Article

Assessing the Future City Post COVID-19: Linking the SDGs, Health, Resilience, and Psychological Impact

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Abstract: This paper explores how the COVID-19 pandemic has affected progress toward urban sustainability. A methodological framework was developed as an integrated-assessment tool for future cities, triangulating indicators that are relevant to cities. The development of this framework was based on understanding the dimensions of sustainable cities and factors related to the urgent crises, and the related lifestyle and psychological factors. The study focuses on the SDGs and health and resilience requirements and links them with the behavioral changes resulting from the COVID-19 pandemic. This paper builds on the advantages of various methodological frameworks by integrating their respective approaches, to offer a more comprehensive solution. A series of measures and actions (scenarios) related to sustainable cities and pandemics are discussed. This approach involves developing relevant indicators by fitting the urban health and resilience goals to the social, economic, and environmental goals of sustainable cities, as well as considering the factors affecting people's perception of cities during and after the pandemic. The paper provides insights into how future cities could be planned, designed, and governed to reduce the impact of health crises and to enable the assessment of cities in relation to the chosen dimensions (health, resilience, sustainability, human).

Keywords: urban planning; assessment tool; sustainable city; pandemic; SDGs; health; resilience; behavior

1. Introduction

"By the time the next century passes its first quarter, more than a billion and a half people in the world's cities will face life and health-threatening environments unless we can create a revolution in urban problem solving"—UN city summit "Habitat II", 1996.

City planning provides reliable answers about how to shape our built environment and, thus, our society. It is a complex process, requiring social, economic, environmental, psychological, and physiological understanding [1]. Over the last decade, cities have been increasingly recognized as key players in our globalizing world [2]. They have become dominant in the global economy, and trends in democratization and decentralization have raised their profile [3]. However, this growth has brought substantial problems and inappropriate practices in the areas of environment, society, and the economy [2]. To resolve these problems, we need to think and act sustainably [4]. Physical planning and design can assist in creating more sustainable consumption patterns. Since 1987, when the need for sustainable development revived the notion that extensive planning was both necessary and feasible, this point of view has gained popularity. Some have argued that the planning system can be applied to achieve significant environmental improvements [5]. The sustainable city has a long-term supply of the natural resources that are the foundation of its development, and it enjoys long-term protection from the environmental risks that could jeopardize this progress [6]. The 2030 Agenda was launched at the beginning of 2016 to lead the world on the path toward sustainability. The sustainable development goals (SDGs) define a set of priorities and development issues. These include the climate

crisis, which has been a global priority for many decades [7]. In 2019, the COVID-19 crisis placed the world on high alert, and many climate-change discussions were put on hold in 2020 [2]. The crisis significantly impacted our daily lives and city planning [8]. It changed the appearance of many of our cities and generated debate over how to handle urban life in the wake of a pandemic [9]. Additionally, the COVID-19 pandemic is seen as essential for the restoration of the SDGs and for supporting resilient communities and healthier, greener, and more equitable economies [10]. Historically, pandemics have affected not only people's lives and health, but also city resilience. Additionally, previous pandemics have been shown to support the growth of cities, leaving them more secure, resilient, and sustainable [2]. During the pandemics, both the form and the function have consistently followed the panic of infection [11], and, indeed, the ways we think of them in search of sustainable and resilient strategies [9]. To reduce the impact of an epidemic before a medical intervention is available, previous societies have looked to the physical and built environment [12], redesigning cities and infrastructure to reduce the spread of infectious diseases. In the 19th century, for example, outbreaks of cholera and other epidemics in crowded cities prompted significant sanitary improvements and the formation of town planning activities.

A city is much more than just a collection of buildings; it is a collection of interconnected systems for interacting, working, and playing that have crystallized into building forms. An examination of these systems can reveal the future face of the city. COVID-19 has had a major effect on our personal and professional lives and on the very foundations of city planning and construction theory and practice, as well as influencing scientific research [13–15]. It has been shown that various physical and social factors affect how people perceive their cities. For example, outdoor activities can be carried out alone or in groups, and they can be connected to physical features such as street furniture, shelters, seating areas, or kiosk stands. As a result, both the "state of body" and the "state of mind" have an impact on how outdoor space is used [16]. The recent global pandemic revealed critical flaws in our built environment and urban design. Various changes were rapidly adopted in response, having a direct impact on human behavior [17]. Despite the various challenges posed by COVID-19, urban planners may draw vital lessons from the crisis, improving their ability to plan and design cities to be resilient and prepared for future shocks—economic, social, environmental, financial, and institutional [18]. The current study highlights the following questions: Where are we on the path toward sustainable cities, as measured by progress toward the SDGs (sustainability requirements)? Will the pandemic lead to more alterations in cities to facilitate future management of such crises (health and resilience)? Could this pandemic represent an opportunity to design cities that respond to the psychological impact of crises (human behavior)? Therefore, this paper seeks to address a basic question: could COVID-19 be a catalyst for integrating the factors that affect the 2030 sustainability agenda, health and resilience requirements, and factors that have a psychological impact, in order to redesign our built environment and the urban form of cities for future generations? This paper was designed to triangulate the relationship between human behavior and various physical and environmental factors, to redefine sustainability in cities post COVID-19.

However, to facilitate the implementation of the plans, technical and non-technical devices and systems should be developed to assess cities' sustainability level, and their preparation for current and future needs. Previously, there was a greater emphasis on developing and implementing environmental-assessment methods to improve energy conservation, green buildings, and high-performance practices [2]. Research in this field has tended to focus on technical issues such as measuring consumption and the impact on the natural environment [19]. However, there is growing recognition of the importance of non-technical issues. Economic viability and social equality are now recognized as important aspects, also influenced by the built environment. This latter reflects a more sustainable approach to city planning, in which the environmental, social, and economic aspects of a project are weighed in relation to one another in the context of the built

environment [20]. The use of an assessment tool during the design/planning process can result in important advantages that are unlikely to be attained through standard approaches. City assessment tools ensure that the right sustainable development goals—whether social, ecological, or economic—are set, through decomposing development into manageable steps [21]. They also reduce operational costs, reduce the environmental impact, and create healthier and more productive urban spaces [22]. Assessment tools assist planners and decision-makers in resolving existing city problems, improving city performance, and maintaining and improving performance over time [1].

The significance of this research is in the implication of the COVID-19 pandemic for future urban planning. This study investigates several dimensions of urban-planning policies that could be significantly affected by this crisis. This study employs a comprehensive analysis of recent work on actual and possible urban-change in the wake of the recent pandemic, linking indicators including social, economic, environmental, and psychological, allowing for a better understanding of city planning and a forecast of the constant changes taking place in our future cities. The paper provides actionable guidelines for how cities might evolve to achieve sustainability, through developing a framework for an assessment of the future city that captures the key aspects of the sustainability indicators, while addressing the urgent need—arising in the wake of the pandemic—for a healthy, resilient, and sustainable city that responds to the psychological needs of its people. The study focuses on the SDGs and health and resilience requirements, and links them with the behavioral changes resulting from the COVID-19 pandemic. An understanding of the complex relationships between the built environment, human behaviors, and people, will ensure the preparedness of our societies for the post-pandemic era.

2. Materials and Methods

2.1. Content Analysis

The study adopts a content-analysis approach. The related aspects for discussion include the concept of a sustainable city and its intrinsic issues (the principles, goals, and objectives of sustainable development); the health-resilient city; and the psychological impact of the pandemic on people. The assessment tools are introduced, with a particular focus on the assessment tool for sustainable cities, through the presentation of conceptual and practical models within this approach.

2.2. Procedures for Literature Analysis

A qualitative-analysis approach was employed to develop the methodological framework for the integrated-assessment tool. This included an extensive review and analysis of the related literature on sustainable-development goals, sustainable-assessment frameworks and indicators, resilience, sustainable cities, and human factor. The literature analysis was also conducted to evaluate the effects of previous pandemics and enhance understanding of the current situation to identify the implications for urban-life dialectics for healthy communities. The study examines the targets and indicators of SDG 3 and SDG 11, which provide a controversial belief of COVID-19 linking to urban space. It investigates the impact of urban resilience in the period before COVID-19, and identifies the psychological effects of the crisis on people amid COVID-19. The paper then suggests an approach for developing an integrated-assessment tool for post COVID-19. This paper develops an integrated-assessment framework that could be used to assess the sustainability of a city in the times of health crisis. This framework considers the implications of health pandemics for the three pillars of sustainability in future post-pandemic cities. This paper discusses the influences on urban health—in terms of its social, economic, environmental, and psychological dimensions—to clear the path toward sustainability in the medium to long term.

3. Framework Development: City-Assessment-Tool Post COVID-19 Development

3.1. Assessment of Sustainable Cities

As this study proposes a framework for an assessment tool, it is necessary to elaborate on the concept of an assessment tool and its relevance to sustainable cities. It is also important to present conceptual and practical models to illustrate the multidimensionality and complexity of the tool.

Sustainability is defined as the dynamic and long-term equilibrium between the economy, the environment, and society [23]. The concept of "sustainability" thus necessitates an integrated- and holistic-system approach that takes into account those three major dimensions [1]. In addition, the concept of "sustainability" emerged from a global political process, providing a satisfying overall framework for national and international governance [24]. Sustainable development is considered the keyword of the 21st century. It is one of the most important opportunities for improvement of quality of life [25]. Sustainable development is also defined in terms of the scale of its application: in short, there is global sustainable development and local sustainable development, which includes urban, regional, and national scales [20]. The concern in this paper is sustainable development on the city scale. Emerging in the late 1980s, the topic of sustainable development in cities has received a lot of attention. Major cities in various countries have made theoretical and practical efforts to pursue sustainability [23]. According to the United Nations Sustainable Cities program, a sustainable city is one in which social, economic, and physical developmental accomplishments are preserved over time. Stronger relationships are established, and this creates a new moral space in which societal values can be modified [26]. The sustainable city is a complex amalgamation of social, economic, political, and ecological forms, which are constantly being articulated and rearticulated within specific spatial contexts and through historical struggles [27,28]. Various associated terms have emerged, including "smart city", "sustainable city", "future city", "green city", "resilient city", "eco-city", "low-carbon city", and "healthy city" [29–32]. It is also common to see combinations of terminology used to describe specific concepts, such as the "smart sustainable city" [31,33]. In this research, the terms "sustainable cities", "healthy sustainable cities", and "pandemic-resilient cities" are used.

The need for sustainable actions on the city scale has been acknowledged, and several approaches have been taken. The first perspective emphasizes that the planning process should promote sustainability to ensure both long-term and immediate benefits. This contends that, for sustainable urban growth, decisions must be taken at three levels: during overall town-planning, in relation to architectural design, and in the construction details [34]. The second perspective, on the other hand, emphasizes the development of a system that can help to ensure that the city is more sustainable and adaptive—an intelligent urban system [35]. The third perspective highlights the value of sustainability assessment as a tool to help decision-makers and policymakers decide on the steps needed to make society more sustainable [22]. Since the concept of sustainability is so broad, the use of sustainability-assessment frameworks is the most common [36]. Sustainability assessment is increasingly recognized as a valuable contributor to sustainable development, particularly for cities [37]. The assessment tool for sustainable cities takes targets from the general concept of sustainability that align with the specific problems of the city; hence, it examines multi-dimensional complex relationships between the environmental, social, and economic aspects [38], with political aspects also integrated into the assessment framework [39]. A multidimensional assessment tool for addressing city sustainability must include the following: a normative guiding concept operationalized for specific targets, a systematic target-related model of the system to be evaluated, and a procedure for integrating key stakeholders and connecting normative and systemic dimensions (Figure 1) [40].
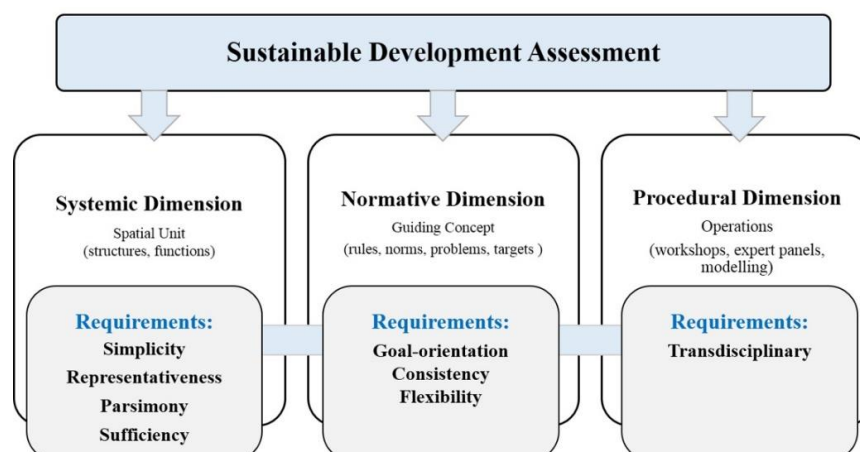
Figure 1. Requirements for measuring a city's sustainability that take into account normative, systemic, and procedural factors (authors, based on the work of [40]).

The process of conducting an integrative analysis of a city system should be emphasized in a sustainability assessment [41]. The principles for assessment of sustainable development include: (1) a holistic perspective that covers the whole system and all of its parts and (2) a horizon of sufficient length to incorporate both human and environmental time-scales, responding to future generations' needs and short-term decision-making requirements [42]. In addition, sustainability assessment should emphasize the social dimension as a formal process of recognizing, anticipating, and evaluating the potential implications [23,43]. Moreover, considering people's perception is a priority of the assessment systems during research and development. For example, one way to describe a sustainable technical system is by assessing the overall system-health as a sustainable functioning system, emphasizing the significance of people's perception as part of social sustainability (Figure 2; [24]). Various urban models have also been proposed to help guide urbanization-sustainability practices. For example, four contemporary alternative models—namely, "free-market cities", "self-reliant cities", "redesigning cities", and "fair-share cities"—were proposed as a basis for sustainable-assessment tools for cities [44]. These models take into account market-trade orientation, economic growth, regulation-of-externalities costs, value systems, technology, and nature.
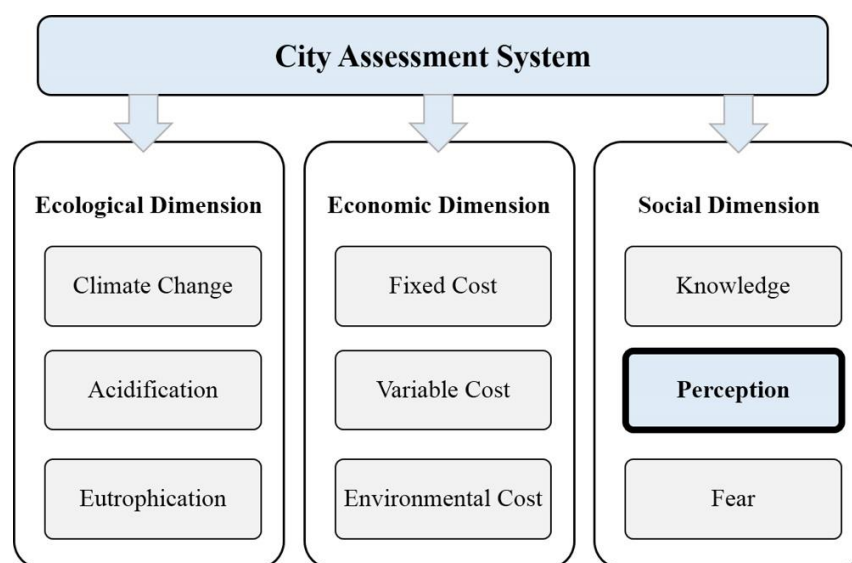

Figure 2. The ecological, economic, and social dimensions of a city assessment system (authors, based on the work of [24]).

The use of indicators to determine sustainability is recommended for managing sustainable-city development [37,45–47]. The majority of scholars have focused their analyses on indicator selection and measurement, with most indicators structured around traditional sustainability pillars [48]. Indicators constitute a simple, quantitative tool for creating sustainable cities that support long-term economic growth, health, and quality of life for their people [49]. According to the extant literature, an indicator should be chosen carefully and must be specific, measurable, sensitive, usable, available, time-related, and cost-effective [45]. Appropriate indicator sets—combined with methodological standards—establish frameworks for assessing sustainability on various spatial levels [50]. It is important to ensure that the indicators suit each city, aligned with its institutions, players, issues, and culture [35]. As cities differ greatly in their data sources and availability, population sizes, historical-development backgrounds, and functioning, numerous frameworks for urban-sustainability indicators have been developed over time [36,48,51]. For example, one sustainability index developed for a Taipei city incorporated four dimensions of indicators (environment, society, economy, and institutions [52]). The sustainable city index for Malaysia includes a set of other indicators to assess urban sustainability [53]. The Northeast China sustainability index consists of 22 indicators, divided into environmental, social, and economic subsystems, and used to analyze the sustainability of 15 typical resources and forecast changes. An organized and systematic analysis that clarifies the developmental history and changes of the city and predicts potential effects can offer a framework to define the complex relations of cities [54]. In addition, the indicators should reveal the implications of the city's current trajectory, rather than simply viewing the city as a single unit [23]. The sustainability indicators can be divided into several categories and levels that are additionally subdivided into related elements [22]. However, to ensure the effectiveness of the indicators, an integrated approach should be used to evaluate them, incorporating a residents' survey, multi-stakeholder engagement, environmental and economic impact-assessment, a goal-programming (GP) method, or the analytical-hierarchy-process (AHP)-approach (Figure 3) [55]).
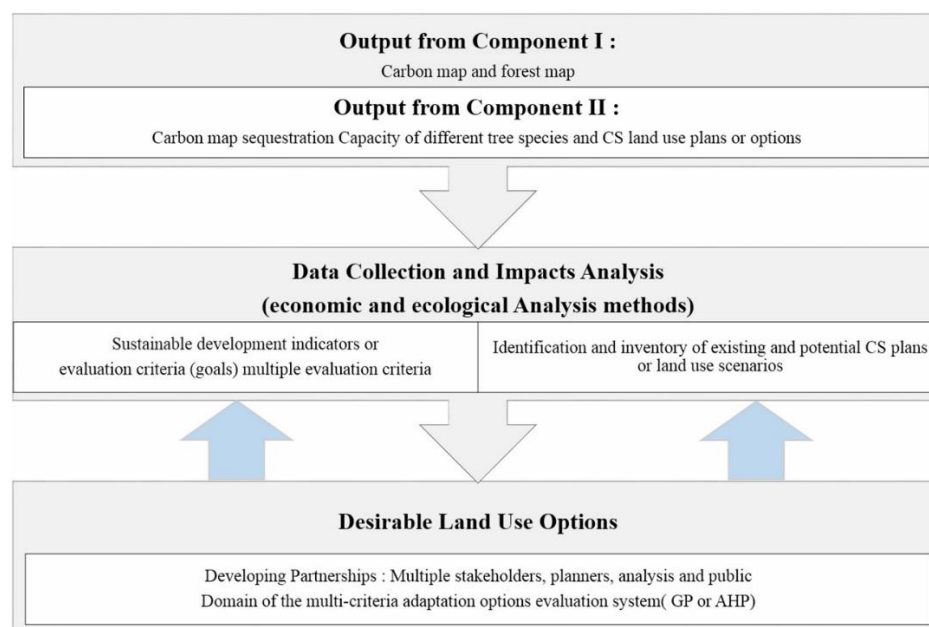

Figure 3. The integrated-assessment framework (authors, based on the work of [55]).

3.2. SDGs and the Pandemic

This section defines the SDCs that are relevant to cities. In addition, it discusses the impact of COVID-19 on the progress of the 2030 Agenda.

3.2.1. The SDGs for Creating Sustainable Cities

The 17 SDGs comprise the UN 2030 Agenda, designed to transform our world by tackling multiple major challenges. Cities can thus adopt these goals as a foundation for their own sustainability performance at the local level. Specifically, relevant to this research paper is SDG 11, "sustainable cities and communities", as this is the most relevant to city situations (Figure 4). SDG 11 identifies the need to "make cities and human settlements inclusive, safe, resilient and sustainable" [18]. It suggests that increasing inclusion, safety, resilience, and sustainability will pave the way for the other SDGs that seek to end poverty, increase equality, boost economic growth, and ensure that residents are living healthy lives [56,57]. SDG 11 identifies resilience as the driving force behind sustainable development, with the urban system needing to maintain consistency throughout all acute shocks, serious stresses, and environmental challenges, to achieve sustainability in a healthy and resilient city. Furthermore, local and city planners should integrate resilience at the development and implementation stages [2]. Goal 11 includes 10 targets and 15 related indicators, the bulk of which are measured at the local city-level, with progress reported at the national level. Goals 1, 3, 6, 7, and 17 address issues of urban poverty and inequality, urban planning, urban health, pollution, environmental degradation, and climate change, as well as other sustainable urbanization difficulties [57]. The purpose is to explore all of the major challenges for cities—including those affecting citizens, societies, mechanisms, and organizations that must continue to function in all circumstances. Being a reliable, healthy, and resilient city means being able to withstand a wide variety of stresses and shocks [58]. The implementation of the 17 SDGs and the new urban agenda is highly dependent on cities [59]. The SDGs provide an analytical framework with which to examine international development. While health and wellbeing are specifically mentioned in SDG 3, they are also a requirement in SDG 11, which seeks to advance inclusive, safe, resilient, and sustainable cities. It is reported in the literature that the SDGs contrast with conventional development agendas, which concentrate on limited sets of measurements, while the SDGs take a comprehensive and multifaceted perspective on development [7]. As a result, the correlations between the SDG indicators, both positive and negative, have enabled the discovery of global patterns.
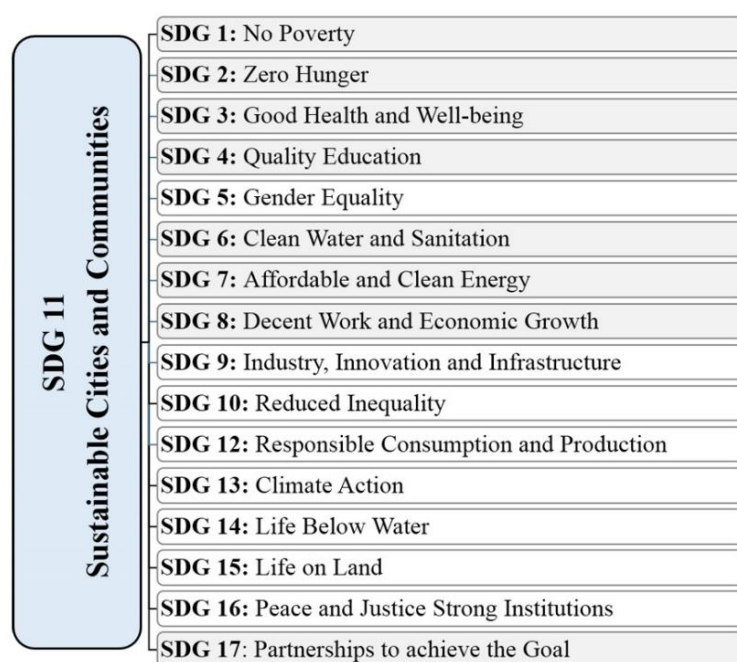

Figure 4. Interlinkages between SDG 11 and other SDGs (authors).

3.2.2. Impact of COVID-19 on the SDGs

The SDGs for the 2030 Agenda were established to address many of the obstacles to the promotion of wellbeing, environmental protection, and economic progress [7]. The SDGs establish a framework of indicators to facilitate global sustainable development [60]. While the SDGs provide a plan for societies to adapt to and recover from the COVID-19 pandemic, the 2030 Agenda has many limitations and constraints. COVID-19 served as a significant stress test for the Agenda. Indeed, reports on the initial phase of the SDG Agenda (2015–2020) suggest that global progress toward the SDGs was weak [61]. It is reported that progress on SDG 1 ("No poverty"), SDG 4 ("Quality education"), and SDG 8 ("Decent work and economic growth") were all strongly affected by the pandemic. Additionally, the analysis shows that SDG 2 ("Zero-hunger") appears to respond to COVID-19 [62]. This situation demonstrates the need for a comprehensive review, the adaptation, and the extension of the targets in order to focus on all facets of sustainable development (i.e., economic, social, and environmental sustainability). A new perspective is required to identify the types of shocks that pandemics, chronic stress, and acute crises could provoke in future [62]. Other concerns have been reported in relation to the global sustainable-development approach. For instance, it has been argued that the world should concentrate on a few key-performance planning initiatives, rather than the entire set of 17 SDGs. The SDGs should be adjusted to make them more practical and more effectively implemented [63]. The UN-Habitat (2020) [10] report has considered the impact of COVID-19 on the SDGs since the begin of the pandemic. Pandemic recovery is considered necessary for the restoration of the SDGs to promote greener, healthier, and fairer economies and more resilient communities. Therefore, various intergovernmental organizations assist the SDGs and have been working to enhance and develop the applicability of the fundamental indicators and concepts of change, in spite of concerns about the effective implementation of the SDGs. Additionally, in response to the slow progress, the UN declared the 2020–2030 period to be a "decade of action" for the SDGs. However, this declaration was made in 2019, before the outbreak of the pandemic [61].

3.3. Health, Resilience, and the Pandemic

In the literature, the terms "healthy cities", "resilient cities", "health-resilient cities", and "sustainable cities" are commonly used, but they are frequently used in ways that are incompatible with their context. This section asks what a health- or pandemic-resilient city is, and what its relationship to the sustainable city is. In addition, it discusses the impact of health pandemics throughout history on the urban form of cities, and the required changes needed due to COVID-19.

3.3.1. A Health-Resilient City

The term "resilient city" has gained popularity as a result of the problems caused by global climate change, as well as the increasing severity and intensity of global disasters and conflicts. "Resilient cities" are those capable of absorbing, recovering from, and planning for economic, environmental, social, and institutional shocks [64]. "Resilience" is the capacity to adjust to shifting social and environmental circumstances, while preserving and enhancing quality of life, long-term ecological productivity, and public and individual health [65]. As previously stated, "sustainability" and "resilience" are distinct but related concepts [66]. They reflect two interconnected agendas. If they are to achieve sustainability and resilience goals, cities must integrate policies and plans for inclusion, resource efficiency, climate-change mitigation and adaptation, and disaster resilience [66,67]. The ability of a system, community, or society to resist, absorb, accommodate, and quickly and effectively recover from the effects of a hazard, is referred to as "resilience" [66]. A resilient city should be continually encouraging improvements in sustainable development. Recognition of this gave rise to the concept of "healthy cities", with calls for urban areas to provide cleaner air, environmentally friendly transportation options, greywater recycling and storage, rainwater collection systems, and other such initiatives [68]. However, the COVID-19

pandemic compelled us to reconsider these ideas, necessitating the establishment of a "health-resilient city", with public health as a top priority. A healthy city is one that is "creating and enhancing physical and social conditions on a continuous basis", according to the World Health Organization (WHO) [69]. A city is said to be "health resilient" if it has the capacity to resist, absorb, accommodate, adapt, transform, and recover quickly from the effects of a health crisis, particularly through the preservation and reconstruction of its fundamental systems and functions to safeguard and improve public health [68]. Some definitions of "healthy cities" concentrate on the communities living within those cities. A healthy community is one that protects and enhances its residents' quality of life, encourages healthy habits, reduces risks to its citizens, and protects the environment [70].

Combining these notions of "healthy" and "sustainable" strengthens both the emphasis on health in urban sustainable development, which has been neglected or underutilized in discussions [71], and the ecological focus on health, which has been largely absent from health promotion up until now [72]. A "healthy and sustainable city" promotes the present and future wellbeing of all individuals, communities of people, and ecological systems. This claim acknowledges the various scales and complexities of the urban environment's physical, social-economic, and environmental components [73]. Constructing health resilience involves enhancing health systems, attending to the needs of vulnerable groups, and boosting organizational competence, social connectivity, and psychological health. To increase preparedness, support stable daily operations, and address social determinants of health, communities need to be resilient [74].

3.3.2. Impact of COVID-19 on Health-Resilience of Cities

The COVID-19 pandemic was a global health crisis—possibly the worst in more than a century [75]. However, this was not the world's first pandemic. Throughout history, pandemics have shaped cities, and numerous health challenges have been reflected in architecture and urban design [75,76]. Cities have long sought resilient and sustainable responses to pandemics [75,77,78]. Our world has suffered as a result of COVID-19. The COVID-19 pandemic affected not only health, but also the urban environment and the economy [75]. All governments were forced to implement health and safety measures to protect their populations from infection, with many imposing lockdowns and social distancing, limiting foreign entry, and so on [79]. However, the pandemic may provide an opportunity to improve cities by incorporating the associated learning into health-related planning and design [75]. The incorporation of a health perspective into public-space architecture planning as a result of a pandemic is not new [80]. Furthermore, the role of social behavior and citizen awareness in combating the pandemic is thought to be critical [76]. Elgheznawy and Eltarabily (2020) [75] propose that the best city designs, especially in light of the current crisis, are sustainable, smart, and social. Cities with these characteristics will be more effective in dealing with future crises (Figure 5). As a result, city planners, designers, and public health officials should be working together to create healthier communities.

The spread of COVID-19, which resulted in a large number of deaths in human settlements, drew city planners' and policymakers' attention to the need for pandemic resilience [73]. Building pandemic resilience extends beyond health systems (Figure 6). Rather, a research agenda is needed to explore the resilience of the health systems and ensure integrated approaches to the health, social, environmental, economic, and institutional systems [81]. The variety and multiplicity of systemic threats requires governance systems that foster societal resilience to a wide range of issues, as well as policies that address particular problems [81].
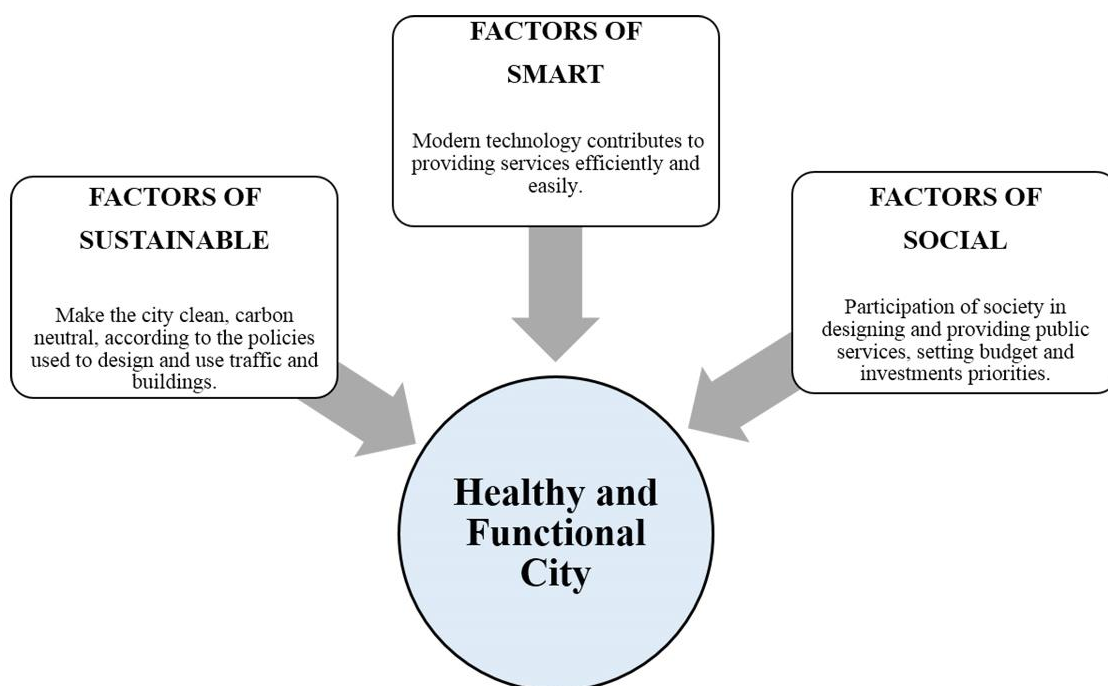
Figure 5. Main pillars of healthy and functional cities (based on the work of [75]).
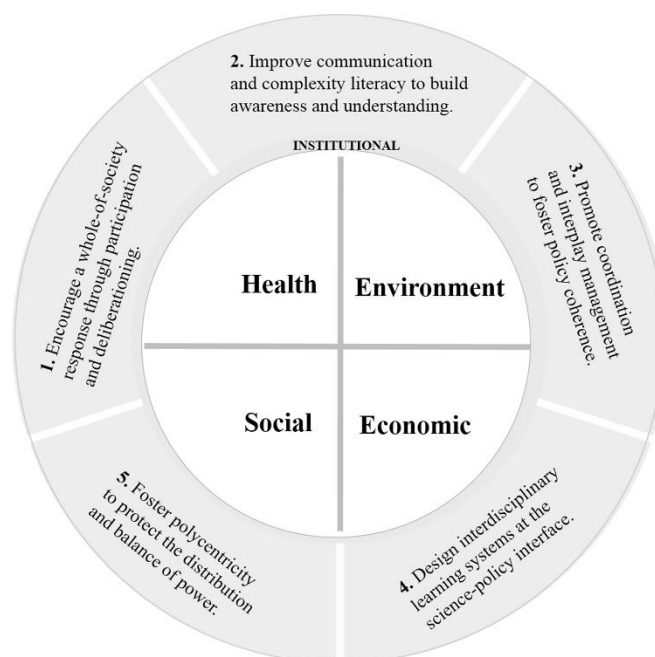

Figure 6. Transformative Agenda to govern pandemics (based on the work of [81]).

A method for assessing pandemic resistance at the neighborhood level was developed (Figure 7). The approach identified a set of pandemic-resilience indicators, which were used to create a multi-dimensional composite pandemic-resilience index for Tehran's neighborhoods [82]. Using the characteristics of 351 communities, the exploratory-factor-analysis method was applied, to determine the physical, infrastructural, socioeconomic, and environmental elements of pandemic resistance.
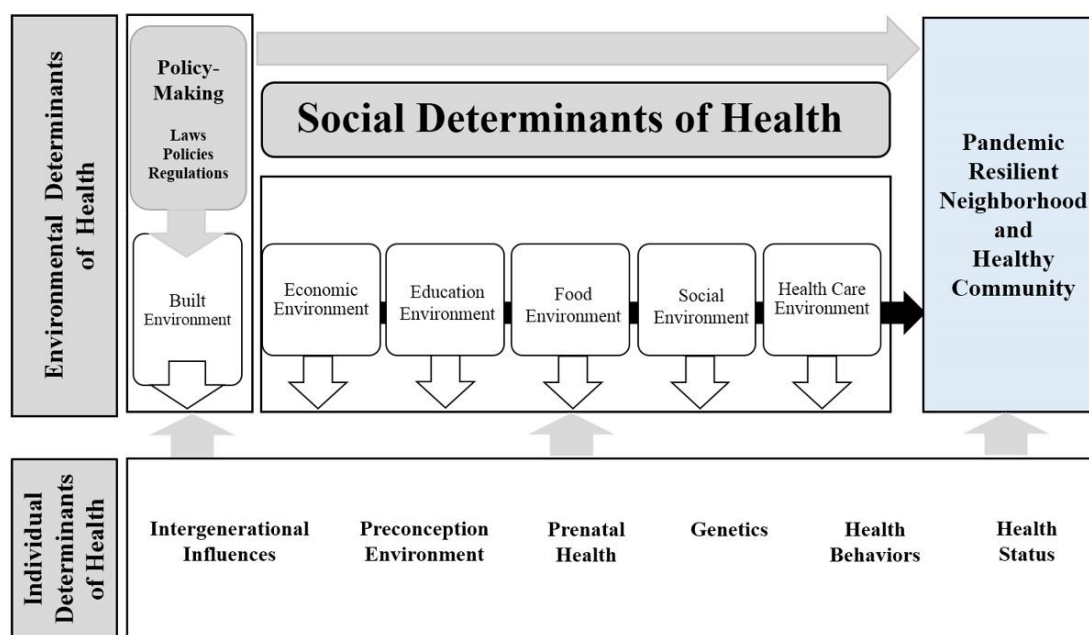
Figure 7. Determinants of neighborhood pandemic-resilience (based on the work of [82]).

3.4. Human Psychology and the Pandemic

The COVID-19 crisis is likely having long-lasting effects on people, and thus a precise understanding of the pandemic's psychological impact is needed. The features of the built environment shape human behavior [83]. Therefore, when planning and designing cities, there is a need to address the psychological impact of COVID-19 on people. This section discusses the psychological effects of the pandemic and the factors affecting people's perceptions of the pandemic, as seen from a behavioral perspective. It then discusses how these factors may affect the planning of cities.

3.4.1. People's Perceptions of the Pandemic

The impact of COVID-19 differed according to age [84], gender [85], profession [86], level of self-control (personal), attitudes toward the meaning of life, coping strategies [87], level of wealth (or poverty) [88], and in terms of how long the pandemic lasted [89]. For example, younger people may have been more susceptible than older people to stress [87], with many children being fearful and perceiving the virus as an enemy [84]. Women, young people, and those who considered themselves to be in the high-risk population, suffered the most [85]. Compared to the general population, health workers reported a stronger sense of being at risk, more worries, and a higher level of knowledge about COVID-19 infection [86]. The fear of being infected—as well as the prolonged quarantine and lockdown—may have had acute and long-term psychological effects on the community [90]. The pandemic's impact persisted over time, even worsening cases of depression, and some vulnerable groups were found to need additional support for their mental health [90]. However, acute COVID-19 stress and general mental distress had less of an impact on those people who generally believed that their lives had meaning [87].

3.4.2. Impact of COVID-19 on Human Psychology

The COVID-19 pandemic changed people's behavior in cities, and had various negative psychological effects [90]. Most people saw it as a serious crisis, and it significantly changed their daily lives, changing their daily routines and leading to the cancellation of important events [85]. The severe restrictions on movement, the isolation, and the social regulations imposed to control the spread of COVID-19 inevitably caused psychological distress [91] and had a negative impact on mental health and wellbeing [88]. On the other hand, the house was recognized as a place of safety and protection [84]. The uncertainty,

combined with the lack of an effective treatment for COVID-19, exacerbated the fears and sense of vulnerability among both adults and children [92].

4. Results and Discussion

The following section presents the conceptual guidelines for developing a sustainable-city assessment tool.

4.1. Reproducing Guidelines for Assessing Sustainable Cities Post COVID-19

Based on the extensive literature analysis, this investigation proposes a framework for the development of an integrated-assessment tool for sustainable cities. This approach is composed of three main phases (Figure 8), as follows. The first phase triangulates the multiple goals and objectives of sustainable development in relation to urgent pandemics, considering health, resilience, and people's perceptions. The second phase involves creating and implementing indicators to support a methodological-assessment framework that takes into account the social, environmental, economic, and health goals of sustainable development. The third phase involves determining the extent to which national governments and city authorities contribute to encouraging the application of sustainability indicators.
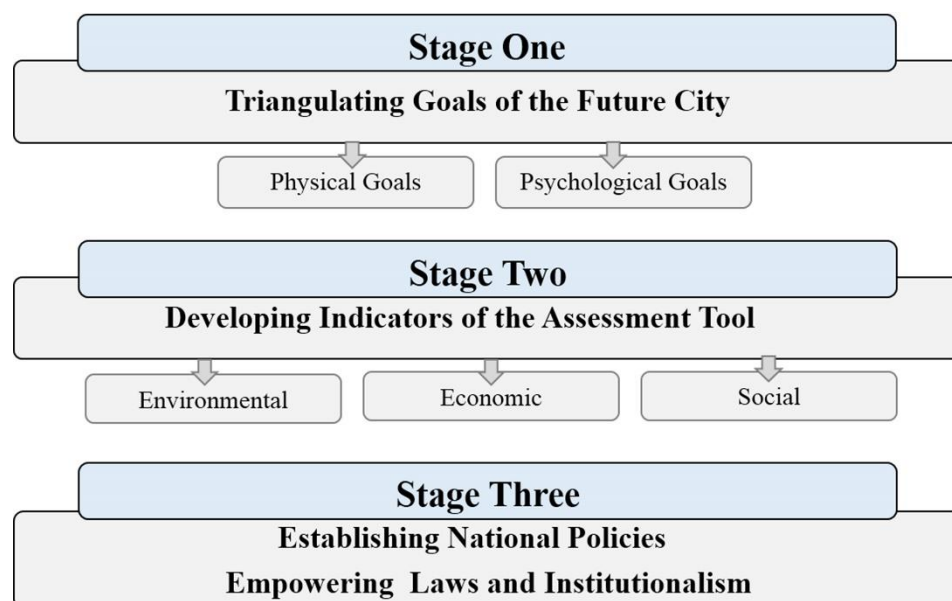

Figure 8. Stages in the development of a framework for the assessment of future (sustainable, healthy, resilient, human) cities (authors).

4.1.1. Stage One: Triangulating the Goals of a Future City

On the local scale, sustainable development should strive to address economic, social, cultural, and political needs; reduce the consumption and waste of non-renewable resources; make sustainable use of renewable resources; prevent biodegradable waste and emissions from exceeding the capacity of local and global sinks to absorb or dilute them without causing harm; prevent poverty; and strengthen local and municipal authorities [39]. These goals are classified into two actions: physical and psychological. They can support sustainability objectives, which are environmental, economic, and/or social.

1. The physical goals should promote the following environmental actions: managing waste extraction, consumption, and disposal; managing waste production to prevent environmental damage; preserving or boosting the size of the biophysical environment, biodiversity, and productivity; reducing the amount of time spent using or encouraging resource-extraction and processing methods that damage the environment; and managing the biophysical environment. They should also promote the following economic actions: supporting increased employment; promoting

self-employment and the expansion of small businesses; creating and managing in an effective and efficient manner; achieving maximum productivity with minimal resources and little waste and pollution; relying on local knowledge and technology, where appropriate; and basing development on a scientific methodology that takes into account, and is driven by, environmental, economic, and social factors.

2. The psychological goals should ensure the following social and health actions: supporting improved levels of education and awareness, including awareness of sustainable development, inclusive development processes, and benefits; taking into account human rights; supporting improved health, safety, and security; supporting interpersonal differences; and supporting increased access to land, adequate housing, public services, finances, information, technology, and communications.

4.1.2. Stage Two: Developing Indicators of the Assessment Framework

The most crucial phase in the creation of the assessment framework is the development of the indicators. As a result, the indicators should be based on careful research and critical analysis of best practice. The parameters used to measure sustainability are "indicators". The abundance of measuring instruments and indicators in this rapidly expanding field demonstrates the importance of the conceptual and methodological work in this area [93]. The indicators must meet a set of precise requirements—specifically, they must be pertinent, understandable, and trustworthy. They need to take into account a long-term view of approximately 20 years. Several studies have proposed strategies for developing indicators. Innes and Booher (2000) [35] propose an indicator strategy based on the notion that cities function as complex adaptive systems, similar to living organisms. The authors suggest three types of indicators: system-performance indicators, policy and program measures, and rapid-feedback indicators. While policy and program measures provide policymakers with feedback on the effectiveness of specific projects and strategies, system-performance indicators are needed to inform the public about the overall health of a community or region. Indicators, according to Wiek and Binder (2005) [40], should represent the primary structures, processes, and functions of the city's economic, environmental, and social spheres, and be used to describe the assessment system. The authors developed sustainability assessments for decision-makers by integrating systematic and normative knowledge from various stakeholders to introduce a variety of indicator-based approaches for cities, which provided crucial information and served as the foundation for integrative sustainability-assessment tools. Reed, Fraser, and Dougill (2006) [94] compiled a summary of the frameworks in use for developing and implementing sustainable practices. They propose that these frameworks can be divided into top-down and bottom-up paradigms.

This paper outlines a strategy for creating sustainable-city assessment indicators. The method consists of three continuously occurring cyclic steps (Figure 9). These are as follows:

Step 1 defining the context;
Step 2 establishing the indicators;
Step 3 evaluating the indicators.

Step 1 Defining the Context

It is important to begin by defining the context in which the indicators are developed. Thus, it is also important to determine the field pertinent to the city under study, taking into consideration the community, significant stakeholders, practitioners, the existing and connected systems, and opportunities and future shocks. This also necessitates a consideration of the process objectives and tactics.

Step 2 Establishing the Indicators

The definition of an indicator should be based on professional experience and academic study. As the measurable components of the sustainability assessment, the indicators may belong to one of the three categories. The goals and objectives of sustainable development, as applied to cities and defined in stage one, are addressed by each of the indicators,

each of which embodies a particular characteristic of the sector they describe. In this research, the selected indicators cover the three pillars of sustainable development (social, environmental and economic). The indicators were extracted from the extant literature on SDGs, health, and pandemic resilience, and based on recommendations from authors regarding sustainable-city indicators. The three types of assessment indicators, as illustrated in Table 1, are discussed in the following paragraphs.
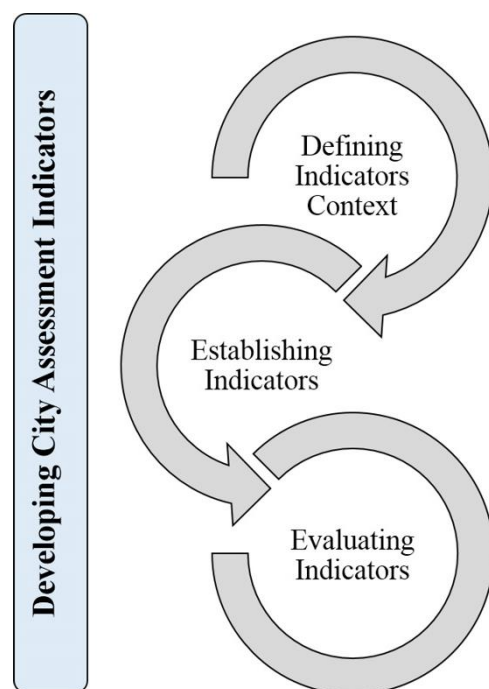

Figure 9. Developing the indicators for a city methodological-assessment framework (authors).

Table 1. Proposed indicators for future (sustainable, healthy, resilient, human) cities and their relevance to the SDGs.

Main indicators	Sub Indicators/Measures	Relevant to SDGs
Social-Dimension Indicators		
Education	Enrolment rate in higher education +15 literacy rate Health and safety within educational environment	SDG 4 (Quality of Education)
Built Environment/	City density Occupancy rate Access to housing	SDG 11 (Sustainable Communities)
Health	Physician density Under-five mortality rate Responsive health-systems Percentage of population with access to health-care services	SDG 3 (Good Health) SDG 11 (Sustainable Communities)
Safety and security	Amount of natural disaster damage/population Perceptions of safety and rates of crimes against property and person	SDG 11 (Sustainable Communities) SDG 3 (Good Health)
Equity (social, economic)	Share of women and ethnic minorities in local government Equitable distribution of services	SDG 5 (Gender Equality)
Infrastructure	Households connected to the water network Households connected to the sanitation network Households connected to the electricity network	SDG 6 (Clean Water and Sanitation) SDG 7 (Affordable and Clean Energy)

Table 1. *Cont.*

Main indicators	Sub Indicators/Measures	Relevant to SDGs
Social-Dimension Indicators		
Green and public spaces	Percentage of preserved areas/reservoirs/waterways/parks in relation to total land area Percentage of trees in the city in relation to city area and/or population size	SDG 11 (Sustainable Communities)
Environmental-Dimension Indicators		
Water quality/Availability	Access to improved water source, piped (% of urban population) Domestic water consumption	SDG 11 (Sustainable Communities)
Mobility and transportation	Satisfaction with public transport (%) Transportation-mode split (percentage of each mode of transportation, i.e., private, public, bicycles, pedestrians) Average commute time and cost	SDG 11 (Sustainable Communities)
Waste	Recycling rate (percentage diverted from waste stream) Volume of solid waste generated	SDG 11 (Sustainable Communities)
Air quality	Annual mean concentrations of air pollutants	SDG 11 (Sustainable Communities)
Energy efficiency	Percentage of total energy consumed in the city that comes from renewable sources Total consumption of electricity in kWh per capita	SDG 7 (Affordable and Clean Energy)
Land use	Shares of built-up area, forest, water, agricultural land, and other areas of the total city area (%) Annual loss of agricultural lands	SDG 15 (Life on Land)
Climate change	Total amount of GHG emissions per city and per capita	SDG 13 (Climate Action)
Economic-Dimension Indicators		
Economic growth	GDP per capita Poverty rate	SDG 8 (Decent Work and Economic Growth) SDG 1 (No Poverty)
Employment (unemployment)	Unemployment rate	SDG 8 (Decent Work)

1. Environmental indicators. Environmental indicators cover broadly a wide range of city sectors. The major aims of a sustainable city are to prevent the ecosystem of its region from being depleted, and to ensure its viability for future generations. Sustainable cities strive to reinvent themselves to maintain a high standard of living for current and future generations, and to create a more hospitable environment for human life. Environmental sustainability protects basic needs for natural-resource preservation and improvement, as well as environmental and habitat conservation and restoration [37,78]. The proposed indicators in this section are concerned with water, mobility and transportation, waste, energy efficiency, land use, and climate change. These indicators are associated with various SDGs: the water, mobility, and transportation and waste indicators are largely related to SDG 11, the energy-efficiency indicator is related to SDG 7, the land-use indicator is related to SDG 15, while climate change is at the core of SDG 13 [59,95,96]

2. Social indicators. Social indicators are concerned with quality of life and level of wellbeing, as well as the protection of social and human rights [78]. They are a measure of how each system is affecting its local community and contributing to a more equal, diversified future [37]. Social indicators focus on an understanding of population density and social equity, and the promotion of social welfare through access to housing, health services, affordable energy, assistance from municipal services, and community projects, as well as other social concerns relevant to the pandemic [78]. Seven indicators are proposed in this research: education; built environment; health, safety, and security; equity; infrastructure; green areas; and public spaces. A key driver of sustainable development is education. The education indicator concerns

the transmission, acquisition, creation, and adaptation of information, knowledge, skills, and values [97]. SDG 4 addresses the provision of high-quality education and the support for lifelong learning. The indicators of safety and security are addressed in SDG 3 and SDG 11 [59,95]. The health indicator is related to the city's investments, values, and access to medical services [98,99]. Today, cities are home to more than half of the world's population. The promotion of health and quality of life should therefore be a priority for cities, especially in the post-COVID-19 era [78]. SDG 3 addresses health and wellbeing, which has a direct bearing on SDGs 11 and 6 [96].

3. Economic indicators. The economic indicator concerns the city's economic growth and development [78,98,99]. One potential economic indicator involves the use of economic statistics (e.g., the unemployment rate, poverty levels, GDP, and inflation rates). These indicators reveal the state of the economy, and enable predictions about its future course. They can be used as a yardstick for determining wealth creation and the capacity to finance sustainability-promoting tasks and actions [37,78]. Economic indicators have been negatively impacted by the pandemic [78], with lockdowns having a negative effect on the local economy. The implications are numerous and widespread, including the societal problems already mentioned [100]. The pandemic also had an impact on small and medium-sized businesses, the food supply-chain, migrant workers, social and geographic inequality, and municipal tax revenues [78]. The economic indicators proposed in this research are economic growth and employment. The targets and sub-targets of SDG 8 directly address these indicators. Employment is essential for people to meet their basic needs and to access education and healthcare services, and it plays a significant role in the economic growth of the nation [95,96].

As Table 2 shows, the proposed indicators cover the three dimensions of sustainable development, and are each relevant to the SDGs. The study identified 16 indicators that could be utilized to measure progress toward sustainable development in cities. They are derived from the literature on the SDGs in the context of cities [56,59,60,95,101–104], as well as the literature on healthy and pandemic-resilient cities [59,78,102] and on sustainability [37,48,105–108].

Table 2. Objectives and characteristics of the indicators for future (sustainable, healthy, resilient, human) cities and their relevance to the SDGs.

Evaluating Indicators	Description	Reference
Accurate	Be accurate and bias-free	[109,110]
Measurable	Be easily measured	[37,109–113]
Reliable	Be reliable and consistent over space and time	[109,111,112]
Usable	Make use of available data	[37,109,112]
Dynamic	Assess trends over time	[109,110,112,114]
Social appeal	Have social appeal and resonance	[111,112]
Predictable	Provide early warning of detrimental change	[112,114,115]
Cost-effective	Be cost-effective to measure	[109,112,114,116]
Systematic	Be representative of system variability	[37,109,114]
Rapid	Be rapid to measure	[111,116]
Time-related	Provide timely information	[109,111]
Clear	Be clear and unambiguous, easy to understand and interpret	[111,112,114,117]
Scientific	Be scientifically robust and credible	[112,114]
Simplicity	Simplify complex phenomena and facilitate communication of information	[52,53,118]

Table 2. *Cont.*

Evaluating Indicators	Description	Reference
Replicable	Be verifiable and replicable	[110,111]
Limited	Be limited in number	[117]
Significance to system/Relevant	Be relevant to the current and future local system/environment	[52,119,120]
Available	Use existing data	[114,115,117]
Sensitive	Be sensitive to system stresses or the changes the system is supposed to indicate	[37,52,114,115]
Usable	Measure what is important to stakeholders	[111]
Targetable	Have a target level, baseline or threshold against which to measure criteria	[114,115]
Accessible/Easy	Be easily accessible to decision-makers	[111]
Diverse	Be diverse, to meet the requirements of different users	[113]
Practical	Be linked to practical action Be developed by the end-users	[110] [111,113]
Extensive	Provide a comprehensive understanding of the city's social, economic, and environmental health	[121]

Step 3 Evaluating the Indicators

The indicators must be evaluated to ensure their adequacy, reliability, and sensitivity. Modeling or empirical methods can be used for this, but the standard must encapsulate best practice. This criterion involves defining the characteristics of the best indicators and allowing the researcher to calculate their validity and reliability. According to the extant literature, the indicators should have the objectives and characteristics shown in Table 2.

4.1.3. Stage Three: Establishing Policies and Laws of Implementation

The third stage of the guidelines considers the extent to which the national governments, city, and municipal authorities are helping to encourage the application of sustainable cities, as well as the national and international contexts required to inspire city consumers, businesses, and governments to make progress toward this goal. This step requires responsive and effective governmental and civic institutions to fulfill needs, build resilience, and manage crises as they emerge. This is an essential stage for building policies and regulation systems to support the implementation of the urban strategies.

5. Conclusions

Future cities should be prepared for unplanned acute shocks. With the pandemic, cities helped in the investigation of the formation of resilient and resistant communities. They used the lessons learned from the pandemic to ensure that emergency preparedness is in place at all levels, in order to respond effectively to future emergencies. An assessment tool that ensures the city is more adaptive and sustainable can constitute an intelligent urban system. The assessment tool should promote sustainability to ensure both long-term and immediate benefits, along with social and economic development. The tool should meet the following criteria: First, it should identify the characteristics of the sustainable future city. Second, it should present the general principles and benefits of the approach. Third, it should explain the process requirements. The end result will be a comprehensive method for the assessment of sustainability.

5.1. The Contributions: Framework for the Assessment of Future Cities Post COVID-19

This section presents the outcome of the study, which is the developed framework for the assessment tool of a future city (Figure 10). The development process incorporates

background information about the major sub-systems that make up the infrastructure of the city and the social and economic aspects, and it should be performed systematically, as explained in the previous section. The proposed assessment-tool framework focuses on the following aspects:

1. Environmental sustainability: robust, lively, fruitful, and diverse biophysical systems that are continuously and steadily providing resources and protecting the conditions for current and future populations.
2. Economic sustainability: flexible systems, infrastructure, and technology able to provide for the needs of present and future populations, while ensuring that limited resources are used and maintained as effectively and efficiently as possible, without harming the biophysical environment.
3. Social sustainability: societies that are safe, secure, healthy, cohesive, content, and educated, with organizational frameworks and a creative capacity that allow limited resources to be shared equitably and in ways that ensure the needs of the present and future populations.

The proposed framework also takes into account the following sustainability, resilience, and health priorities:

1. Environmental priorities include energy, transportation, land use, water, and waste systems.
2. In the context of social exclusion, an analysis of the social state is important for understanding people's various needs. Participation is another important consideration, because sustainability involves networks of actors and institutions; thus, analyses of local actors' interactions modes are required. Local actors participate in both the regulation and the simulation of sustainable development, as well as participating in and influencing government regulations.
3. Economic priorities and financial resources should be taken into account, as the creation of an assessment tool for green building necessitates a financial budget. Financial resources are occasionally a significant barrier to growth. As there can be long delays for approval, the need for financing must be considered from the start of the proposal. Some of the areas covered by subsidies include planning, technical support, research (pilot studies, etc.), construction costs, actions advancing regional goals that are not locally cost-effective, and pay-for-performance incentives. However, operational and maintenance costs are not covered by subsidies.
4. It is important to lessen the potential effects of future pandemics on people's health and wellbeing, including effects on mental health and the promotion of psychological distress due to isolation and reduced social-networks. The needs of various age groups and demographics should be taken into account at the planning stages, emphasizing social and inclusive policies that could mitigate any effects of a pandemic and lockdown. In essence, it is necessary to attend to people's psychological, educational, social, health, and wellbeing needs.

5.2. The Conclusions, Recommendations, and Directions for Future Research

This paper aims to develop a framework for an assessment of the future city that captures the key aspects of the sustainability indicators, while addressing the urgent needs arising in the wake of the COVID-19 pandemic. The study focuses on the SDGs, and health and resilience requirements. Additionally, the study emphasizes an understanding of the complex relationships between the built environment, human behaviors, and people, to ensure the preparedness of our societies for the post-pandemic era. Thus, the study discusses the factors that affect the sustainability 2030 Agenda and health and resilience, as well as factors that affect human psychological needs, in order to redesign our built environment and the urban form of cities, to respond to future pandemics. This paper suggests an approach to developing tools for assessing the sustainability of cities in times of health crises. It presents new indicators and a framework for a future (sustainable, healthy, resilient and human) city-assessment tool, incorporating lessons learned from COVID-19, to ensure that cities are better prepared for future pandemics. The conceptual framework

shows how various tasks may fit into a cycle of repeated sustainability-assessment. It highlights the importance of methodological adaptability and triangulation when using a variety of sustainability tools to address changing local conditions. The framework also addresses challenging and contentious issues, as understanding these will offer the greatest chance of future growth.
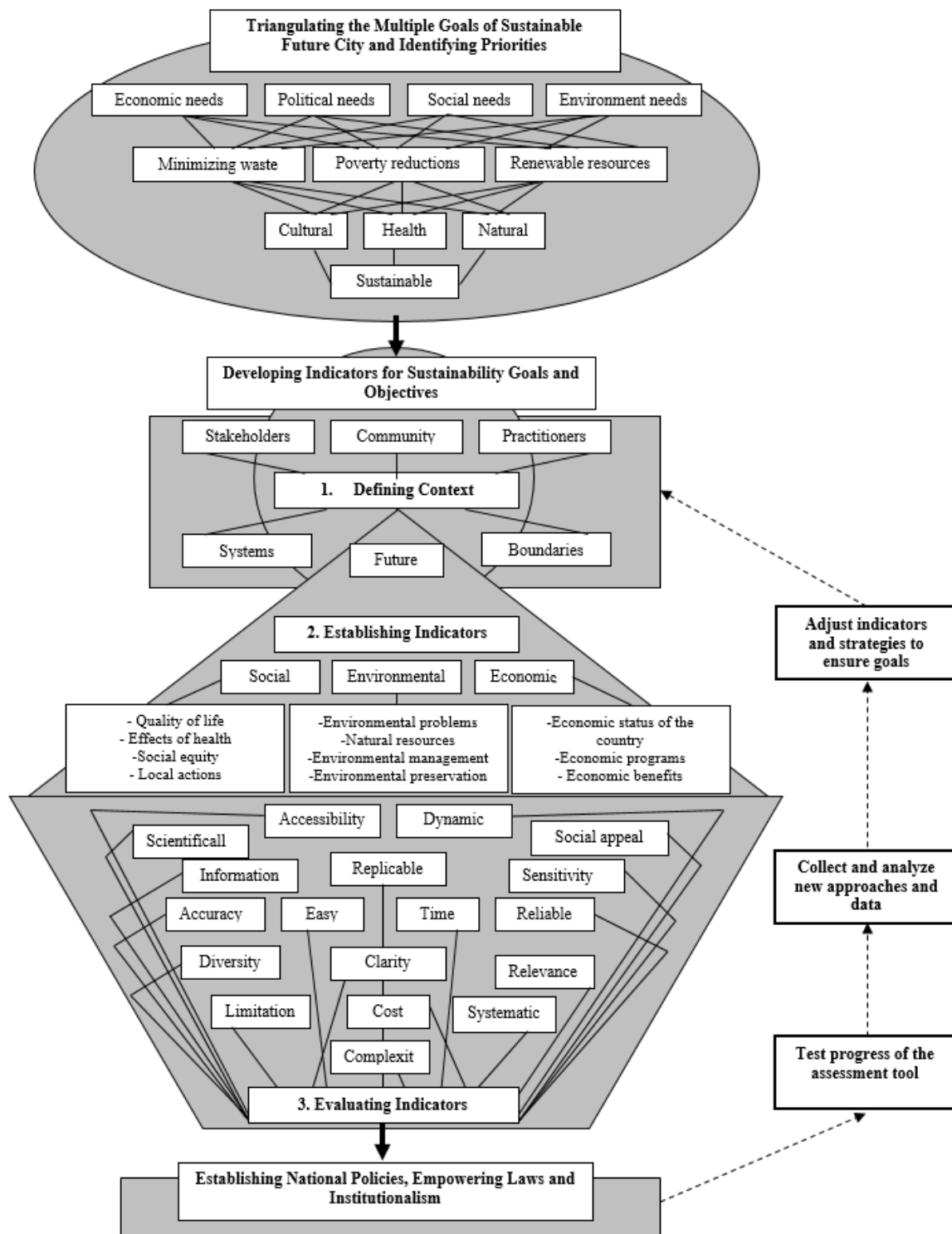

Figure 10. The proposed framework for assessing future (sustainable, health, resilient, human) cities (authors).

This paper concludes with several recommendations for creating an assessment framework for future cities. First, the development of such a framework should be supported by technical expertise and scientific research. Second, the development should be a participative and collaborative process, involving multiple stakeholders. The working group, agency participants, experts, and members of the public should all be identified as important players in the process. Third, the key objective should be to address sustainability strategies and goals. Fourth, the assessment framework should be appropriate for the city's local context, taking into account its culture, issues, residents, practices, and institutions. To advance their shared goals, each city or region must develop its own indicators. Fifth, urban communities can benefit from one another's ideas and work, and they should incorporate expert work into their discussions. Sixth, the framework for the assessment must be iterative. The feedback loop between tasks serves as a representation of this. The primary goal at the feedback stage is to gather information that is user-friendly, and to investigate the opportunities made possible by the new information technology in the new facilities. Seventh, the planning policies of cities can help people cope with major crises by facilitating meaningful experiences. Plans must be created to support the populace in developing coping mechanisms that allow them to maintain their health even in a context of isolation and reduced social-networks.

This structured investigation contributes to the discipline of urban planning studies, and documents the novelty of resilient and responsible urbanism, thus promoting health, environmental resilience, and livability in cities. However, the limitation of the study due to the lack of empirical investigation, should be considered. Therefore, future studies could carry out empirical research in developing the indicator system through establishing new indicators, defining the weighting system for establishing the importance of indicators, and defining their validity and reliability. In addition, it would be efficient to build upon this study to investigate how cities perform under other types of crises, such as a war of a sources crisis of water or energy, and develop assessment-indicator frameworks for cities, considering such circumstances. In addition, investigating the impact of technology and smart urban systems on city performance in pandemics would be interesting.

References

1. Newman, P.; Kenworthy, J. *Sustainability and Cities: Overcoming Automobile Dependence*; Island Press: Washington, DC, USA, 1999.
2. UN-Habitat—United Nations Human Settlements Programme. United Nations Human Settlements Programme (UN-Habitat)—Annual Report 2021; UN-Habitat: 2022. Available online: https://unhabitat.org/annual-report-2021 (accessed on 27 October 2022).
3. Patel, Z. Of questionable value: The role of practitioners in building sustainable cities. *Geoforum* **2006**, *37*, 682–694. [CrossRef]
4. Droege, P. The Renewable City: Dawn of an Urban Revolution. *Bull. Sci. Technol. Soc.* **2006**, *26*, 141–150. [CrossRef]
5. Holden, E.; Norland, I. Three Challenges for the Compact City as a Sustainable Urban Form: Household Consumption of Energy and Transport in Eight Residential Areas in the Greater Oslo Region. *Urban Stud.* **2005**, *42*, 2145–2166. [CrossRef]
6. Heinke, G.W. The Challenge of Urban Growth and Sustainable Development for Asian Cities in the 21st Century. *Environ. Monit. Assess.* **1997**, *44*, 155–171. [CrossRef]
7. Pradhan, P.; Costa, L.; Rybski, D.; Lucht, W.; Kropp, J.P. A Systematic Study of Sustainable Development Goal (SDG) Interactions. *Earth's Future* **2017**, *5*, 1169–1179. [CrossRef]
8. Hakovirta, M.; Denuwara, N. How COVID-19 Redefines the Concept of Sustainability. *Sustainability* **2020**, *12*, 3727. [CrossRef]

9.   Sharifi, A.; Khavarian-Garmsir, A.R. The COVID-19 pandemic: Impacts on cities and major lessons for urban planning, design, and management. *Sci. Total Environ.* **2020**, *749*, 142391. [CrossRef]

10.   UN-Habitat—United Nations Human Settlements Programme. Progress towards the Sustainable Development Goals. Report of the Secretary-General. 2020. Available online: https://sustainabledevelopment.un.org/content/documents/26158Final_SG_SDG_Progress_Report_14052020.pdf (accessed on 27 October 2022).

11.   Ellin, N. *Postmodern Urbanism*; Princeton Architectural Press: New York, NY, USA, 1999.

12.   Megahed, N.A.; Ghoneim, E.M. Antivirus-built environment: Lessons learned from COVID-19 pandemic. *Sustain. Cities Soc.* **2020**, *61*, 102350. [CrossRef]

13.   Allam, Z.; Jones, D.S. On the Coronavirus (COVID-19) Outbreak and the Smart City Network: Universal Data Sharing Standards Coupled with Artificial Intelligence (AI) to Benefit Urban Health Monitoring and Management. *Healthcare* **2020**, *8*, 46. [CrossRef]

14.   Haleem, A.; Javaid, M.; Vaishya, R. Effects of COVID-19 pandemic in daily life. *Curr. Med. Res. Pract.* **2020**, *10*, 78–79. [CrossRef]

15.   Saadat, S.; Rawtani, D.; Hussain, C.M. Environmental perspective of COVID-19. *Sci. Total Environ.* **2020**, *728*, 138870. [CrossRef] [PubMed]

16.   Worpole, K.; Knox, K.; Foundation, J.R. *The Social Value of Public Spaces*; Joseph Rowntree Foundation: York, UK, 2007.

17.   Alnusairat, S.; Al-Shatnawi, Z.; Ayyad, Y.; Alwaked, A.; Abuanzeh, N. Rethinking Outdoor Courtyard Spaces on University Campuses to Enhance Health and Wellbeing: The Anti-Virus Built Environment. *Sustainability* **2022**, *14*, 5602. [CrossRef]

18.   UN-Habitat—United Nations Human Settlements Programme. Cities and Pandemics: Towards a More Just; UN-Habitat: 2021. Available online: https://unhabitat.org/cities-and-pandemics-towards-a-more-just-green-and-healthy-future-0 (accessed on 27 October 2022).

19.   Ali, H.H.; Al Nsairat, S.F. Developing a green building assessment tool for developing countries—Case of Jordan. *Build Environ.* **2009**, *44*, 1053–1064. [CrossRef]

20.   Libovich, A. Assessing green building for sustainable cities. In Proceedings of the World Sustainable Building Conference (SB05Tokyo), Tokyo, Japan, 27–29 September 2005; pp. 1968–1971.

21.   Gibbard, S.; Caldeira, K.; Bala, G.; Phillips, T.J.; Wickett, M. Climate effects of global land cover change. *Geophys. Res. Lett.* **2005**, *32*, 1–4. [CrossRef]

22.   Ness, B.; Urbel-Piirsalu, E.; Anderberg, S.; Olsson, L. Categorising tools for sustainability assessment. *Ecol. Econ.* **2007**, *60*, 498–508. [CrossRef]

23.   Yoon, S.W.; Lee, D.K. The development of the evaluation model of climate changes and air pollution for sustainability of cities in Korea. *Landsc. Urban Plan.* **2003**, *63*, 145–160. [CrossRef]

24.   Assefa, G.; Frostell, B. Social sustainability and social acceptance in technology assessment: A case study of energy technologies. *Technol. Soc.* **2007**, *29*, 63–78. [CrossRef]

25.   National Research Council, U.S.A. *Our Common Journey: A Transition toward Sustainability*; Athens Center of Ekistics: Washington, DC, USA, 1999; Volume 66, pp. 82–101. Available online: http://www.jstor.org/stable/43623329 (accessed on 27 October 2022).

26.   UNCHS—United Nations Centre for Human Settlements (Habitat). *Cities in a Globalizing World: Global Report on Human Settlements*; Routledge: London, UK, 2001.

27.   Whitehead, M. (Re)Analysing the Sustainable City: Nature, Urbanisation and the Regulation of Socio-environmental Relations in the UK. *Urban Stud.* **2003**, *40*, 1183–1206. [CrossRef]

28.   Valentin, A.; Spangenberg, J.H. A guide to community sustainability indicators. *Environ. Impact Assess. Rev.* **2000**, *20*, 381–392. [CrossRef]

29.   De Jong, M.; Joss, S.; Schraven, D.; Zhan, C.; Weijnen, M. Sustainable–smart–resilient–low carbon–eco–knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization. *J. Clean. Prod.* **2015**, *109*, 25–38. [CrossRef]

30.   Bibri, S.E.; Krogstie, J. Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustain. Cities Soc.* **2017**, *31*, 183–212. [CrossRef]

31.   Martins, F.; Patrão, C.; Moura, P.; de Almeida, A.T. A Review of Energy Modeling Tools for Energy Efficiency in Smart Cities. *Smart Cities* **2021**, *4*, 1420–1436. [CrossRef]

32.   Schraven, D.; Joss, S.; de Jong, M. Past, present, future: Engagement with sustainable urban development through 35 city labels in the scientific literature 1990–2019. *J. Clean. Prod.* **2021**, *292*, 125924. [CrossRef]

33.   Höjer, M.; Wangel, J. Smart Sustainable Cities: Definition and Challenges. In *ICT Innovations for Sustainability*; Advances in Intelligent Systems and Computing; Springer: Berlin/Heidelberg, Germany, 2015; pp. 333–349. [CrossRef]

34.   De Schiller, S.; Martin Evans, J. Sustainable urban development: Design guidelines for warm humid cities. *URBAN Des. Int.* **1998**, *3*, 165–184. [CrossRef]

35.   Innes, J.; Booher, D. Indicators for Sustainable Communities: A Strategy Building on Complexity Theory and Distributed Intelligence. *Plan. Theory Pract.* **2000**, *1*, 173–186. [CrossRef]

36.   Wu, J.; Wu, T. Sustainability indicators and indices: An overview. In *Handbook of Sustainability Management*; World Scientific Publishing Co.: Singapore, 2012; pp. 65–86.

37.   Chao, A.L.; Lopez, A.; Gallego, A.C.; Alvarellos, A. Indicators Framework for Sustainable Urban Design. *Atmosphere* **2020**, *11*, 1143. [CrossRef]

38.   Lipošćak, M.; Afgan, N.H.; Duić, N.; da Graça Carvalho, M. Sustainability assessment of cogeneration sector development in Croatia. *Energy* **2006**, *31*, 2276–2284. [CrossRef]

39. Satterthwaite, D. Sustainable Cities or Cities that Contribute to Sustainable Development? *Urban Stud.* **1997**, *34*, 1667–1691. [CrossRef]

40. Wiek, A.; Binder, C. Solution spaces for decision-making—A sustainability assessment tool for city-regions. *Environ. Impact Assess. Rev.* **2005**, *25*, 589–608. [CrossRef]

41. Ross, S.; Evans, D. Use of life cycle assessment in environmental management. *Environ. Manag.* **2002**, *29*, 132–142. [CrossRef]

42. Hardi, P.; Zdan, T.J. *Assessing Sustainable Development: Principles in Practice*; Hardi, P., Ed.; International Institute for Sustainable Development: Winnipeg, MB, Canada, 1997.

43. Devuyst, D. Linking impact assessment and sustainable development at the local level: The introduction of sustainability assessment systems. *Sustain. Dev.* **2000**, *8*, 67–78. [CrossRef]

44. Haughton, G. Searching for the Sustainable City: Competing Philosophical Rationales and Processes of 'Ideological Capture' in Adelaide, South Australia. *Urban Stud.* **1999**, *36*, 1891–1906. [CrossRef]

45. Bell, S.; Morse, S. Sustainability Indicators Past and Present: What Next? *Sustainability* **2018**, *10*, 1688. [CrossRef]

46. Cohen, M. A Systematic Review of Urban Sustainability Assessment Literature. *Sustainability* **2017**, *9*, 2048. [CrossRef]

47. Huang, L.; Wu, J.; Yan, L. Defining and measuring urban sustainability: A review of indicators. *Landsc. Ecol.* **2015**, *30*, 1175–1193. [CrossRef]

48. Michalina, D.; Mederly, P.; Diefenbacher, H.; Held, B. Sustainable Urban Development: A Review of Urban Sustainability Indicator Frameworks. *Sustainability* **2021**, *13*, 9348. [CrossRef]

49. Ahvenniemi, H.; Huovila, A.; Pinto-Seppä, I.; Airaksinen, M. What are the differences between sustainable and smart cities? *Cities* **2017**, *60*, 234–245. [CrossRef]

50. Spangenberg, J.H. Scenarios and Indicators for Sustainable Development: Towards a Critical Assessment of Achievements and Challenges. *Sustainability* **2019**, *11*, 942. [CrossRef]

51. Mori, K.; Christodoulou, A. Review of sustainability indices and indicators: Towards a new City Sustainability Index (CSI). *Environ. Impact Assess. Rev.* **2012**, *32*, 94–106. [CrossRef]

52. Lee, Y.-J.; Huang, C.-M. Sustainability index for Taipei. *Environ. Impact Assess. Rev.* **2007**, *27*, 505–521. [CrossRef]

53. Choon, S.-W.; Siwar, C.; Pereira, J.J.; Jemain, A.A.; Hashim, H.S.; Hadi, A.S. A sustainable city index for Malaysia. *Int. J. Sustain. Dev. World Ecol.* **2011**, *18*, 28–35. [CrossRef]

54. Lu, C.; Xue, B.; Lu, C.; Wang, T.; Jiang, L.; Zhang, Z.; Ren, W. Sustainability Investigation of Resource-Based Cities in Northeastern China. *Sustainability* **2016**, *8*, 1058. [CrossRef]

55. Yin, Y.; Xu, W.; Zhou, S. Linking carbon sequestration science with local sustainability: An integrated assessment approach. *J. Environ. Manage.* **2007**, *85*, 711–721. [CrossRef] [PubMed]

56. Osman, T.; Kenawy, E.; Abdrabo, K.I.; Shaw, D.; Alshamndy, A.; Elsharif, M.; Salem, M.; Alwetaishi, M.; Aly, R.M.; Elboshy, B. Voluntary Local Review Framework to Monitor and Evaluate the Progress towards Achieving Sustainable Development Goals at a City Level: Buraidah City, KSA and SDG11 as A Case Study. *Sustainability* **2021**, *13*, 9555. [CrossRef]

57. Siragusa, A.; Vizcaino, P.; Corbane, C.; Politis, P. *SDG 11 Synthesis Report to the High Level Political Forum 2018. Tracking Progress Towards Inclusive, Safe, Resilient and Sustainable Cities and Human Settlements*; United Nations Publications, Ed.; United Nations: New York, NY, USA, 2018.

58. European Commission. The Future of Cities, Opportunities, Challenges and the Way Forward. 2019. Available online: https://urban.jrc.ec.europa.eu/thefutureofcities/the-resilien-city#the-chapter (accessed on 27 October 2022).

59. Ramirez-Rubio, O.; Daher, C.; Fanjul, G.; Gascon, M.; Mueller, N.; Pajín, L.; Plasencia, A.; Rojas-Rueda, D.; Thondoo, M.; Nieuwenhuijsen, M.J. Urban health: An example of a "health in all policies" approach in the context of SDGs implementation. *Glob. Health* **2019**, *15*, 87. [CrossRef]

60. Salem, M.; Tsurusaki, N.; Divigalpitiya, P.; Kenawy, E. An Effective Framework for Monitoring and Measuring the Progress towards Sustainable Development in the Peri-Urban Areas of the Greater Cairo Region, Egypt. *World* **2020**, *1*, 1–19. [CrossRef]

61. Van Zanten, J.A.; van Tulder, R. Beyond COVID-19: Applying "SDG logics" for resilient transformations. *J. Int. Bus. Policy* **2020**, *3*, 451–464. [CrossRef]

62. Alibegovic, M.; Cavalli, L.; Lizzi, G.; Romani, I.; Vergalli, S. COVID-19 & SDGs: Does the Current Pandemic have an Impact on the 17 Sustainable Development Goals? A Qualitative Analysis 2020, FEEM Policy Brief No. 07-2020. Available online: https://ssrn.com/abstract=3711326 (accessed on 27 October 2022).

63. Naidoo, R.; Fisher, B. Reset Sustainable Development Goals for a pandemic world. *Nature* **2020**, *583*, 198–201. [CrossRef]

64. OECD. *Building Resilience: New Strategies for Strengthening Infrastructure Resilience and Maintenance*; OECD Public Governance Policy Papers; OECD Publishing: Paris, France, 2021. [CrossRef]

65. Beatley, T.; Newman, P. Biophilic Cities Are Sustainable, Resilient Cities. *Sustainability* **2013**, *5*, 3328–3345. [CrossRef]

66. Grafakos, S.; Gianoli, A.; Tsatsou, A. Towards the Development of an Integrated Sustainability and Resilience Benefits Assessment Framework of Urban Green Growth Interventions. *Sustainability* **2016**, *8*, 461. [CrossRef]

67. Daudey, L.; Matsumoto, T. Integrating urban resilience and resource efficiency into local green growth strategies: The case of fast-growing cities in Southeast Asia. *Int. J. Urban Sustain. Dev.* **2017**, *9*, 226–241. [CrossRef]

68. Dias, N.; Jayakody, C.; Amaratunga, P.; Abenayake, C.; Jayasinghe, A. Health resilient cities in a post COVID world. In *COVID 19: Impact, Mitigation, Opportunities and Building Resilience*; National Science Foundation: Colombo, Sri Lanka, 2021; pp. 621–635.

69. Nutbeam, D. Health Promotion Glossary. *Health Promot. Int.* **1998**, *13*, 349–364. [CrossRef]

70. Dannenberg, A.L.; Jackson, R.J.; Frumkin, H.; Schieber, R.A.; Pratt, M.; Kochtitzky, C.; Tilson, H.H. The impact of community design and land-use choices on public health: A scientific research agenda. *Am. J. Public Health* **2003**, *93*, 1500–1508. [CrossRef] [PubMed]

71. Dora, C.; Haines, A.; Balbus, J.; Fletcher, E.; Adair-Rohani, H.; Alabaster, G.; Hossain, R.; de Onis, M.; Branca, F.; Neira, M. Indicators linking health and sustainability in the post-2015 development agenda. *Lancet* **2015**, *385*, 380–391. [CrossRef]

72. Hancock, T. It's the environment, stupid! Declining ecosystem health is THE threat to health in the 21st century. *Health Promot. Int.* **2011**, *26* (Suppl. 2), ii168–ii172. [CrossRef]

73. Crane, M.; Lloyd, S.; Haines, A.; Ding, D.; Hutchinson, E.; Belesova, K.; Davies, M.; Osrin, D.; Zimmermann, N.; Capon, A.; et al. Transforming cities for sustainability: A health perspective. *Environ. Int.* **2021**, *147*, 106366. [CrossRef]

74. Wulff, K.; Donato, D.; Lurie, N. What is health resilience and how can we build it? *Annu. Rev. Public Health* **2015**, *36*, 361–374. [CrossRef]

75. Elgheznawy, D.; Eltarabily, S. Post-Pandemic Cities—The Impact of COVID-19 on Cities and Urban Design. *Archit. Res.* **2020**, *10*, 75–84. [CrossRef]

76. Reyes, R.; Ahn, R.; Thurber, K.; Burke, T.F. Urbanization and Infectious Diseases: General Principles, Historical Perspectives, and Contemporary Challenges. In *Challenges in Infectious Diseases*; Springer: Berlin/Heidelberg, Germany, 2013; pp. 123–146.

77. Grijalba Castro, A.I.; Ramírez López, L.J. Sustainability and Resilience of Emerging Cities in Times of COVID-19. *Sustainability* **2021**, *13*, 9480. [CrossRef]

78. Santa, S.L.B.; Cremonezi, G.O.G.; Soares, T.C.; Deggau, A.B.; de Andrade Guerra, J.B.S.O. Healthy Sustainable Cities and the COVID-19 Pandemic: A Sustainable Development Goals Perspective. In *COVID-19: Environmental Sustainability and Sustainable Development Goals*; Muthu, S.S., Ed.; Springer: Singapore, 2021; pp. 141–167. [CrossRef]

79. Suriyankietkaew, S.; Nimsai, S. COVID-19 Impacts and Sustainability Strategies for Regional Recovery in Southeast Asia: Challenges and Opportunities. *Sustainability* **2021**, *13*, 8907. [CrossRef]

80. Nieuwenhuijsen, M.J. Urban and transport planning, environmental exposures and health-new concepts, methods and tools to improve health in cities. *Environ. Health A Glob. Access Sci. Source* **2016**, *15* (Suppl. 1), 38. [CrossRef] [PubMed]

81. Wernli, D.; Antulov-Fantulin, N.; Berezowksi, J.; Biller-Andorno, N. *Governance in the Age of Complexity: Building Resilience to COVID-19 and Future Pandemics*; Geneva Science Policy Interface: Geneva, Switzerland, 2021.

82. Lak, A.; Hakimian, P.; Sharifi, A. An evaluative model for assessing pandemic resilience at the neighborhood level: The case of Tehran. *Sustain. Cities Soc.* **2021**, *75*, 103410. [CrossRef] [PubMed]

83. Alnusairat, S.; Ayyad, Y.; Al-Shatnawi, Z. Towards Meaningful University Space: Perceptions of the Quality of Open Spaces for Students. *Buildings* **2021**, *11*, 556. [CrossRef]

84. Idoiaga, N.; Berasategi, N.; Eiguren, A.; Picaza, M. Exploring Children's Social and Emotional Representations of the COVID-19 Pandemic. *Front. Psychol.* **2020**, *11*, 1952. [CrossRef] [PubMed]

85. Rodríguez-Rey, R.; Garrido-Hernansaiz, H.; Collado, S. Psychological Impact and Associated Factors During the Initial Stage of the Coronavirus (COVID-19) Pandemic Among the General Population in Spain. *Front. Psychol.* **2020**, *11*, 1540. [CrossRef] [PubMed]

86. Simione, L.; Gnagnarella, C. Differences Between Health Workers and General Population in Risk Perception, Behaviors, and Psychological Distress Related to COVID-19 Spread in Italy. *Front. Psychol.* **2020**, *11*, 2166. [CrossRef]

87. Schnell, T.; Krampe, H. Meaning in Life and Self-Control Buffer Stress in Times of COVID-19: Moderating and Mediating Effects with Regard to Mental Distress. *Front. Psychiatry* **2020**, *11*, 582352. [CrossRef]

88. Roychowdhury, D. 2019 Novel Coronavirus Disease, Crisis, and Isolation. *Front. Psychol.* **2020**, *11*, 1958. [CrossRef]

89. González-Sanguino, C.; Ausín, B.; Castellanos, M.; Saiz, J.; López-Gómez, A.; Ugidos, C.; Muñoz, M. Mental Health Consequences of the Coronavirus 2020 Pandemic (COVID-19) in Spain. A Longitudinal Study. *Front. Psychiatry* **2020**, *11*, 565474. [CrossRef]

90. Ghiretti, F.; Gildoni, G.; Grassi, G.M.; Torricelli, L.; Benassi, E.; Bonaretti, E.; Bonazzi, F.; Borelli, S.; Cagnolati, F.; Covati, K.; et al. Psychological Support to the Community During the COVID-19 Pandemic: Field Experience in Reggio Emilia, Northern Italy. *Front. Psychol.* **2020**, *11*, 561742. [CrossRef]

91. Al-Tammemi, A.a.B.; Akour, A.; Alfalah, L. Is It Just About Physical Health? An Online Cross-Sectional Study Exploring the Psychological Distress Among University Students in Jordan in the Midst of COVID-19 Pandemic. *Front. Psychol.* **2020**, *11*, 562213. [CrossRef]

92. Provenzi, L.; Baroffio, E.; Ligabue, S.; Borgatti, R. The Little Professor and the Virus: Scaffolding Children's Meaning Making During the COVID-19 Emergency. *Front. Psychiatry* **2020**, *11*, 817. [CrossRef] [PubMed]

93. Rijsberman, M.A.; van de Ven, F.H.M. Different approaches to assessment of design and management of sustainable urban water systems. *Environ. Impact Assess. Rev.* **2000**, *20*, 333–345. [CrossRef]

94. Reed, M.S.; Fraser, E.D.G.; Dougill, A.J. An adaptive learning process for developing and applying sustainability indicators with local communities. *Ecol. Econ.* **2006**, *59*, 406–418. [CrossRef]

95. Henzler, K.; Maier, S.D.; Jäger, M.; Horn, R. SDG-Based Sustainability Assessment Methodology for Innovations in the Field of Urban Surfaces. *Sustainability* **2020**, *12*, 4466. [CrossRef]

96. Maier, S.D.; Beck, T.; Francisco Vallejo, J.; Horn, R.; Söhlemann, J.-H.; Nguyen, T.T. Methodological Approach for the Sustainability Assessment of Development Cooperation Projects for Built Innovations Based on the SDGs and Life Cycle Thinking. *Sustainability* **2016**, *8*, 1006. [CrossRef]

97. Muench, S.; Anderson, J.; Bevan, T. Greenroads: A Sustainability Rating System for Roadways. *Int. J. Pavement Res. Technol.* **2010**, *3*, 270–279.
98. Giles-Corti, B.; Lowe, M.; Arundel, J. Achieving the SDGs: Evaluating indicators to be used to benchmark and monitor progress towards creating healthy and sustainable cities. *Health Policy* **2020**, *124*, 581–590. [CrossRef]
99. Anand, A.; Winfred Rufuss, D.D.; Rajkumar, V.; Suganthi, L. Evaluation of Sustainability Indicators in Smart Cities for India Using MCDM Approach. *Energy Procedia* **2017**, *141*, 211–215. [CrossRef]
100. Boltze, M.; Tuan, V.A. Approaches to Achieve Sustainability in Traffic Management. *Procedia Eng.* **2016**, *142*, 205–212. [CrossRef]
101. García López, J.; Sisto, R.; Benayas, J.; de Juanes, Á.; Lumbreras, J.; Mataix, C. Assessment of the Results and Methodology of the Sustainable Development Index for Spanish Cities. *Sustainability* **2021**, *13*, 6487. [CrossRef]
102. Guillén-Mena, V.; Martin, K.; Irulegi, O. Review of indicators for the definition of sustainable cities. Action criteria. In Proceedings of the 12th European Conference on Energy Efficiency and Sustainability in Architecture and Planning, Bilbao, Spain, 29–30 September 2021; pp. 75–88.
103. Fawzy, N.; Ammer, S.; Abdalmoity, E. Requirements for Reaching the Sustainable Goals of Development to Plan New Areas in Arab Republic of Egypt. *Int. J. Sustain. Dev. Plan.* **2021**, *16*, 579–590. [CrossRef]
104. Salem, M.; Tsurusaki, N.; Divigalpitiya, P.; Osman, T.; Hamdy, O.; Kenawy, E. Assessing Progress Towards Sustainable Development in the Urban Periphery: A Case of Greater Cairo, Egypt. *Int. J. Sustain. Dev. Plan.* **2020**, *15*, 971–982. [CrossRef]
105. Sharifi, A. A critical review of selected smart city assessment tools and indicator sets. *J. Clean. Prod.* **2019**, *233*, 1269–1283. [CrossRef]
106. Kaur, H.; Garg, P. Urban sustainability assessment tools: A review. *J. Clean. Prod.* **2019**, *210*, 146–158. [CrossRef]
107. Hong, S.; Kweon, I.; Lee, B.-H.; Kim, H. Indicators and Assessment System for Sustainability of Municipalities: A Case Study of South Korea's Assessment of Sustainability of Cities (ASC). *Sustainability* **2019**, *11*, 6611. [CrossRef]
108. Qahtany, A.A.; Rezgui, Y.; Li, H. A consensus-based framework for the sustainable urban planning development: 'As an approach for Saudi Arabian cities'. *Int. J. Environ. Sci. Dev.* **2014**, *5*, 124–131. [CrossRef]
109. Breckenridge, R.P.; Kepner, W.G.; Mouat, D.A. A process for selecting indicators for monitoring conditions of rangeland health. *Environ. Monit. Assess.* **1995**, *36*, 45–60. [CrossRef]
110. UNCCD—United Nations Convention to Combat Desertification. Elaboration of an International Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa: Final Text of the Convention—Note by the Secretariat; United Nations: 1994. Available online: https://wedocs.unep.org/20.500.11822/27569 (accessed on 6 December 2022).
111. Abbot, J.; Guijt, I. *Changing Views on Change: Participatory Approaches to Monitoring the Environment*; International Institute for Environment and Development: London, UK, 1998.
112. Rubio, J.L.; Bochet, E. Desertification indicators as diagnosis criteria for desertification risk assessment in Europe. *J. Arid Environ.* **1998**, *39*, 113–120. [CrossRef]
113. Freebairn, D.M.; King, C.A. Reflections on collectively working toward sustainability: Indicators for indicators! *Aust. J. Exp. Agric.* **2003**, *43*, 223–238. [CrossRef]
114. Swart, R.; Raskin, P.; Robinson, J. Critical challenges for sustainability science. *Science* **2002**, *297*, 1994–1995. [CrossRef] [PubMed]
115. Zhen, L.; Routray, J.K. Operational indicators for measuring agricultural sustainability in developing countries. *Environ. Manag.* **2003**, *32*, 34–46. [CrossRef] [PubMed]
116. Krugman, P. Urban Concentration: The Role of Increasing Returns and Transport Costs. *Int. Reg. Sci. Rev.* **1996**, *19*, 5–30. [CrossRef]
117. United Nations Commission on Sustainable Development. *Changing Consumption Patterns: Report of the Secretary-General, Commission on Sustainable Development Acting as the Preparatory Committee for the World Summit on Sustainable Development*; United Nations: New York, NY, USA, 2001.
118. Pieri, C.; Dumanski, J.; Hamblin, A.; Young, A. *Land Quality Indicators*; World Bank: Washington, DC, USA, 1995.
119. Gibson, R.B.; Hassan, S.; Holtz, S.; Tansey, J.; Whitelaw, G. *Sustainability Assessment: Criteria and Processes*; Taylor & Francis: Abingdon, UK, 2013. [CrossRef]
120. Mitchell, G.; May, A.; McDonald, A. PICABUE: A methodological framework for the development of indicators of sustainable development. *Int. J. Sustain. Dev. World Ecol.* **1995**, *2*, 104–123. [CrossRef]
121. Balachandra, P.; Sudhakara Reddy, B. *Benchmarking Bangalore City for Sustainability—An Indicator-Based Approach*; The Center for Infrastructure, Sustainable Transportation and Urban Planning Indian Institute of Science: Bangalore, India, 2012.