15-Minute City Model

As alluded to above, the basic dimensions and objectives of the 15-Minute City are not new and indeed align with the work of urban thinkers who concern themselves with how to build sustainable urban forms, particularly with the compact city and the eco-city, as well as their integration under the umbrella term of sustainable cities. One common denominator is proximity, which is associated with both of these models under their mixed land use strategy. This is adopted to achieve not only the environmental benefits of sustainability, but also the social and economic benefits observable in empirical evidence garnered from case studies (see, e.g., [55–57]. Proximity enables human settlements to be self–sustaining by having everything that residents need within the surroundings of their communities or neighbourhoods. The International Economics and Finance Society illustrates the notion of 'access by proximity', an conceptbased on 15 interdependent dimensions that characterise urban forms as interconnected urban ecosystems, as shown in Figure 2.

Register [58], who coined the phrase 'access by proximity' in relation to the eco-city, argues that the closeness to important functions and activities, such as housing, work spaces, shops, educational and cultural facilities, and places for socializing as necessary to create healthy cities characterized by walkable centers, transit villages, discontinuous boulevards, and agricultural land close by. Farr [59] proposes an integrated approach combining the various dimensions of eco-urbanism and compact urbanism with sustainable urban

infrastructure, and then extends this idea to close the loop on resource use and bring everything into the city with the aim to, among others, accomplish the following:

- Minimize the consumption of non-renewable and slowly renewable ones;
- Generate less waste by means of reuse and recycling;
- Lower air and water pollution;
- Enhance the quality of life by affording greater accessibility to services and facilities within a short distance; and
- Enhance the application of the 5Rs (Refuse, Reduce, Reuse, Repurpose, Recycle).
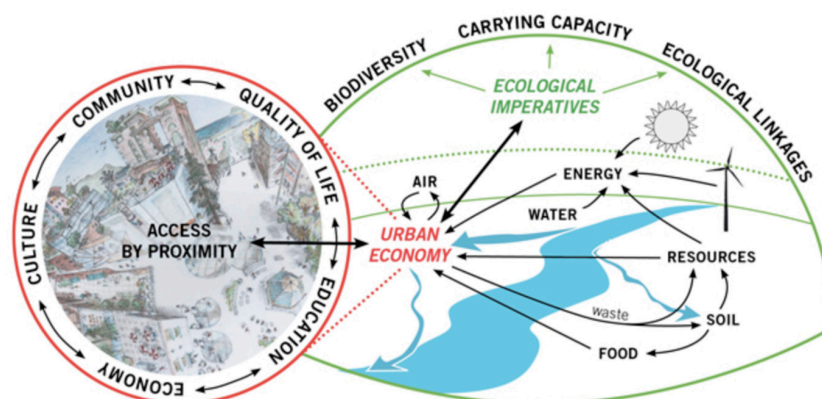

Figure 2. Urban forms as interconnected urban ecosystems. Sourced from IEFS (2014, reprinted with permission from Bibri S.E [39]).

As discussed in Bibri's [60] examination of a case study analysis, it has been found that the environmental, economic, and social benefits of sustainability are produced by proximity, which are of high relevance to the 15-Minute City model as highlighted in Table 1.

Table 1. The multidimensional benefits of proximity for sustainability. Adapted from Bibri [60].

Environmental sustainability
- Lowering energy consumption and reducing pollution due to closeness to workplaces, services, facilities, and public spaces;   - Reducing car dependency and thus CO_2 emissions due to shortened commute times and decreased travel needs;   - Reducing CO_2 emissions due to minimising the use of transportation energy, materials, water, and products;   - Limiting the consumption of building and infrastructure materials;   - Reducing the pressure on ecosystem services provided by green and natural areas;   - Limiting the loss of green and natural areas; and   - Protecting rural and agricultural land through the optimum use of land resources.

Economic sustainability
- Supporting local services and businesses through providing a larger customer basis for commercial activities;   - Revitalizing city centers through the promotion of shops, businesses, and accessible infrastructure and facilities;   - Extending and enhancing public transportation infrastructure and facilities;   - Higher productivity due to shorter travel time to workplaces, diversity, and vitality;   - Attracting skilled labour force by high quality of life due to better access to a diversity of local services and jobs;   - Maintaining the diversity for choice among workplaces, service facilities, and social contacts; and   - Requiring less and cheaper per capita infrastructure provision due to more efficient public service delivery.

Table 1. *Cont.*

Social sustainability

- Creating a better quality of life through more social interaction, community spirit, and cultural vitality due to access by proximity and the opportunity for walking and cycling;
- Reducing crime and providing a feeling of safety through natural surveillance;
- Improving social equality through better access to services and facilities and flexible design of housing in terms of mixed forms and affordability;
- Greater accessibility due to lower cost enabled by shorter intra-urban distances;
- Lowering transport costs, higher mobility for people without access to a car, and improved human health due to more cycling and walking;
- Enhancing social cohesion through a sense of belonging and connectedness;
- Supporting human, psychological, and physical health through ready access to public space, walkability in neighbourhoods, and social contact;
- Enhancing liveability in terms of social stability and cultural and recreational possibilities; and
- Healing spatial segregation by forging the physical links and bridging barriers between communities.

Another common dominator is that, while the advent of cars brought some significant improvements in operations, performances, and service delivery in cities, their unprecedented increase in use and population dependency overshadows these benefits. In particular, their influence on urban planning has been criticized by numerous architects, urban thinkers, and scholars. Among the concerns raised include wanton fragmentation on the social front, emphasizing individual (personal) choices at the expense of the larger society [61]. As a result, it is observed that cities have become centres for increased social inequality [62], sources of which being the unending sprawl [63] and unsustainable urban physical morphology [64]. Such negatives have prompted reconsideration in the urban realm as a means to guarantee sustainability, social cohesion, and integrity in the physical realm of urban areas. On this, Christopher Alexander [65], Leon Krier [66], Michael Mehaffy [67], Jane Jacobs [68] and Nikos Salingaros [69], among others, have produced substantial written works on the need for humane scale planning principles to be at the core of urban planning, so as to guarantee sustainable, healthy, and vibrant cities.

Christopher Alexander [70] has been very vocal on the need for urban designs and planning to focus on building humane and liveable cities. This is clear from his numerous works on the subject and discourse, which include the Pattern Language [71] and the four volume Nature of Order [72–75]. The latter is structured such that it covers different aspects, including the phenomenology of 'Wholeness' that is central to be perceived to be key in achieving liveable cities. The compilation of his work, addressing different aspects of urban designs and systems, could be, in their own right, termed as a roadmap to achieving the two main objective in cities, as well as ensuring such aspects as urban complexity, harmony, and vibrancy.

However, the attempt to decrease car use by restricting parking even in some of the leading eco-districts in the world (e.g., Royal Seaport and Hammarby Sjöstad in Stockholm, Sweden) has faced substantial criticism [76]. One of the arguments advanced in this regard is that the public modes of transportation should be present within the eco-districts from an early stage in order to shift travel patterns away from private car use. Otherwise, the travel habits of the residents may be affected in that they become dependent on cars for transportation. This was raised as a concern in the evaluation of Hammarby Sjöstad district as something to be improved and incorporated in future urban development projects [77]. As a consequence of the growing preferences among the residents to use private cars, parking spaces were raised to match the allocations in effect in Stockholm. Otherwise, new problems could be created in terms of residents parking outside their neighbourhoods where parking regulations are not as strict as those set with the Royal Seaport district [78]. Conversely, in the Western Harbour district in Malmö, Sweden, a district which is based on environmentally sound transport approach, public spaces are mostly closed to cars as there

is a range of opportunities for cycling and walking along pleasant routes. This is intended to be part of the planning of the 15-Minute City as a way to avoid future contentions, adding to other features of sustainable transportation such as carpools (biogas and electric), mobility management, and behavioural change.

The compact city, as envisioned by Salingaros [79], allows cities to be sustainable while catering to greater diversity in regard to issues such as culture and social classes. This aligns with proximity-based dimensions, especially in ensuring urban vibrancy at a human scale. It also ensures that people do not become overly dependent on cars, as they will be able to access different amenities within their areas or neighbourhoods due to the seamless connection of proximal zones. For example, Western Harbour is 'a district with a mixture of housing, services, industries, workplaces, education, and recreation. The district has a unique, attractive location with urban and natural features; it is within walking distance of the inner city, has good transport links By continuing to develop these qualities and building a mixed city, it will be possible to link Western Harbour to the central parts of Malmö' [80]. The narrow streets proposed in the compact city concept are seen as a way of discouraging traffic build-up in cities; hence, this would allow urban residents save both time and money spent off roads. Currently, there is precedence for setting speed limits within residential neighbourhoods in urban areas as a means to discourage car usage, as well as reduce negative impacts such as accidents [81]. This has been adopted in cities such as Paris, Bruxelles, Grenoble, Oslo, Graz, Helsinki, Valencia, Zurich, Lille, Bilbao, and others, with strategies to reduce car speed to around 30 km per hour or less, thus discouraging traffic in certain parts of the city. Interestingly, there is also a growing consensus on the banning of large vehicles such as SUVs within urban centres, in view of their threat to urban dwellers and unsustainability [82,83]. Reduction of cars would also translate to a reduced number of accidents and, at the same time, would allow people to have opportunities to interact as they walk or cycle in cities. The compact city would ultimately help reduce energy consumption, which would have positive bearing on environmental sustainability.

However, adopting the 15-Minute City concept and its proximity dimension in policies has a strategic value, such as the reduction of cars in cities. This cannot be a drastic policy intervention, as it may have severe drawbacks on the socioeconomic fabric. For example, how would the urban poor gain access to work or access basic infrastructures and amenities if connective threads are cut? Therefore, the above proposed approaches could work in a symbiotic manner, coupled with the introduction of other policies, such as banning of large vehicles plus other automobiles with capacities to cause accidents in certain parts of the urban environment while increasing the city's capacity and efficiency (cost and speed) for public transportation [84]. This would particularly help in reducing traffic, as well as the carbon footprint from the transport sector. Additionally, the aspect of introducing walkable pathways and bicycle lanes (with end-of-journey amenities) would help in the transition journeys to sustainable mobility.

The idea of close-knitted cities supporting the proximity-based dimension was to ensure that people are not trapped in the modernist maze of cities that could only be accessible using cars. However, though this idea did not fully materialize in the 1980s due to the competing modernists model that, as argued by Scruton [85], prevailed at the time, the current happenings in the global arena (especially with the COVID-19 pandemic) have vindicated Krier's ideas. Even before the pandemic, cities across the world grappled with sprawl and single-use structures that intensified the social alienation that urban residents had to endure. With modernist approaches, cities have endured heavy traffic and high energy consumption as a result of having energy-intensive architectural structures and other vices that are detrimental to liveability. Cities have also lost their flavour as centres of interaction and have become places where social alienation and inequality have been rising.

Therefore, now that there is an almost general consensus that city planning needs to be re-imagined ensuring that the social aspect is given precedence, Krier's ideas and roadmap toward creating close-knitted communities should be given attention. This would strive

to conserve historical and cultural attributes as key dimensions for social cohesion [86]. Similarly, ensuring that every element added in a neighbourhood does not compromise but add to social aspects such as leisure, work, culture, or liveability. For example, the transport strategy in Gothenburg for a close-knit city in the context of the compact city indicates how the transport system needs to be developed as more people live, work, shop, study, and meet in the city; that is, transportation systems need to be developed in relation to mixed land uses [55]. Gothenburg strives after a mix of uses, not only as part of transforming central renewal areas, but also as part of developing strategic nodes, as it enriches the city and makes the surrounding development more attractive to people. It is important to note is that the conditions for a mixture of businesses, housing, and activities in Gothenburg relate to what they call a 'close-knit city' [87].

While the different models may call for general time recommendations for desired walking, commuting, or access times, those should not however be taken literally, such that urban infrastructures and elements are strictly constrained within 15 min radii. The urban restructuring needs to take into account different dynamics and unique urban morphologies which already exist in different cities. To accomplish this, urban planners can borrow the extensive work of many celebrated urban thinkers [65,66,68,69] who advocate for human scale urban areas. This means that the different components, such as residential areas, walkways and bicycle lanes, markets, schools, recreation centres, and others, should not operate as single entities, but rather be put together to collectively enhance human interactions and social life. Jacobs [68] noted that, in the course of urban planning, it could be possible to alienate people, especially by not having them participate in creating the city. That is, planning and implementing projects without the participation of residents who are the main consumers may ultimately alienate these individuals. In fact, participation and consultation is a key strategy for achieving sustainable urban forms in terms of improving social cohesion.

As argued by Bibri and Krogstie [76], the sustainable form of the city can only be created through the cooperation between citizens and other private and public sector actors by means of dialogue as part of the planning process. With that in mind, an urban area, though presented as a 15-Minute City would fall short of what Leon Krier expressly describe in his book '*The City Within the City*' [66], where he advocates for urban neighbourhoods (quarters) to be designed in such a manner that residents can comfortably achieve all their daily functions. Further, the 15-minute concept also needs to be guided by the prescripts of Alexander [65], who advocated for cities to be built in such a way that they evoke the aspect of 'wholeness'; where small 'blocks' are craftily ordered in a way that at the end, a 'complete' whole is achieved. This relates to the spatial scaling of sustainable urban forms, i.e., the order of magnitude of a land area that shapes a process as well as emerges from a process [36].

According to Caniggia and Maffei [88] scale is the "*different level of complexity of the components internally arranged to construct a whole*", where one scale can be a mere "component among components" at another. Smith [89] describes scale as "*materially real frames of social action*" or "*the spatial resolution of contradictory social forces*". Both definitions are of particular relevance to the 15-Minute City where spatial scale is viewed as materially concrete, digitally instrumented, computationally augmented, and ubiquitously networked frames of socio-technical actions taking place over different temporal scales. This conception entails the integration of the physical and technological dimensions constituting the constructed whole as a result of the actions of people and the processes of urban infrastructure as embedded in spaces. While "*the technological artefacts as a key materiality are an indispensable co-producer of scale-related outcomes over different time scales . . . , the other materialities, which concern compact and ecological designs of the built form, are indispensable co-producers of both scale and scale-related outcomes*" [52].

The outcomes of the complexities generated by the spatial scaling of urban form is associated with the effects of sustainability as processes. This also pertains to the 15-Minute City as an urban model in that the spatial pattern of the various shapes and sizes of the

physical objects characterising its built-up areas at different spatial scales is considered key to producing the benefits of sustainability and enacting its effects. However, the stable relationships between sustainable activities and urban modes are not easily generalizable on the basis of structure–process or form–function [90]. The same endeavour to apply sustainable development to urban form might increase one aspect of sustainability (e.g., environmental) on one scale (e.g., the urban) while decreasing it on another (e.g., neighbourhood). Therefore, there is a need for more effective ways to address and implement the spatial scaling of sustainable urban form in an attempt to increase the positive outcomes of sustainability. This is of focus in the 15-Minute City model through its digitalisation dimension in terms of the role of urban computing and intelligence in planning and design.

In Bibri's (2021f) case study research, the author analyses and discusses, the emerging conceptions of and approaches to spatial scales that should be considered in the planning and design of the smart sustainable city—a concept which integrates the compact city, the eco-city, and the smart city. The author highlights the innovative potential of urban computing and intelligence for enhancing and transforming the spatial scaling of sustainable urban form through the processes of monitoring, understanding, and analysing the different aspects of spatial scaling for generating the kind of designs that improve sustainability.

5. The '15-Minute City' within the Narrative of Future Smart and Inclusive Cities

One of the key factors aiding in the success of the 15-Minute City model is that of the creation of close knitted communities. Indeed, the social dimension is an important aspect in urban planning and can be further explored via the application of technological frameworks and digital solutions within the discourse of both the smart city and the smart sustainable city. This is driven by the need to evolve urban intelligence and planning functions in response to the emerging trend of building models of these cities functioning in real time from routinely sensed data. Numerous studies highlight the role of emerging data-driven smart approaches to urban planning in improving the different aspects of sustainability in the context of both smart cities and sustainable cities (e.g., [91–94]).

However, it is important to recognize that advanced technologies are associated with shortcomings in matters related to society, ethics, and sustainability. Hence, their application in urban planning would need to be complemented with sound planning ideas to consolidate its usefulness in achieving sustainable outcomes as anticipated in the New Urban Agenda of the UN HABITAT [95] or in urban goals of the UN [96]. One sustainable aspect that cannot be overlooked, and which technology tends to ignore is that of cultural identity. In most cases, technology has been seen to be an enabler of overriding some cultural traditions, especially in the building and construction sector, where cultural products are replaced by modernists' architectural pursuits [68]. In such cases, cultural sustainability is being threatened and the identity that glues people together is watered down, thus prompting the disorientation and creation of new cultures that too often do not reverberate with urban social dimension [97]. For example, in the recent past, technology has enabled the creation of autonomous vehicles, which were celebrated in some quarters as the future of urban transport sector. In this context, built environments will need to be restructured to facilitate such vehicles. However, as this happens, some argue that humans, who are the target beneficiaries of these technologies, will have to forfeit some social life norms such as interactions, decision making, and communication, and instead become mechanized, self-centred, and may lose enthusiasm in other social aspects such as community participation, caring, and others. In addition, as noted by Yaldız, et al. [98], in cases where cultural products and heritage are altered and overshadowed by the application of technologically oriented products such as architectural and urban products, a substantial number of individuals are seen to have little regard to the sustainability concerns, leading to compromises in conservation and preservation efforts.

The social challenges of relying on technologically oriented planning approaches are expected to continue to increase as more advanced technologies emerge. However, it is

possible to counter those by ensuring that at the planning table, socially oriented participants are incorporated. One way of facilitating this is by ensuring that proximity-based dimensions in cities are given priority. The recent COVID-19 pandemic and the associated stringent measures that were introduced in different cities and countries internationally, are examples of the urgency to ensuring this dimension as part and parcel of urban planning especially in future cities. Cities known to have embraced digital solutions were not spared by the health protocols such as grounding of transportation services and lockdowns. However, in cities such as Paris, Bucharest, Lisbon, and others, which integrated some socially oriented infrastructures (e.g., bicycle lanes), residents were somehow able to circulate in a more effective fashion, as reported by Vandy [99].

Further, after the successful positive stories from cities of how bicycles have emerged as a potential alternative to transportation, especially in helping observe social distancing, cities are now seen to accelerate and facilitate cycling culture [20]. This is a positive start towards the actualization of the proximity-based dimension, which in turn can prompt the adoption of planning practices such as the 15-Minute City model. Indeed, sustainable transportation is about the service provision that reflects its environmental and social costs while balancing travel needs with environmental quality, accessibility, and liveability, thereby its key role in achieving sustainable urban forms. In the long run, this will lead to cities tapping on both social and environmental outcomes. With the technological aspects being part of the conceptualized planning model, these outcomes are expected to be achieved in an efficient and improved way. On this, Allam, Bibri, Jones, Chabaud, and Moreno [18] explore how the emerging technologies such as 6G can aid in unpacking the model of the 15-Minute City while leading to more socially cohesive urban fabrics, which can in turn lead to net-zero urban ambitions. The 6G here denotes an anticipated sixth-generation wireless cellular connectivity technology expected to succeed the current 5G technology. It is anticipated that it will increase the current frequencies, provide higher capacity, and reduce latency, thus providing a connectivity speed which is more than 1000 times faster than 5G technology. Thereby, it will help overcome some notable challenges such as data transfer, real-time connectivity, and communication between installed smart devices, among other challenges.

Physical networks, one of the key components of urban fabrics, entail "the physical characteristics of urban areas in terms of components, buildings, spatial patterns, scales, streetscapes, infrastructure, networks, and functions, as well as socio-cultural, ecological, economic, and organizational structures" [36]. More socially cohesive urban fabrics in the 15-Minute City can also be achieved by physical planning through promoting the different forms of mixed land use patterns, namely physical mix, social mix, economic mix, and temporal mix [100]. These are key to reducing socioeconomic segregation and/or balancing out existing economic and social differences. For example, the Comprehensive Plan for Stockholm City states that neighbourhoods will be linked and physical barriers isolating certain areas will be removed by developing new areas, improving public transportation, and providing more public spaces using physical planning tools [76].

However, the actual benefits encapsulated in the smart city concepts are numerous and can be calibrated to suit societal dimensions further through the inclusion of the proximity-based foundational criteria. Against this backdrop, the 15-Minute City is seen as an ideal model that could potentially assist in revamping the smart city concept to benefit urban dwellers in many spheres. Therefore, as urban leadership takes stock of contemporary challenges pertaining to socioeconomic dimensions, it should consider this new model as a potent urban alternative model. This is due to the fact that it proposes neighbourhoods that are self-sufficient, more sustainable, and more socially vibrant, while also allowing for economic prosperity that is in line with contemporary pursuits.

6. Unpacking the 15-Minute City within the Global South

When considering the financing option for infrastructural development, it is of crucial importance to recognize that most economies are financially stressed, following the extension of their debt ceilings, which may obscure debt repayment capacities [101]. Even as precautionary measures are taken into consideration (in varied geographies), it is worth noting that the post-pandemic recovery would be quicker and smoother if infrastructural development is at par or commensurate to the projected economic growth [102]. This calls for alternative financing models to be devised—especially those that would guarantee sustainable infrastructural development, as well as save economies from further debt traps. In this case, as noted above, some economies (including Australia, Japan, the UK, Canada, and United States) can comfortably turn toward embracing and actualizing Modern Monetary Theory (MMT) [103]. However, as MMT is not applicable to all, the majority of countries must find innovative and creative ways to spur their economies [104].

One possible avenue that could be exploited in the case of the 15-Minute City is the use of fiscal mechanisms to encourage the private sector to consider investing in public sector projects. Nonetheless, there have been heavy criticism in the past on this approach in the case of developing economies where sound arenas may not always be present, even if it may be observed as a potent avenue for financial security in the case of the use of private funded vehicles [105]. In particular, the public worries about issues related to value-for-money, corruption, and quality of the work that the private partners may produce, particularly when the required checks are not in place. Omobowale et al. [106] note that with these models in economies with sluggish and weak institutional frameworks, there are many cases of lack of accountability, transparency, disclosure, independency, and reporting that inhibit the success of the implemented projects. Mostly, such shortfalls in governance come about when leaders responsible for the public sector are still in firm control of the private sector [107]. This presents the challenge of conflict of interest, which hinders the success of most projects initiated by governments. With conflicts of interests, pertinent components of public–private sector partnerships (such as community participation) are overlooked or ignored, with most projects being imposed on communities. The civil society organisations and other stakeholders are thus not given due attention or participation opportunities [108].

Another potential approach that can be adopted in the exploitation of available financial mechanisms is the introduction and institutionalization of the fiscal incentives targeting funds that the private sector can align with public objectives. This can then be modelled so that each geography can enact its own 15-Minute city model in accordance with the capacities and constraints of both local governments and those of private partners. However, to ensure that there are no issues of conflict of interest, non-disclosure, lack of transparency, and/or other associated drawbacks, there must be a framework to help define what constitutes public objectives. This can be achieved by ensuring total participation of all stakeholders. In the case of the 15-Minute City model, the participation would be even more robust as it has defined boundaries.

Global Infrastructure [109] highlights that those incentives could be made more robust, such that their scope include both financial and non-financial components such as the legal and regulatory frameworks, macroeconomic stability, and health competition [110]. This way even small private players, which include both vulnerable and/or marginalized groups, may have the opportunity to compete with larger enterprises that are mostly seen to be favoured by governments in cases where the private sector is given the opportunity to participate in public sector projects. By making these incentives available, the government does not only benefit by having infrastructural development done in a quality and efficient manner, but also from the human capital growth that comes about in the form of job creation and up-skilling of local workers. Incentives also lead to investments in desired public programs, as per the urban users' desires (being the primary beneficiaries); thus, this financing model would be appropriate to financing the 15-Minute City model.

On the subject of the desires of urban users, the 15-Minute City may utilize a technological perspective, allowing them to use a driven smart approach to strategic planning for

infrastructural development including districts, streets, buildings, facilities, public spaces, public transport routes, and road infrastructures based on information collected on mobility, physical movement, intensive activity, and residents' expectations. In addition, the 15-Minute City can benefit from integrating the urban data regarding the various uses of urban areas to build scenarios in response to the need for urban revitalization and renewal. The focus should be on revitalizing the inner-city through initiatives aimed at reorganizing existing structures in neighbourhoods that are in decline in response to socio-economic issues. Furthermore, by building in favour of cycling and walking in response to the needs of urban users, car traffic can be reduced in the 15-Minute City centers.

7. Discussion

The need for paradigm shifts in the design language from modernists to previous traditional design language and style has been identified by the outbreak and subsequent global spread of the COVID-19 pandemic. It has been noted that urban planning has largely been dominated by modernist ideology and structures (e.g., numerous single use dimensions and districts), which show lower resilience than those comprised of complex and intricate traditional neighbourhoods [111]. With respect to the latter, people did not need to travel far to access most of the basic urban services, while in the former, with car dependency on the norm and lockdowns in effect, accessing basic commodities, infrastructures, and facilities became an issue. Proximity of the different urban facilities, as emphasized by the different urban thinkers, has proven to be an important element in urban planning. Further, even in this eon where digitalisation of the urban fabric has become custom, complex cities are seen to have higher responsiveness and complexity, especially in terms of liveability and advancing sustainability agendas.

Going forward, new proposals on proximity-based dimensions and supporting liveable urban fabrics, such as the 15-Minute City model, will be seen as the future of urban planning and this affirms the philosophies and principles advanced by the aforementioned authors, as well as many others. There is notable resistance to the change observed regarding the implementation of the concept, namely the idea that it can create segregation between neighbourhoods that can be transformed and those that cannot. On this, it will be important to recognize that urban transformations take time and need to be performed with inclusivity in mind to benefit the larger whole. As such, in this regard, urban policy must be shaped carefully.

The emphasis on dimensions such as proximity, diversity, ecology, and others [112] that have given a headway to this new model in responding to urban challenges show that the modernist approach has been erroneous and outright risky. Therefore, it is paramount that during this period, where there is an increasing consensus on the need to rethink urban planning, the emphasis is placed on incorporating all the different urban dimensions in future plans. This is true even though cities are constantly changing as more technological advancements are emerging and new phenomenon such as urbanisation and rapid population are increasing. The objective in planning should be to ensure that cities reclaim their roles in being centres for social interactions and not only in economic growth as previously solely emphasised. As expressed by Gehl [113] cities should be built for people and not for the 'machine' that modernists often refer to. They should be compact with a diverse but optimal density to ensure there is no motivation for sprawl. In this case, as Moreno, Allam, Chabaud, Gall, and Pratlong [20] underscore in the 15-Minute city model, every neighbourhood in a city should offer opportunities for residents to actualise basic social aspects such as interaction, caring, community participation, and self-actualisation.

In terms of sustainability, it is noted that reduced vehicular travel will lead to fewer emissions from the burning of fossil fuels and subsequently higher air quality. In addition, drawing on the latest IPCC report, it would be safe to argue that the 15-Minute City can aid in cementing new urban morphologies that are more responsive to human and climate needs. This can be further expanded by the implementation of smart city technologies under the umbrella term of the smart sustainable city, with the aim of not only increasing

the efficiency and performance of cities, but also of expanding on the liveability dimension, which is promoted by the 15-Minute City model.

The proximity pillar of the 15-Minute City is associated with the environmental, social, and economic benefits of sustainability, and, therefore, successful implementation of this feature will have a significant bearing on achieving and balancing the three dimensions of sustainability. This can further be realised by what smart urbanism has to offer, as well as reflects on in terms of the varieties and outcomes of smart city development and highlight as to the opportunities, potentials, and benefits of applied technology solutions. Central to smart city policies are emerging the digital infrastructures and related big data technologies, digital flows, big data analytics, and compute-intensive AI processes to monitor, understand, manage, regulate, and plan urban systems as well as resources, services, and risks.

8. Conclusions and Future Work

The implementation of the 15-Minute City is currently predominant in cities located on the Global North. This could be attributed to the fact that these cities have sufficient financial reserve and capacity to engage in major infrastructural reforms, even despite the impacts of the COVID-19 pandemic. To ensure that an equitable global urban landscape is observed, where all geographies can benefit from the concept, there will be a need to ponder on fiscal mechanisms that can aid in reinforced participation by the private sector, while leading to common objectives for increased urban liveability and sustainability. However, it is noted that appropriate frameworks are required in those geographies to ensure transparency and low-risk profiles. If this practice is pursued, we foresee the creation of contextual implementation of the 15-Minute City across geographies, based on localized needs and investment capacities and profiles, and when advanced technologies are applied to cities, they should be directed for enhancing sustainability, equity, the quality of life, and resilience [114].

While it is arguable that proximity dimensions are a critical component to consider in rethinking urban planning models that would not only guarantee environmental sustainability but also human scale aspects, it is critical to highlight that it cannot be a standalone solution. As such, this paper cedes that there is need for future research work that would explore how this dimension could be integrated in tandem with other emerging planning concepts to achieve a 'whole' human oriented urban area. In particular, future research should note how proximity-based planning can be rendered more efficient within the smart city concept as well as other emerging approaches to urban planning and design such as Smart Sustainable City [115] and the Metaverse as a virtual form of data-driven smart cities [116] in the context of future cities. With respect to the latter, with emerging innovative technologies, such as Artificial Intelligence, Big Data, the IoT, and Digital Twins providing advanced computational understandings of human behaviour, the Metaverse has the potential to redefine city designing activities and service provision by increasing urban efficiencies, accountabilities, and quality performance. However, the concept of proximity is most likely to be redefined. In this regard, future research needs to focus on the extent to which emerging urban planning and design approaches will, in shaping digitally powered urban or virtual environments, lead to limitations in how the social milieu and urban life will be framed within them and render invisible specific cultures, practices of inhabitation, places, and social groups. In particular, both virtual and smart approaches to urbanism tend to distort the reality of the city and the particularities of localities with respect to the history, feelings, specificities, concerns, heritage, knowledge, and trajectories of urban communities. Moreover, with the realization that the current challenges of the COVID-19 pandemic and the ensuing geopolitical conflict between Russia and Ukraine are expected to continue having first-hand influence on liveability futures, incorporating other more complex dimensions will be critical, as concerns in urban areas are seen to be shifting from sustainability-oriented to a larger prospect being more human-oriented [117]. The aspect of decarbonization while attracting finance, and lead to ecological resilience

should also be pursued, as there are studies showcasing the economic potential of such approaches [118–120]. To this end, therefore, it will also be important for future studies to explore the ethical concerns of rapid urbanization and the perceived changes brought about by proximity-based planning principles.

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