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Review

Compact Development Policy and Urban Resilience: A Critical Review

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Abstract: Sustainable development and urban resilience are dominant urban planning paradigms that have become buzzwords in urban planning and policy domains over the past 2–3 decades. While these two paradigms have been analyzed and scrutinized in different studies, the interconnection between them in policy realms is understudied. Compact development policy is expected to contribute to a variety of sustainability goals. However, these goals' alignment with the principles and goals of urban resilience is under question. This research tries to shed some light on this issue. A critical review method is employed to understand how compactness as a sustainable urban development policy relates to different principles and dimensions of urban resilience. First, the conceptual and theoretical relationship between urban resilience and compact city is established. Next, the resulting framework is used to critically analyze 124 articles to understand how the compact city policy relates to urban resilience from different dimensions and principles. Densification and intensification, mixed land use and diversity, and spatial connectivity and public transportation are identified as principles of the compact city. Finally, the interconnection between compact city policy and urban resilience dimensions and principles is explored and assessed through examining the selected literature. The results of the review show some alignments between compact city policy outcomes and urban resilience. However, the level of alignment may vary depending on the context, scale, or dimension. In other words, while compact city in one scale/dimension can increase urban resilience to a specific adverse event or stressor, it might increase vulnerability to others in another scale/dimension. From the policy perspective, compact development policy and urban resilience principles should clearly be defined a priori to reach favorable outcomes.

Keywords: sustainable development; urban resilience; compact city; urban planning; urban density; climate change

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1. Introduction

The 21st century is the era of unprecedented urbanization, uncertainty, and vulnerabilities [1]. Most people now live in cities, and the high concentration of population and assets could make cities more vulnerable than non-urban areas [2]. While planners and policy-makers have promoted sustainable cities for over three decades, limited success has been achieved due to factors such as ineffective management approaches, uncertainties, and rapid changes [3]. Before the COVID-19 pandemic, the main criticism of development policies was focused on mitigating the adversity of urbanization and its adverse effects on nature [4]. However, the COVID-19 pandemic brought divergent voices, ranging from the unsustainability of development policies to the integration of perspectives for transformations from a resilience lens to the fore [5]. Compact development has long been touted as a planning and policy instrument that leads to sustainable urbanism [6]. As planning also has the responsibility to find solutions to disrupting events [7], and given the

increasing attention to enhancing resilience, clarifying the connection between the compact city as a sustainable development policy and urban resilience can provide insights for more integrated and robust urbanization in the future [8].

The connections between resilience and sustainability have received increasing attention in recent years, and it is argued that these concepts/buzzwords have been misused [9]. The burgeoning literature on sustainability and resilience shows how these approaches in planning and other disciplines have gained currency in terms of theoretical and practical usage. Resilience is a contested approach or framework applied in different areas such as disaster resilience, engineering resilience, ecological resilience, socio-ecological resilience, evolutionary resilience, and climate change resilience [8]. Similarly, the conceptualization of compact urban development varies depending on geographical, institutional, social, economic and political contexts and there is a lack of consensus on definitions, principles, processes, and outcomes [10].

Resilience is the response to challenges, disturbances [8,11], and disruptions of internal and external (sub)systems [12]. As mentioned, sustainability is a normative perspective on the problems of urbanization. Several studies investigate the interconnection between sustainability and resilience theory [8,11,13–16]. These concepts have been sought in planning systems through institutional and governance capacities without clearly distinguishing them [16]. Many studies have analyzed the relationship between urban resilience and sustainability in urban planning [17,18]. These studies examine the sustainability–resilience relationship from different perspectives, including land management [19], urban sprawl [20], urban design principles [21], urban form [22–25], and morphology [26]. However, to the best of our knowledge, the relationship between the compact city as a sustainable development policy and urban resilience as a new paradigm has not been investigated through an integrated framework. After the emergence of COVID-19, the well-being of residents came to the fore of the urban planning discourse that questioned the sustainability of conventional development policies [27]. Specifically, there have been major debates on the adaptation capacity of urban areas to COVID-19 disaster [28]. Compact development as a sustainable development policy has not been investigated in relation to urban resilience. As a step towards filling this gap, this research tries to shed some light on the interlinkages between compact development and urban resilience. Clarifying such interlinkages is needed to understand how compact urban development could contribute to urban resilience. In general, compact cities have some specific principles such as densification, mixed land use, public transportation, and better connectivity that contribute to different outcomes like higher efficiency of infrastructures, better accessibility to services, lower emission of carbon, lower travel distance, etc. Our hypothesis is that these outcomes might be favorable from an urban resilience perspective. However, in some cases these outcomes might increase the vulnerability of cities to specific natural and human-induced threats.

2. Materials and Methods

2.1. Analytical Framework

Nowadays, policy-makers are more interested in research that provides a clear and practical summary of complex studies in the literature [29]. Compact urban development, sustainable urban development, and urban resilience are complex research areas and empirical research is needed to unpack such complexities. Therefore, in this research, we will analyze different principles of compact development that have been empirically analyzed in previous studies.

Compact urban development contains several features and various expected outcomes. As the outcomes of this policy are highly context-dependent, we will focus on the main characteristics of compact development policy. Despite similarities, the dimensions and features of compact development in the literature are not homogenous. For example, Burton [30] and Lin and Yang [31] described compact development by characteristics such as high density, intensification, and mixed land use. Jabareen's research [32] explains this policy by characteristics such as compactness, density, mixed land use, diversity, and sustainable

transport. Other studies in the last two decades have also mentioned other characteristics and features such as transport network connectivity, transit infrastructure availability, pedestrian access, accessibility to living and working spaces, density of economic activities, and so on [6,10,28,33–42]. These characteristics could be categorized into three main areas: densification and intensification; mixed land use and diversity; and spatial connectivity, accessibility, and public transportation (See Figure 1). It is worth mentioning that there are also other types of compact development policies such as 15-min neighborhoods. However, the main focus of this study is on the most common definition of compact city that is developed in the literature as explained earlier.

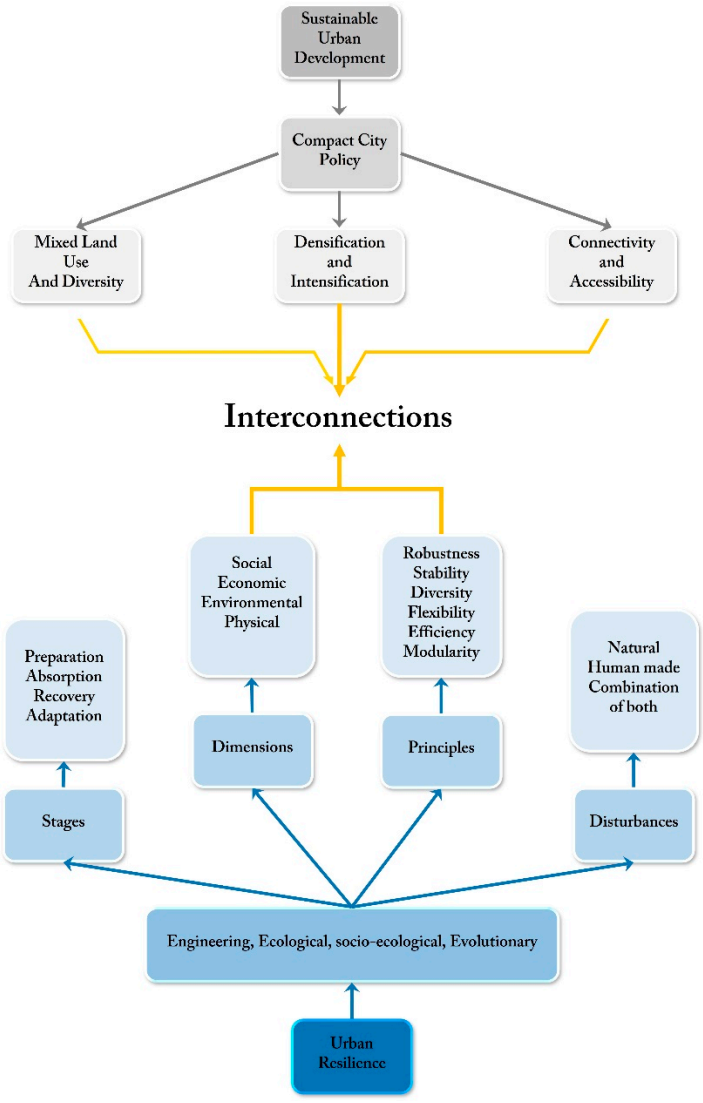

Figure 1. Theoretical framework of research.

Meanwhile, resilience is a buzzword and new guiding principle in various research and policy domains characterized differently in different fields and contexts. In general, disruptions are caused by nature, such as flooding and earthquake, or by humans, such as wars and terrorist attacks, or a combination of them, such as the COVID-19 pandemic. Cities react to these disruptions in different stages: preparing for them, dealing with them in the absorption stage, recovering from them and reaching a new normal, and finally adapting and living with them [43]. Several measures are proposed to reach a resilient city, such as increasing flexibility, stability, robustness, modularity, diversity, and efficiency [22,23,25]. Resilience could also be framed based on four main dimensions, including social, economic, environmental, and physical (Figure 1). To explain the interconnection between compact

city development policy and urban resilience, two main questions and some sub-questions are designed. First, how are urban resilience and sustainability developed and interlinked in the literature? Second, to what extent are different aspects of urban resilience included in the compact city principles?

2.2. Literature Selection and the Content Analysis Procedures

To understand the relationship between compact city policy principles and different principles and dimensions of urban resilience, we have relied on the peer-reviewed literature. A broad literature search was conducted on 1 April 2021, on the "Web of Science" and "Scopus". The search string was a combination of words related to density (dense, densification, intensification, etc.), diversity (mixed land use, diverse, diversification, etc.), connectivity, urban (city, town, metropolis, etc.), and resilience (resilient). This search returned 2341 articles. We excluded the papers that did not include at least one of the compact city principles (density or intensity, diversity or mixed land use, and connectivity or public transport) in titles or abstracts. Overall, 178 papers were relevant to compact city policy principles. The full text of these papers was screened, and those irrelevant to urban resilience principles and dimensions were excluded. After this, 93 papers remained in our collection. While reading the selected papers, we also added 31 additional papers from the list of references relevant to the study's scope. Finally, 124 papers were carefully read to extract the needed information on the linkage between compact city policy and different principles and dimensions of urban resilience.

Different methods exist to review the literature and understand what has been done in a specific area [44]. The appropriate method should be chosen based on the study's objectives [45]. We applied content analysis to answer research questions. This method is not exhaustive and just focuses on the published works that have partially or thoroughly covered the subjects of our research questions. Content analysis is a method of analyzing qualitative data that could be applied either in inductive or deductive approaches qualitatively and/or quantitatively [46]. While the inductive approach is for when there is no previous hypothesis and the researcher tries to conceptualize the subject based on the data, the deductive approach is research that tests a specific theory or hypothesis using a data-structured review protocol. We have applied a deductive content analysis to test our hypothesis based on our primary research and review questions. We first scrutinized the literature to grasp how the compact city emerged in sustainable development policies and how it is understood in relation to urban resilience literature. Next, a framework for hypothetical relationship is constructed based on this preliminary review. Then, this framework of hypothetical relationships is tested based on the empirical studies conducted in the literature.

3. Resilience and Compact Development Policy

3.1. Urban Resilience as a New Paradigm

Resilience is a buzzword that has emerged along with sustainability in planning discourse [1]. Interestingly, these two concepts are interchangeably used by researchers and policy-makers [16,47]. However, the nature of resilience and its emergence in planning has a different story and is conceptualized differently in various disciplines [48]. Many definitions have been provided for the term resilience. From an urban planning perspective, *resilience is a response to climate change uncertainties and socio-economic insecurities* [49] (p. 307). Resilience could be the magnitude of disturbance that could be absorbed by the system or the speed of recovery from disturbance [50]. While the former is referred to as ecological resilience in the literature, the latter is known as engineering resilience [51]. Engineering resilience focuses on the capacity of the system to get back to its initial equilibrium conditions, and ecological resilience refers to the maintenance of necessary functions or the level of disturbance the system can absorb to reach a new equilibrium [52]. This distinction is based on systems' persistence, transformability, and adaptability to cope with disturbances [43]. However, in the literature, both approaches are considered equilibrium resilience [53]. Two

other approaches that emerged in the new millennium, socio-ecological and evolutionary resilience, are non-equilibrium resilience [54]. While both equilibrium and non-equilibrium conceptualization of resilience are related to urban planning, the latter aligns more with urban planning contents and processes [1,49,55].

Some have considered resilience as bouncing back to the previous state, while in planning bouncing forward is a more plausible position [1,8,56]. Adaptation and transformation are two distinct approaches to urban resilience. Adaptation thinking suggests modest and incremental changes in the face of shocks. In contrast, the transformation approach is more radical and proposes a reconfiguration of the system to new dynamics and objectives in the long term [11]. The transformation approach to resilience is closer to the dynamic nature of cities as the continuity of urban functions depends on reorganization and innovation of the system [14]. Accordingly, to have a long term perspective, resilience "of what, to what, for whom, where and why" are key questions to justify the goals and processes of the urban resilience approach [57]. This clarification enables policy-makers to build the future more efficiently [8]. Urban resilience covers a variety of areas, including hard and soft assets. However, Ostadtaghizadeh, Ardalan [58] identified five main aspects that include social, economic, institutional, physical, and natural resilience, as the dominant areas. These dimensions could be empirically measured through characteristics of resilient cities; *redundancy, diversity, efficiency, robustness, interdependencies, adaptability, resources, independence, ingenuity, connectivity, redundancy, inclusion, and integration* [23,43]. Resilience has been used differently in urban studies literature as a goal, analytical tool, metaphor, and system characteristic [55]. In this research, urban resilience is considered as a characteristic of a city to understand how compact city principles could contribute to urban resilience.

3.2. Sustainability and Resilience

Sustainable development was institutionalized in *our common future* report (1987) and the *Earth Summit* (1992) in Rio de Janeiro. In the 1987 report, sustainable development was defined as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [59]. Afterwards, many global and local initiatives were taken to formulate the processes and actions that could be done to reach urban sustainable development. For example, European countries initiated several collaborations from the Aalborg Charter (1994) to Basque Declaration (2016) to develop policies for sustainable cities. The initial definition of sustainability featured three main pillars including environmental, social, and economic dimensions [14]. Institutional and cultural dimensions were later raised by scholars to become two other pillars of sustainability [60–63]. These dimensions were explored in different regions around the world to contextualize the concept of sustainability. For example, in the European context, culture plays a critical role to reach sustainable development [64]. In this context, culture is not only an instrument to economic development, rather the reciprocal interlinkages between sustainability and culture are developed to have a sustainable culture and cultural sustainability [65].

However, due to changes in the nature of urbanization and higher uncertainties and unpredictability of our world, the redefinition of conventional sustainable development became a necessity [66]. In the new era, sustainable development is (a) "*development that meets the needs of the present while safeguarding Earth's life-support system, on which the welfare of current and future generations depends*" [67]. Accordingly, urban sustainability is " . . . . *making up cities . . . . without compromising the possibilities of development of surrounding areas . . . . . reducing the harmful effects to the environment*" [68]. In other words, the new definitions of sustainable development goals have changed to be closer to the concept of urban resilience [14]. Resilience could be known as a new perspective to supplement sustainability. It has been argued that, in conventional perspective, a number of goals are achievable to sustainability and stability of urban functions. But the sustainability of the system in the era of uncertainty is a kind of paradox. Urban resilience is a new perspective that can deal with this paradox [3].

In many parts of the world, governments face various environmental, social, and economic challenges due to rapid urban growth and climate change [6]. The interconnection between urban sustainability and urban resilience became an issue for planners and policy-makers to deal with the new situation [69]. In other words, *resilience demands a new way of thinking about sustainability* [3]. To have a sustainable development, cities should be resilient [70]. Some have used sustainability and resilience interchangeably. Furthermore, as sustainability and resilience are buzzwords that have been overused by scientists, policy-makers, and professionals, over time, the difference between them becomes less noticeable. The changing perspective of nature from an asset to a potential threat, through the process of securitization, has contributed to a paradigm shift from sustainability to resilience in urban planning [4]. However, it has been argued that the sustainability of a system in the changing world is highly dependent on the resilience of its functions [12].

The relationship between resilience and sustainability has been investigated in the literature. Sustainability could be a component of resilience, resilience could be an element of sustainability, or these two concepts could be distinct [17]. Some argue that while sustainability is a normative feature of the urban system that envisions future development, resilience is not normative but is an attribute of the system that could be implemented at different levels [14]. Sustainability could also be used as a framework to explore the relationship between humans and the environment at different scales to deal with global change policies and make evidence-based decisions for better futures. On the other hand, resilience provides some guiding principles for dealing with uncertainties and disturbances, adapting to constant changes, and transitioning to more desirable development pathways [13]. Urban resilience is highly associated with Sustainable Development Goal 11, which focuses on urban systems [14]. Based on what is discussed in this section, some key differences between sustainability and resilience are represented in Table 1. Sustainability and resilience in policy making do not necessarily align with each other. For example, efficiency of resources and infrastructures is a policy to reach sustainable development. However, this efficiency may reduce the power of cities to deal with disturbances when redundancy is not considered [14]. In this research, the connection between sustainability and resilience is made through compact city policy. In other words, we examined how the compact city policy aligns with different dimensions of urban resilience.

Table 1. Some key differences between sustainability and resilience.

	Sustainability	**Resilience**
Differences	Long term processes aiming at avoiding global threats	Ongoing processes aiming at solving the problems caused by global threats that have already occurred
	Preserving resources	Adapting to a new normal
	Outcome-based	Process-based
	Institutional and policy-based	Responsive and action-based
	The dominance of the normative approach	The dominance of the analytical approach

Resources: [11,12,14,16,17,68].

3.3. Compact City as a Sustainable Development Policy

Compact city or compact development policy is not a new concept and strategy in planning theory and practice. During the 1990s, this policy gained traction in planning discourse as a solution to enhance the sustainability of urbanization processes and mitigate its negative environmental externalities [39,71–75]. The compact city is one of the most accepted policies that emerged in urban planning to reach urban sustainability [76]. The compact city, as a containment policy, was a response to the increasing urban sprawl in contexts such as North America and Australia [77]. The sustainability of compact cities is discussed and revealed in different studies [78]. Increasing the efficiency of existing resources and infrastructures is one of the core sustainable development strategies [14].

On the other hand, one of the main logics behind the compact city is utilizing current infrastructure by increasing the density and connectivity of spaces [79].

While compact city policy might have various aspects, the three main pillars of this policy are high-density development, mixed land use, and connectivity (mainly focused on public transport) [30,31,80]. From research and practice, there are many pieces of evidence that "*compact city policy can help achieve urban sustainability in many mutually reinforcing way*" [80]. Some critical contributions of compact development to sustainability are efficient resources consumption [81], higher efficiency of infrastructures [82], conservation of the natural environment [83], increased livability [84,85], and higher accessibility to public transport [85]. However, it is discussed that compact development could have some negative impacts, including higher energy consumption [42], lower housing affordability [86], lower community well-being [87], increased stress [38], and reduced satisfaction and mental health [36,88]. While compact urban form seems economically and environmentally efficient, consumers may not consider these issues and prefer to live in lower-density neighborhoods [75,79]. Additionally, this policy may cause some negative effects including higher traffic congestion, reduced housing affordability, lower urban design and green spaces quality, increased air pollution, higher rates of crime, and social exclusion [6,80]. Therefore, there is still a tendency towards a car-dependent lifestyle in the countryside of the cities where people can have access to big yards and detached houses [79]. In other words, the preference of developers, managers, and final users are hardly in the same direction as those of urban scholars and policy-makers that favor compact urban development [41,89], and a multiplicity of values should be taken into consideration in development plan preparations and planning processes [37,40,72]. The car-dependent development has contributed to urban decline in metropolitan regions [90]. Moreover, COVID-19 showed the inefficiency of this policy regarding meeting the needs of citizens [28,91]. Despite the emergence of contradictive arguments regarding compact city, it is still a dominant sustainable development policy. However, more elaboration on the compact development policy is needed to maximize its utilities and overcome potential drawbacks.

The compact city is indeed not all good. It may also involve trade-offs. However, the advantages outweigh the trade-offs, making it a viable policy to achieve sustainability and better welfare for residents [76,92]. Bibri, Krogstie [6] found from a literature review and a case study analysis that the compact city policy in general contributed to more economic, social, and environmental sustainability. Similarly, Ahfeldt and Pietrostefani [38] by reviewing 321 empirical analyses found that the compact city contributes to some outcomes that are favorable from a sustainability perspective. Additionally, Bibri [93] emphasizes that despite the contribution of compact city to the sustainability of urban development, the economic benefits outweigh the social and environmental sustainability. However, this policy has different definitions and dimensions in different contexts. To reach sustainability, Bibri [94] discussed that all aspects of the compact city should be considered and deliberately implemented. For example, one of the key principles of compact cities is densification of development to leave more areas for green spaces [95]. But, over(super)-densification is an unsustainable state that harms the environment and society and puts the city in risk [2]. Moreover, Boussauw, Neutens [96] found that if densification of neighborhoods is supplemented by better accessibility, the travel time reduces. They concluded that from a transportation perspective, the sustainability of the compact city is viable. In the same way, Dempsey, Brown [97] discussed that densification can bring many social, economic, and environmental benefits, if it socially, spatially, and institutionally considers the planning and design qualities.

4. Resilience and Compact Development Principles

4.1. Densification and Intensification

Density is the most prominent characteristic of compact development. Density might refer to morphological or functional characteristics of urban growth [98–100] and can be explained by built-up area, population, and employment measures [101,102]. However,

in compact development literature, it has been equally used to compact development itself, not as a characteristic of this policy [72]. Despite this, density as a component of compact development policy should be investigated with other components such as connectivity and mixed land use. Density plays a critical role in the resilience of cities, both positively and negatively. While high-density urban areas economically, socially, and environmentally benefit the environment and residents, the vulnerability could also increase as the congestion of population and assets increases [2]. Densification of jobs, population, infrastructures, and buildings might affect different aspects of urban resilience. Few papers have analyzed the linkages between density and urban resilience. However, we have scrutinized the outcomes of densification in case study papers to understand how these outcomes align with urban resilience dimensions.

Socially, densification of development as one of the compact city's main features could negatively affect housing prices and affordability. Chhetri, Han [86] found a negative effect of densification on housing affordability in the case of Australia. Additionally, the results of Antoniucci and Marella's [102] analysis of 114 Italian cities suggest that the housing price in less dense cities is more resilient than in denser cities during a recession period. This means that densification might contribute to less resilient cities, as it increases the vulnerability of low-income social groups [102]. Despite these potential negative impacts, increasing urban density, specifically in central parts of metropolitan areas, is one of the leading solutions to boost livability. In the US context, smart growth is associated with a higher density of population, employment, and buildings to enhance social cohesion and social contacts. Density increases social capital as an attribute of social resilience due to greater opportunity for social contact in urban spaces [24].

Environmentally, densification has led to contradictive outcomes in terms of carbon emission, risk reduction, urban microclimate, etc. The results of a literature review on the relationship between compactness of development and carbon footprints by Angel, Franco [103] showed that there is no significant relationship between these two, and the footprint is mainly affected by topography. Ewing, Hamidi [104] also found that density alone is not important in reducing vehicle miles traveled in American cities. Other factors such as mixed land use, urban design, and connectivity may play even more critical roles. It has been argued that higher population density reduces travel distance and encourages transit development, but it might contribute to traffic congestion. On the other hand, employment density could increase travel time and congestion [105]. Density directly affects the urban microclimate, specifically increasing urban heat island and wind speed [106]. This effect might come from different aspects of urban living besides the density, but the most influential variable is the intensification and densification of buildings and infrastructure [107]. Lemonsu, Viguié [108] empirically analyzed the effect of compactness on urban heat islands and concluded that densification negatively affects community vulnerability and increases heat wave risk. But, an empirical analysis of the impacts of high-density buildings on outdoor microclimate in the case of Toronto revealed that this compactness policy reduces temperature during the day, thereby increasing climate comfort for residents [109]. Romirez-Aguilar and Lucas Souza (2019) [110] showed that higher density could increase the temperature as the sky view factor (SVF) reduces in compact areas, diminishing air circulation in cities. In summary, higher density in urban areas directly and indirectly affects urban microclimate. While some empirical studies have shown the negative effects of densification on heat islands and wind speed, they have discussed that climatic well-being (making more pleasant places for residents) is reachable through urban form optimization.

From the risk reduction perspective, high-density development on the regional scale increases urban resilience in the face of natural hazards [111]. More intensified and compact urban development is highly associated with lower damage in flooding disasters [112]. In other words, higher density provides the opportunity to control urbanization and avoid the expansion of population settlements in naturally vulnerable lands [112]. However, the centralization of infrastructures, exposure of the population in vulnerable places, and

limited open spaces are the main indirect adverse outcomes of compactness that could reduce urban resilience if densification occurs in risk-prone areas [48].

Pandemics and contagious diseases are among the common threats to urban lives. The vulnerability of cities to these diseases has recently been recognized in urban planning discourses that explain how urban resilience could enhance community well-being and urban functionality [27,113]. The literature provides a conflicting picture of the impact of urban density on the transmission and spread of contagious diseases and pandemics. No association was found between population density and the transmission of 1918–1918's influenza [114]. The same results were found for the case of COVID-19 in American counties [35]. It should be noted that this study is about total population density on a county scale, and the results of these studies do not fit with the concept of compact development on the urban scale.

However, some studies show that the densification of development is positively associated with the spread of viruses such as N1H1 and COVID-19. For example, an empirical evaluation of the N1H1 pandemic showed a significant relationship between population density and transmissibility [115,116]. A similar relationship is reported for the spread of COVID-19. They found that areas with higher population density have a higher rate of COVID-19 cases. However, the results of a study conducted in Wuhan, China, showed that as the medical services in the city were clustered in certain areas, people living in suburban areas with lower density had the problem of lower accessibility to services. In other words, residents of high-density areas have easier and more convenient access to medical services than low-density residents [117].

COVID-19 resulted in the questioning and criticizing of different aspects of urban development policies, specifically premature judgements on urban issues such as densification during the early months of the pandemic [118]. Density is among the most common factors that have been analyzed in relation to the COVID-19 pandemic. While in public domain there are some arguments that density increases the risk of infection in urban areas, several papers have shown that high-density neighborhoods do not necessarily have higher rates of COVID-19 cases [119,120]. Specifically, a literature review conducted by Alidadi and Sharifi [121] revealed that the effect of density on COVID-19 spread is contrasting in different contexts and scales. Many papers have shown that higher population and job density in urban areas increases the likelihood of COVID-19 transmission in cities like New York, Hong Kong, Wuhan, and Tehran [122–125]. However, in the long term, cities and neighborhoods with higher population density have lower rates of mortality [126]. The contribution of density in this situation is twofold. First, research has shown that larger cities with higher density follow the restrictions better than low-density areas. Second, residents of high-density cities have better accessibility to health services and infrastructures that could improve the support of infected people. In general, there is no doubt that higher population and job density contribute to higher rate of infection in urban areas [121]. But this statement is not supported by sufficient pieces of evidence in the long term. More importantly, other urban factors, such as congestion of people in public transports and higher mobility of population, are more critical factors than density per se. Therefore, premature interventions and judgements should be avoided as the public media may overreact to these topics during a crisis.

4.2. Mixed Land Use and Diversity

Mixed land use is a critical component and instrument of contemporary urban planning [127]. Mixed land use was a response to the mono-functionality of urban spaces after World War II to bring back urban life and diversity of functions. Over the past decade, mixed land use has been advocated as a functional tool for promoting sustainable urbanization [128]. This planning tool and policy is based on having a heterogeneity of functions and places in the neighborhood, including institutional, residential, commercial, industrial, recreational, etc., and has two main benefits. Firstly, mixed land use contributes to the concentration of activities in smaller spaces and reduces travel time and distance. Secondly,

mixing uses provides an opportunity for more diversity and vitality [129]. Mixed land use can be different through space and time. Mixed land use refers to shared premises; vertical, horizontal, and temporal combination of various land uses that are functionally and morphologically interlinked. As shown in Figure 2, a building can be split into two parts, one of them for residential and another for working purposes. The second category is similar to the central areas of cities where residential buildings are located near commercial and recreational buildings. The third group is called vertical as some floors of a building are allocated to working and the rest to residential or other land uses. The last one is characterized by time dimension that refers to the buildings that, for example, have one function during working days, but on the weekends residents use them for another purpose [130].

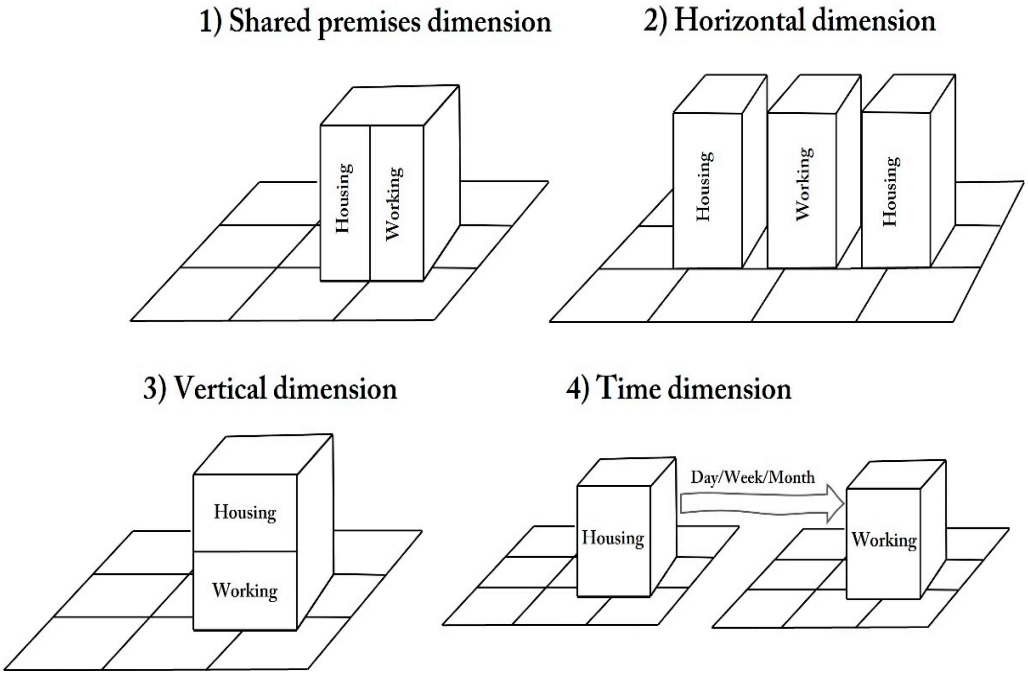

Figure 2. Different dimensions of mixed land use [130].

As a component of compact urban development, mixed land use has several environmental (reducing car dependency and air pollution), social (increasing walkability and cyclability, enhancing social capital, and improving social relations), and economic (reducing travel costs, increasing property value, and infrastructure efficiency) benefits. Croucher, Wallace, and Duffy (2012) [131] showed that the level of mixed land use is associated with residents' physical and mental health as it provides the opportunity for physical activities through active transportation options. Specifically, vulnerable populations (75 or above) who live in mixed land use neighborhoods have healthier lifestyles due to being more active and independent and having easier access to their basic needs. Mixed land use directly affects these demographic groups as the mortality rate is 20% less than in other neighborhoods [132]. Mixed land use is closely linked to the diversity and redundancy principles in urban resilience literature [21,133]. Social capital, one of the main characteristics of social resilience, is affected by the built environment; mixed land use contributes to more social interactions and gatherings [20,134]. Therefore, it can increase both cognitive and structural social capital [135].

However, some negative issues are associated with mixed land use, including overcrowding, a higher crime rate, and lower privacy and parking space areas [135]. It has been argued that industrial activities may threaten residential areas by increasing exposure to toxic and dangerous substances that subsequently increase vulnerability to human-made disasters. However, changes in businesses' and industries' nature that have made them cleaner and safer has made this discussion less relevant [127]. Indeed, mixed land use

provides the opportunity for place-making, increases efficiency and movement of people in the spaces, and better access to facilities and amenities that will contribute to a more livable and resilient city [136].

Moreover, a vast body of empirical research has demonstrated the association between mixed land use and crime rate. An empirical analysis in the case of Los Angeles showed that mixed land use might negatively affect social crime control mechanisms [137]. This issue might negatively affect crime and violence in mixed land use neighborhoods. Additionally, the increased presence of outsiders in the neighborhoods, facilitated by mixed land use, along with criminogenic facilities, the anonymity of visitors, and lower local guardianship, potentially affect crime and violence [138]. However, as the crime rate varies in neighborhoods with the same level of mixed land use but different socio-demographic characteristics, other factors may be more influential in predicting crime occurrence that need to be better studied [137]. Some land uses such as bars, stores, transportation, and gas stations might generate the opportunity for crime and violence, while residential mobility, ethnic diversity, and local guardianship act as crime and violence prevention measures [138].

4.3. Spatial Connectivity and Public Transportation Accessibility

Connectivity is about the level of mobility and movement of people and vehicles through the city. There are other types of connectivity, such as digital connectivity and energy and sanitation connectivity, that may contribute to greater sustainability of urbanization. These infrastructures, specifically digital connectivity, facilitate the transmission of information and money, and provision of services that reduce the mobility of population. These contributions could enhance the sustainability of urban development. However, based on the main goal of the current research, we focused on the implications of spatial connectivity that is one of the principles of the compact city. A compact city development policy recommends a well-connected and networked system of mobility in a city to facilitate movement, reduce distances and time, increase efficiency, and protect the environment through a multi-modal transportation system. Well-connected networks affect different aspects of urban resilience by reducing GHG emissions and car dependency, enhancing community well-being, increasing the walkability and livability of urban spaces, and, more importantly, improving the accessibility to services and facilities in case of disturbances [25]. Additionally, the connectivity and clustering of development mitigate natural disasters such as flooding on both regional and urban scales [111].

Compact urban development facilitates accessibility to urban amenities and services through higher connectivity than sprawled urban form [18]. The connection and easy mobility of people and vehicles through the urban structure are one of the main features of urban resilience [21] that is also critical in compact development policy implementation. GHG emissions are major drivers of climate change, one of the main threats to urban life in the 21st century. Mitigating GHG emissions is one of the main goals of urban resilience that could be controlled by urban form, specifically compact development. While there is no consensus about the effect of compactness on travel demand, vehicle miles travel, and traffic congestion, there is evidence that doubling urban density contributes to an approximately 50% reduction in households' travel-related CO_2 emissions [139]. Furthermore, they suggested that doubling government support in public transportation reduces CO_2 by about 46%. Empirical research by Barrington-Leigh and Millard-Ball [140] showed that while increasing connectivity has only small effects on reducing GHG emissions, more mitigation benefits could be achieved by combining it with other measures such as land use mix and density. Their projection for American cities showed that vehicle travel and emissions would fall by more than 3% if street connectivity increased. Similarly, a meta-analysis by Stevens [141] revealed that connectivity significantly influences driving patterns, but this impact is not very high. Such measures reduce car dependency and increase public transportation efficiency and modal shift [104]. In a similar paper, Jia et al. (2019) revealed

that street connectivity improves physical health by, among other things, changing the walking and cycling behavior of children and adolescents.

The relationship between spatial connectivity and urban resilience is thoroughly investigated by Sharifi [25] in a literature review. He discusses that connectivity has different meanings in urban planning and urban resilience. However, higher connectivity through increasing intersections leads to over-allocation of space to streets. As a result, it may leave fewer spaces for integration of lower remained land for green and open spaces in metropolitan regions. Accordingly, smart design measures should be followed to maximize the benefits of increased connectivity while avoiding potential trade-offs. Furthermore, it has been argued that deploying new technologies such as the Internet of Things (IoT) can increase the efficiency of infrastructures in compact cities to have more resilient cities [142]. Additionally, as Balogun, Marks [113] discussed, the digitalization of processes and services reduces the need for mobility and lowers CO_2 emission while it enhances the capabilities of cities to adapt to new shocks. Remote working, online meetings, online education, e-health services, online shopping, and online participation in political processes are among the benefits of connectivity through technology deployment [66,143].

5. Discussion

As discussed in the paper, the paradigm shift from sustainability to urban resilience has been dominant in urban studies and related disciplines in recent decades. Sustainability has mainly been considered as a long-term goal that focuses on the outcomes of urban development, while urban resilience is primarily about the processes. Compact development is a sustainability policy that is expected to lead to specific goals in the long term. This paper aimed to find an interlink between compact development policy and urban resilience dimensions. We found from the literature that previous research has analyzed various outcomes of compact development without focusing on urban resilience principles and goals. Therefore, aligning these two areas could shed some light on the potential contributions of compact development policy to urban resilience. Our content analysis results show that compact development policy components and principles lead to heterogeneous outcomes. These outcomes might positively or negatively impact urban resilience [20]. Resilience is not just empowering a particular part of a system to a specific disturbance. Instead, the whole system should be resilient to all potential disturbances [144].

Densification and intensification, mixed land use and diversity, spatial connectivity, and public transportation accessibility are the main components (principles) of compact development policy. These components (principles) have been studied in relation to social (social capital, social interactions, social diversity, housing affordability), public health (physical and mental health, infectious diseases such as N1H1 and COVID-19), environmental (urban heat islands, urban microclimate, GHG emission, wind speed), and physical (travel demand, transportation infrastructure, natural hazards) resilience while some have also investigated the effect that these areas might have on risk reduction (open spaces) and lower vulnerability (resilience principles such as diversity, redundancy, centralization, connectivity).

From a social perspective, compact development policy may increase social capital, social interactions, and social awareness through densification, mixed land use, and encouraging public transport. However, some studies have found that densifying neighborhoods may lead to gentrification, lower housing affordability, and social segregation. Additionally, mixing different land uses such as residential, stations, and bars might increase criminal activities. Specifically, increasing the density in these neighborhoods will increase the number of targets for offenders. This may reduce the sense of place in these areas due to social diversity.

From an economic perspective, compact development increases the advantage of economies of scale and concentration. Implementing this policy will increase the efficiency (a principle of resilient city) of infrastructures in different areas such as transportation, public health, safety, and energy. Local governments could increase the efficiency of public

transport and other infrastructures as they just utilize the current infrastructures instead of developing new ones around the city. As a result of the compact development policy, consumers have better access to public transport in most parts of the city and are closer to their job location [145]. There are, however, two main drawbacks mentioned in the literature. First, compactness has been claimed to reduce housing affordability or increase housing costs. But as Hamidi and Ewing [146] discussed, transportation cost reduction compensates for higher housing prices in compact cities. Second, some arguments from an urban resilience perspective have been that the congestion of infrastructures and assets leads to a vulnerable state.

Environmentally, urban sprawl has negative effects and externalities and may degrade urban resilience in the long run [147]. Unplanned urban sprawl in natural lands that destroy wetlands and other natural assets increases vulnerability and reduces capacities for post-disaster relief [148]. Furthermore, the relationship between the urban microclimate and compact development reveals that urban form directly affects urban climatic well-being. Still, this effect can be mitigated by optimizing urban structure in densified areas [107]. Further, compact cities have less health vulnerability to heat-related diseases than sprawled cities [149]. In addition, energy consumption and efficiency are highly correlated with land use regulations, specifically the density and diversity of houses and buildings. Energy consumption in low-density single-family zones is about twice of densified multi-family zones [150]. Holden and Norland [150] and Clark [105] showed that urban form indicators do not just influence energy consumption and GHG emission. They concluded that higher density, accessibility to public transportation, walkability, and connectivity of neighborhoods are the main drivers of higher energy efficiency in the case of Greater Oslo and 52 urbanized areas in the US. The effect of the built environment on travel behavior and distance has been widely investigated in the literature. Existing research has analyzed the impact of density (population, employment, and building), diversity (mixed land use), and design (street connectivity and accessibility) on the VMT and GHG emissions in urban areas. However, the misleading hypothesis in these studies is that they consider density as the only measure of compactness, while a combination of all factors (density, diversity, connectivity, and centrality) has more power to explain the issue [104].

Exposure to disasters and risk reduction are two other main areas that are affected by compact development policy. For example, comparing low and high-density development in flooding disasters, there are significantly more economic and human losses in areas that are less dense [111,112]. In the case of COVID-19, there are conflicting results on the association between COVID-19 cases and housing, population, or building density [151]. An empirical analysis of COVID-19 pandemic infection and mortality rate in US counties showed that the association between compactness and the pandemic is not straightforward. While densification might adversely affect the pandemic situation in urban areas, connectivity as another component of compact development has a more robust and positive influence [35]. In other words, while spaces with higher population density contribute to higher population exposure to disasters, these areas have greater amenities and capacities during the recovery phase [24]. This result is also correct in the case of COVID-19. Neighborhoods with more density, mixed land use, and connectivity might have more exposure to the pandemic but also enjoy better accessibility to different open and green spaces and medical and health facilities. Precisely, mixed land use spaces embrace a variety of compatible activities in a place that could contribute to spatial diversity and greater accessibility [27].

One of the main critical goals of compact development is to preserve natural and open spaces. In a compact city, densification should be balanced with accessibility to open and green spaces throughout the city. Indeed, densification is a sensitive policy that is highly context-dependent and has an optimum threshold. While densification might increase urban resilience, over-densification could increase vulnerability by threatening livability and community well-being [106]. Moreover, open space preservation is one of the critical policies to prepare for disasters and increase urban resilience that could be reached through

compact development policy. Through increasing density in suitable areas, more spaces could be saved to be allocated for open spaces [24].

6. Conclusions

There are many arguments about the two main urban planning paradigms: sustainability and resilience. Many studies have investigated the interconnection between these two concepts. However, to the best of our knowledge, the interlinkages between compact city policy and urban resilience have not been thoroughly investigated. This study tried to analyze the alignment between compact city principles and different aspects of urban resilience.

In conclusion, the relationship between compact development and urban resilience is complex when we look at different aspects of resilience. While compact development might positively affect some components of urban resilience, it may negatively impact some other components. For example, social capital and disaster preparedness in compact cities are high. However, the high concentration of people, infrastructures, and assets could reduce urban resilience [20]. Although some aspects of compact development might exert vulnerability to some threats, such as COVID-19 transmission, as this policy enhances community well-being and health, it should be advocated by planners and policymakers for post-COVID urbanization [35]. Empirically, sustainability and resilience are interconnected concepts that, without one of them, the other one cannot be reached [15]. The results of this review show that compact development is a multivariate concept and its evaluation should be done in an integrated way. Compact development policy has different principles that will contribute to more resilient cities if all of these principles are considered.

This research has some policy implications for the future of sustainable and resilient cities. First, policy-makers should deliberately consider both sustainability and resilience as the supplementary paradigms. In other words, the compact city as a sustainable development policy may have some drawbacks such as congestion of jobs in central areas. Decentralization and distribution of jobs is a policy that reduces the risk during crises as functions are distributed in different parts of the city. In contrast, over congestion and super-density may increase the vulnerability and undermine resilience. This policy should be contextualized based on local conditions and potential threats. Additionally, mixing different land uses can enhance public health and reduce the mobility of people during disturbances such as COVID-19. Therefore, this policy contributes to improving sustainability and resilience of the city during critical situations. Moreover, many urban policy issues involve trade-offs and the compact city is not an exception. During COVID-19, people blamed density for the virus's transmission. Such sentiments could trigger new waves of urban sprawl. To mitigate such concerns, focusing on improving living conditions in denser areas is essential. For example, as Florida, Rodríguez-Pose [118] discusses, increasing the accessibility to services and walkability in dense urban neighborhoods can contribute to maintaining interest in compact cities in the post-COVID era.

This study has some limitations that need to be addressed in the future. First, we could not focus on specific components because compact development and sustainability are two broad research areas. Therefore, we propose a more detailed focus on the areas that were found to be critical in this study in order to analyze their impacts on urban resilience. Second, distinguishing between morphological and functional compactness is a critical issue [33]. Therefore, more empirical research is needed to analyze these two aspects of compact development and their relation to urban resilience. Third, we developed a theoretical framework that explains the potential relationship between compact development and urban resilience. We propose that some empirical research implement this framework in case studies from different geographical contexts.

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