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REVIEW
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Revisiting Urban Resilience: A Review on Resilience of Spatial Structure in Urban Refugee Neighborhoods Facing Demographic Changes

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Providing a durable and sustainable approach based on urban resilience is essential for solving many spatial challenges in neighborhoods with sudden refugee influxes. As refugees settle in different locations in host cities, many of these neighborhoods have high urbanization, poor infrastructure, and over-population and their conditions impact their urban stability, livability, and quality of life. Hence, this study will review the urban resilience literature focusing on a set of resilient spatial elements of a neighborhood to support the design and planning of refugee settings. First, the theories of urban resilience are reviewed to identify the characteristics of resilience and classify the reviewed literature by different focused categories of spatial resilience. Second, the resiliency of spatial structure are explored focusing on the links between resilient characteristics and urban form attributes at the neighborhood scale. The review summarizes a set of resilient spatial measurements that use urban form indicators of resilient characteristics facilitated by geospatial technologies. Further, a framework of resilient spatial structure for refugee neighborhoods is proposed using existing urban resilience frameworks. The proposed framework includes factors of urban form attributes at the neighborhood scales (e.g., blocks, plots, and building scale), resilience in refugee contexts, and urban resilience mechanisms. The study is not limited to providing an operative resilience knowledge. It provides spatial strategies for humanitarian organizations and inter-governmental agencies to improve the vulnerable spatial structures of refugee settings and to broaden opportunities for the assessment, profiling, communication, monitoring, and planning of resilient refugee neighborhoods.

Keywords: resilient urban form, resiliency of refugee settings, resilient neighborhoods, resiliency in developing cities, urban stability, livability

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INTRODUCTION

The world faces complex humanitarian emergencies including warfare (Shaluf, 2007). The crisis of warfare threatens safety, wellbeing, health, and security of communities and individuals (Coalition, 2013). The main features and consequences of warfare are decades of displacements and millions of Forced Migrants (Newman and Van Selm, 2003). This mass displacement of Forced Migrants causes permanent or semi-permanent changes of residence due to the continued existence of the crisis.

While not an international legal concept, Forced Migration includes refugees, internally displaced people (IDPs), asylum seekers, and others (Castles, 2003). Refugees flee their origin country and cross international borders, and cannot return home often due to wars, persecution, and violence (Kennedy, 2008). Currently, there are many refugee settlements in the world but more specifically in developing countries (McAdam, 2018). They settle in scattered refugee camps or urban neighborhoods in cities of host countries and transform these locations physically, socially, and economically. In fact, according to some sources, about 60% of refugees are classified as urban refugees who live in urban areas of host cities (Park, 2016). Therefore, refugees create sudden and rapid stress on urbanization with unexpected economic activities, uncertain political issues, and new social fabrics.

The relationships between refugee communities, host cities, and inter-governmental organizations are complex. In general, refugees are described as invisible, hidden, and marginalized. Refugees as a disadvantaged community suffer from economic frustrations and exclusion (Valtonen, 2004; Blocher and Gulati, 2016). Unfortunately, children and women make more than 50% of refugees (DATA, 2019), who face health problems, psychological disturbances (Fazel and Stein, 2003), and identity issues (Smith, 2013). A critical challenge is identifying the conditions of refugee settings for proper considerations in the official management of these settings (Sajjad et al., 2020). Often, refugee neighborhoods face spatial challenges such as a lack of urban services, accessibility, and spaces for social activities due to a sudden increase in population (Blank, 2019; Tsavdaroglou, 2020). Therefore, there is an urgent need to study refugee situations to understand their everyday experiences, struggles, and aspirations.

To fill-in the gap, this study focuses on examining the spatial conditions of refugee neighborhoods in host countries. It aims to help build some knowledge on how urban resilience can contribute to the improvement of these neighborhoods. Traditional refugee protection procedures and solutions include quick and short-term responses focused on basic needs. These procedures and solutions show the discontinuation between the reality of refugee living and official policies and practices. In contrast, urban resilience is a more long-term solution that prepares the urban system for any future disturbances. So far, the resilient approach has been inadequately explored concerning refugee settings and their spatial structure in relation to the specific stress of demographic changes. Therefore, this research will develop and apply tools and techniques to improve urban resiliency using spatial structures. Moreover, the qualities of resilient urban system should help decision-makers understand the importance of spatial resilience while preparing for refugee influxes, and help international organizations think beyond the current protection strategies to develop urban resilience.

In this article, the literature is reviewed exploring urban resilience and resilient urban form. It contains an overview of urban resiliency types, approaches, characteristics, solutions, and measurements focusing on urban form. It also contains the social aspect of urban resilience. Additionally, it reviews the conceptual frameworks pertaining to urban form resilience associated with refugee neighborhoods.

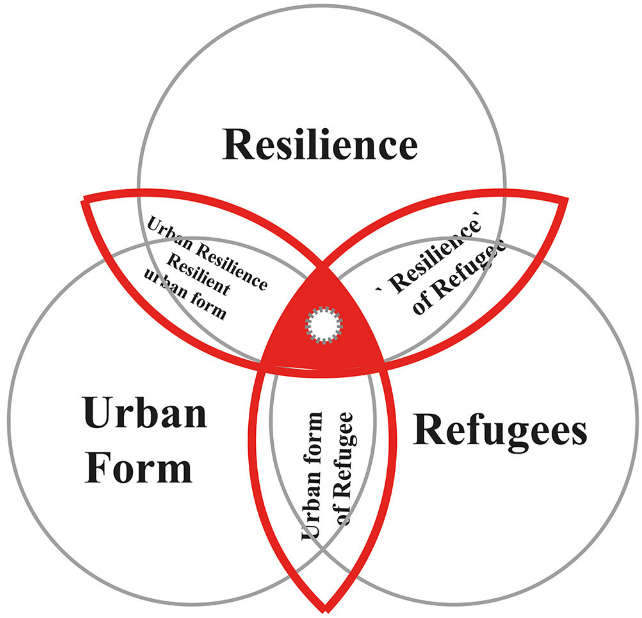

FIGURE 1 | The three research domains.

RESILIENT URBAN FORM OF REFUGEE NEIGHBORHOODS

The main reason for the vulnerability of the refugee context is sudden refugee influxes that shape cities as these cities continue to accept uncertain numbers of these influxes at unexpected intervals as long as the reasons for the crisis continue to exist (Kirbyshire et al., 2017). Thus, the refugee setting is one of non-equilibrium urban formation (Sullivan and Homewood, 2003) where pressure and demands on urban systems and components including housing and urban services exist. Therefore, this study considers the resilient urban form of refugee neighborhoods in the following three research domains: Urban Resilience or Resilient Urban Form, Urban Forms of Refugees, and Resilience of Refugee (**Figure 1**).

The study focuses on the resilient urban form because an adequate response to population influx challenges is important to prepare the urban system, sub-system, and components (Kirbyshire et al., 2017). In this regard, the literature on urban refugees in cities shows their neighborhoods with low accommodation standards, informal processes, and poorly designed overcrowded housing (Alhusban et al., 2019). The literature also shows poor public transportation, less accessibility to amenities, and a lack of open spaces (Alhusban et al., 2019). Moreover, refugees influence their urban form settings with physical and spatial characteristics of their previous neighborhoods for a better sense of place (Mazumdar et al., 2000). Therefore, refugee waves change and transform the social context in an incoherent manner and the physical context with informality and unknown architectural styles.

In the domain of "resilience of refugee," resilience expands to empower refugees by including specific resilience strategies accounting for behaviors, resources, components, and conditions to work in refugee settings (Netto et al., 2021). The resiliency approach provides an opportunity for a more suitable solution for all residents while preparing the urban system, sub-system, and components for population influx challenges (Kirbyshire et al., 2017). More particularly, a community resilience approach enhances the relationship of the people-place relationship as part of the integrated approach of refugees in their urban contexts and building their social capital (Berkes and Ross, 2013; Tippens, 2020). Eventually, the main objective for the resilience of refugees is a reduction of risks using urban resilience in their geographic places.

This study develops a conceptual framework that is based on the literature review of the three domains. The flow diagram in **Figure 2** helps understand the three domains of the framework. The framework shows the resilient urban form domain as three temporal phases: pre-, during-, and post-disaster or disturbance. Resiliency has different functions in these temporal phases related to maintenance and resistance, recovery, adaptation, and transformation. In the resilience of refugee domain, the refugee contexts can employ resilience concept in many physical, community, individual, economic, and policy aspects. The aspects involve different agents and their institutions including refugee and citizen population besides host governments and humanitarian organizations. Meanwhile, the urban form of refugee domain consists different refugee settings namely: refugee camps, urban refugee neighborhoods, and refugee resettlement areas. However, the article will focus on engaging resilience in physical structures due to refugee influxes

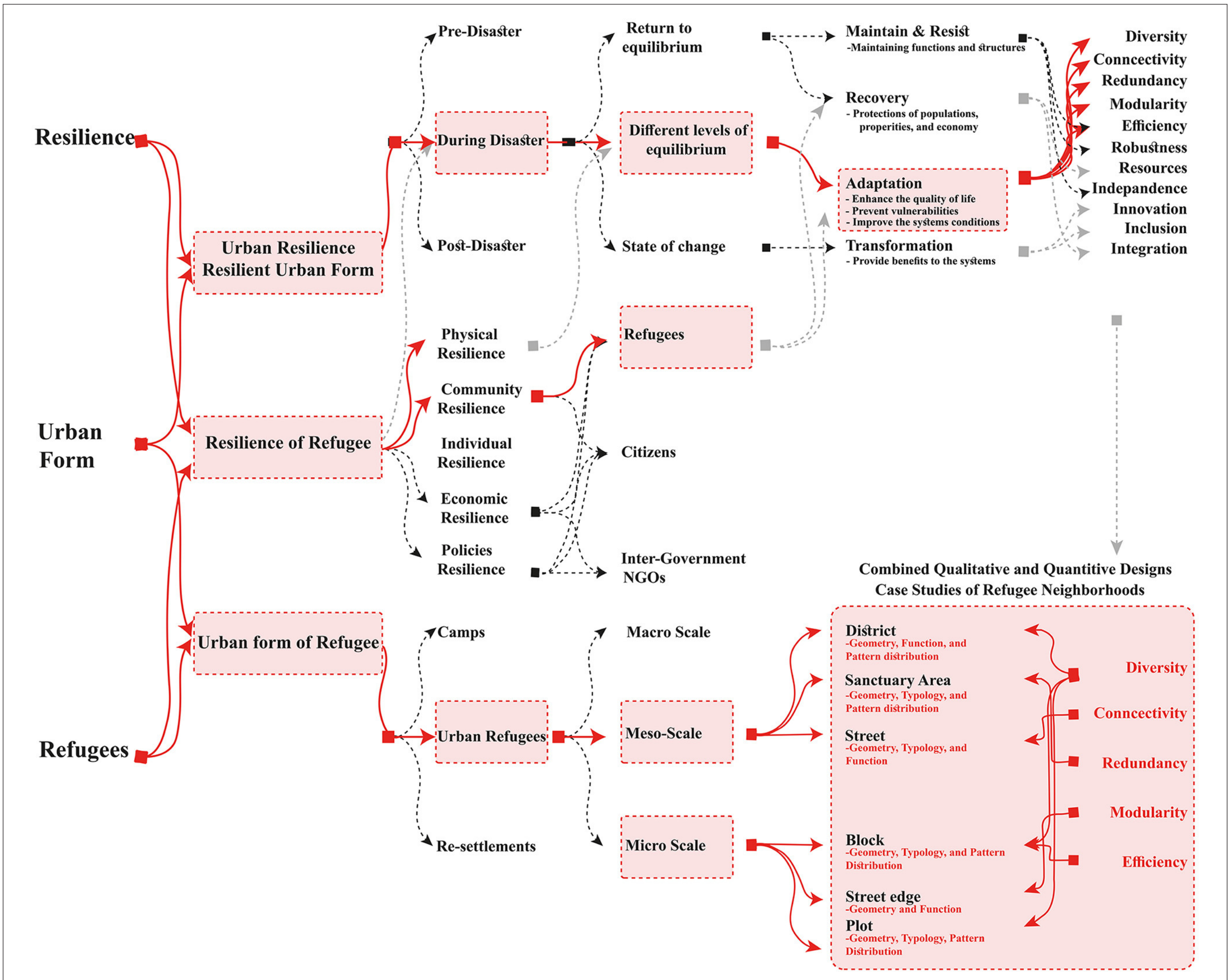

FIGURE 2 | The conceptual framework.

and consequent demographic changes. The article will also focus on urban forms attributes and will provide a resilient assessment tool by using metric-based methods for different morphological scales. Generally, the framework highlights the contribution of this research to the study of resilient morphological components combining qualitative and quantitative approaches. Accordingly, the review materials were collected through different research databases, such as google scholar and Scopus. For measurable resilient characteristics of urban forms, the review considered the following set of physical factors:

1) geometry (layout, height, numbers),
2) pattern distribution (density, relationship),
3) typology (type of routes, spaces), and
4) functioning (land use, transit).

The review expanded on the operational definitions of resilient characteristics and included measurements to quantify the resilient urban form of refugee neighborhoods. The measurements test the resilient urban form using numeric and visual representations of resilient characteristics through descriptive analysis. The measurements are metric-based assessment of resilience that indicate different urban form attributes within the spatial scales of neighborhoods (Sajjad et al., 2021). The spatial resilience supports community resilience in neighborhoods especially for the refugee population, therefore this enhances the overall urban resilience. However, this study focuses on the resilient urban form of refugee neighborhoods only recognizing that economic, social, and environmental indicators of urban resilience are also important in the refugee context.

URBAN RESILIENCE (OR, RESILIENT URBAN FORM)

Nowadays, resilience is a promising concept in different areas of research including ecology, psychology, sociology, and urban design and planning. In terms of urban systems, resilience has been expanded from the details of our built environment to the major and comprehensive functions of urban systems. The concept started before the 19th century as a design principle in traditional construction to improve the resiliency of buildings (Hassler and Kohler, 2014). The timeline of resiliency research demonstrates a developmental pattern with different phases: generation, emergence, synthesis, and now operationalization (Beigi, 2015).

Urban resilience was introduced to integrate resilience with urban development (Chelleri, 2012; Yamagata and Maruyama, 2016). It refers to urban systems that maintain stability in multiple states. It also refers to adaptive concepts with many applications in cities (Hassler and Kohler, 2014; Beigi, 2015). Currently, urban systems in most cities are far from a state of equilibrium under a pressure from many factors and due to the complexity of their own processes (Batty, 2012). The geography of rapid population influx is one of the factors that can affect spatial structure, economy, livelihood, social pattern, and services in cities (Kirbyshire et al., 2017). Accordingly, there is a necessity to rethink these systems, so they are resilient and are capable to absorb, recover, adapt and transform in response to these changes. Urban resilience is a solution to prepare the urban system for any further disturbances as well as to respond to the ongoing shock of refugee waves and to adapt to any previous ones. In this regard, it is important to know the challenges faced by cities, more particularly spatial challenges, due to drastic demographic changes resulting from refugee influxes and to know how to structure an appropriate analysis to study these complex spatial challenges.

In general, urban resilience enhances the quality of life while focusing on the urban systems of a city (Ribeiro and Gonçalves, 2019). Yet, the conceptual frameworks of urban resilience differ by their considerations. Some of the existing frameworks consider all the city systems to be responsive to any stressor or shocks, such as the City Resilience Framework (Index, 2014). This framework is divided into every category of urban systems with different indeterminate qualities and goals. In contrast, the conceptual framework of Rockefeller Foundation has 4 different dimensions of the city-systems of urban resilience: leadership and strategy (knowledge); health and wellbeing (people); infrastructure and ecosystems (place); and economy & society (organization) (Reiner and McElvaney, 2017).

In term of resilience of refugee, there is some value in highlighting climate change in a resilience framework (Tyler and Moench, 2012). Therefore, some urban resilience frameworks use a multidisciplinary approach focusing on climate change adaptation (Kim and Lim, 2016). The resilience framework provided by Woolf et al. (2016) also considers informal settings with aspects of external resources, qualities, assets, and capacities (Woolf et al., 2016). Others adapted a city resilience framework focusing on issues related to rapid influxes such as shelter, health, services, economic development, employment, social and political inclusion, and cohesion (Kirbyshire et al., 2017). Recently, a framework was developed to include the mechanisms of urban systems by the types of disturbances (Ribeiro and Gonçalves, 2019). The model focuses on five dimensions: natural, economic, social, physical, and institutional, and integrates redundancy, robustness, connectivity, independence, efficiency, resources, diversity, adaptation, innovation, inclusion, and integration. These are some of the urban resilience characteristics discussed in this article. Nevertheless, a comprehensive conceptual framework of resilient urban form has remained elusive because of the complexity of urban systems and the existence of multiple processes and operations (Davidson, 2010).

Urban resilience tries to ensure equity of resources and services, recognizing the needs of different communities, besides equitable participation in policies and procedures (Meerow et al., 2019). Thus, it is quite common that the resiliency of refugees addresses shelter, healthcare, infrastructure, basic services, employment, economic development, political and social inclusion, and the risk of violence (Kirbyshire et al., 2017). Based on the different needs and complexities of refugee settings, the resilience maturity model (RMM) provides a tool to help multi-level of governance to build resilient city planning (Hernantes et al., 2019). RMM is developed by a collective of experts from different European countries with a sequence of five stages of start, moderate, advance, robust, and vertebrate for stakeholders (NGOs, internal government and refugee themselves), leadership and governance (international and national policies), infrastructure and resources, preparedness (officials and refugees), and cooperation (residents and refugees) (Resilience, 2020). Accordingly, RMM can be applied to obtain tangible resilience of refugee with developed strategies and community engagements.

Table 1 presents a list of the literature on different areas of urban resilience. **Table 2** includes a summary of a few relevant publications in different fields. It includes the definitions of resilience, the resilient characteristics, the identification of a focus, and the types of resilient urban form considered in these studies. **Table 3** lists various measurements for defining resilient urban form. Finally, **Table 4** includes the link between various neighborhood attributes and resilient characteristics as discussed in the literature. Based on the findings presented in these tables, it may be suggested that the literature allows us to learn about urban resilience background and provides enough materials for a proper multi-scale conceptual framework for building resilience in specific spatial settings with abilities to respond to an ongoing shock or a disturbance.

In 2016, urban resilience had as many as 25 definitions (Meerow et al., 2019). As noted above, **Table 2** includes some of these definitions. In these definitions, a frequently cited function of urban resilience includes the capacity of urban systems to adapt to a shock or stressor (Adger et al., 2002; VLAD, 2020). The other functions of urban resilience have included absorption, recovery, and transformation of specific urban components and strategies in disturbed contexts (Hassler and Kohler, 2014). In general, resilient urban form starts with pre-disaster planning and preparation to decrease any specific decline of a system (Sustainable network) (Sharifi, 2019a), and to enhance the absorption (limit disturbance impacts), redundancy (alterations and reorganization), and flexibility (adjustable system) when disaster is accruing. In after-disaster stage, the characteristics of resilience are recovery, solving the problem (respondent), and adaptation (Sharifi, 2019a). The definitions also include identifications of whether resiliency is a quality, a process, or a result (Southwick et al., 2014).

However, the overall objective of urban resilience is to enhance quality of life (QOL) for all populations (Sharifi and Yamagata, 2018; Ribeiro and Gonçalves, 2019). Accordingly, the resilience of urban form is dependent on the specific needs and priorities of populations within specific geographical areas (Sharifi and Yamagata, 2018). All resilient urban form must seek answers to the following five questions (Meerow et al., 2016):

- Who? Who is included or excluded in urban system? This refers to the fact that different population groups have different concerns and priorities related to resilient urban forms (Sharifi and Yamagata, 2018).
- What? The prioritization in urban resilience considers contextual aspects while thinking of different population groups and their interactions (León and March, 2016; Sharifi, 2019a).
- When? The focus here is on timeline to obtain the goal of resiliency. The temporal scales are essential to study the resilience of urban form (Sharifi and Yamagata, 2018). Each resilient urban form of pre-disaster, during-disaster, and after-disaster phase has definite resilient characteristics.
- Where? This refers to the fact that the resilience of urban form can be expanded to various dimensions and directions in the complex urban systems and can enhance the urban resilience of cities (Kim and Lim, 2016).
- Why? The "why" question defines characteristics, resilience level of interventions, and the main purpose of this intervention (Sharifi and Yamagata, 2018).

While urban forms of cities are dynamic and complex with human and environment sub-systems, complex adaptive theory approaches the complexity of all urban systems besides interconnecting the theoretical basis of resilient characteristics (Dianat et al., 2022). The CAS theory emphasizes the interconnections of heterogeneous components (Carvalhaes et al., 2021). On the other hand, disaster resilience indices (DRI)

TABLE 1 | A list of the literature on urban resilience classified by subject area.

Categories	References
Urban resilience definitions	Pickett et al., 2004; Brand and Jax, 2007; Southwick et al., 2014; Yiwen and Jiang, 2015; Meerow et al., 2016; Yamagata and Maruyama, 2016; Baravikova and Chelleri, 2018; Sharifi, 2020; VLAD, 2020
Urban resilience framework	Tyler and Moench, 2012; Index, 2014; Salat and Bourdic, 2014; Kim and Lim, 2016; Woolf et al., 2016; Kirbyshire et al., 2017; Reiner and McElvaney, 2017; Sharifi and Yamagata, 2018; Ribeiro and Gonçalves, 2019; Sajjad and Chan, 2019
Urban resilient characteristics	Cervero and Kockelman, 1997; Godschalk, 2003; Vialard, 2012; Bordoloi et al., 2013; Hassler and Kohler, 2014; Lowry and Lowry, 2014; Wood and Dovey, 2015; Feliciotti et al., 2016; Jacobs, 2016; Boeing, 2018; Sharifi, 2019a; Shi et al., 2021
Resilient spatial form	Moudon, 1986; Montgomery, 1998; Salingaros, 2000; Nyström and Folke, 2001; Godschalk, 2003; Pickett et al., 2004; Mehaffy et al., 2010; Salat et al., 2010; Marcus and Colding, 2011; Chelleri, 2012; Vialard, 2012; Allan et al., 2013; Davis and Uffer, 2013; Anderies, 2014; Villagra et al., 2014; Mehaffy, 2015; Wood and Dovey, 2015; Feliciotti et al., 2016; León and March, 2016; Apparicio et al., 2017; Kirbyshire et al., 2017; Samuelsson et al., 2019; Sharifi, 2019a,b; Sajjad et al., 2021
Social equity and resilience	Adger et al., 2002; Pickett et al., 2004; Davidson, 2010; Cote and Nightingale, 2012; Berkes and Ross, 2013; Wheeler, 2013; Anderies, 2014; Sharifi, 2016; Ziervogel et al., 2017; Östh et al., 2018; Borie et al., 2019; Fitzgibbons and Mitchell, 2019; Meerow et al., 2019

TABLE 2 | A summary of the literature on urban resilience, identified based on relevance to this article.

Author (year)	Field (discipline)	Definitions	Elements	Identification	Resilient urban form
Alberti et al. (2003)	Agricultural, environmental and biological science	"The degree to which cities tolerate alteration before reorganizing around a new set of structure and processes"	• Alteration structure and processes • Reorganization • New structure and processes	Quality, Process, and Result	Alternative and reorganization of Urban form components
Godschalk (2003)	Engineering	"a sustainable network of physical system and human communities"	• Sustainable network	Result	Sustainable urban form networks and components
Pickett et al. (2004)	Agricultural, environmental and biological science	"… the ability of a system to adjust in the face of changing condition"	• Adjustable system	Quality	Adjustable urban form
Wardekker et al. (2010)	Business management and accounting; psychology	"… a system that can tolerate disturbances (event and trends) through characteristics or measures that limit their impacts, by reducing or counteracting the damage and disruption, and allow the system to respond, recover, and adapt quickly to such disturbances"	• Characteristics of the system of less damaged • Respondent system • Recovered system • Adaptation system	Quality, Process, and Result	Measurable disturbed urban form and responsive, recovery and adaptative components

are a less challenging approach to taking a temporal snapshot of vulnerability (**Figure 3**). DRI uses CAS as a theoretical background of resilience complexity and focuses on discussing specific dimension and identifying the dimension of resilience indicators (Carvalhaes et al., 2021). DRI first identifies resilient characteristics and resilient metrics; then provides the required improvements for implementable solutions (Carvalhaes et al., 2021). Also, DRI is essential to support the resilient quality of adaptation which is a process that enables the system to maintain its identity, to be able to cope with trends and shocks, and reduce vulnerability to disturbance. Moreover, this approach focuses on the component of spatial distribution of vulnerability in its conceptual framework for resilient city and resilient community (Jabareen, 2013). Therefore, resilient urban forms have spatial aspects of a multi-level hierarchical structure that is essential in the resilience of cities and that has the required characteristics of resilient urbanism (León and March, 2016; Sharifi, 2019b). In the built environment, time, actors, and scale are most important in resilient urban form (Hassler and Kohler, 2014); therefore, as a simple approach, the complexity of urban form is introduced in a hierarchical manner of scales (Sharifi, 2019b).

Hierarchy is one simple way to approach the complex urban form. This approach includes macro, mesoscale, micro scales (Sharifi, 2019a). Macroscale clarifies the regional and metropolitan levels as well as the whole city level that has city's size, types of development, distribution patterns, and connectivity. Mesoscale includes elements of neighborhood scale and the community level. Finally, microscale of the building level has the structures and designs of buildings (Sharifi and Yamagata, 2018; Sharifi, 2019a). These three geographical scales help us understand spatial distributions and elements relations, thus defining the related characteristics of resilient urban form.

In this hierarchy, neighborhoods have the primary spaces of social production and perception (Wheeler, 2013). Neighborhoods consist of physical structures with spaces arranged to facilitate social interaction among residents (Brower, 2020). Their urban spaces have different morphological elements: plot, street edge, street, block, sanctuary space, and district (Feliciotti et al., 2016; Sharifi, 2019a). An approach to resiliency at the neighborhood scale must consider these elements focusing on the following resilient characteristics: diversity, connectivity, redundancy, modularity, and efficiency (Feliciotti et al., 2016). Ultimately, implementing resilience in neighborhood structure will help obtain interconnected resiliency in other urban systems to produce socio-economic and environmental benefits.

Next, the article will describe some of the resilience characteristics using quantitative measurements (Salat et al., 2010). It will focus on topology, programmatic satisfaction, and the quality of urban forms at the neighborhood scale (**Table 3**). It is hoped that the measurable parameters of resilient characteristics will allow a comparison of resiliency across different neighborhoods of different urban fabrics. The description will also include computation tools such as GIS, Space Syntax, and CityZoom to help quantify the resilient characteristics and to help develop a urban resilience knowledge system in refugee neighborhoods using various layers of information for better decision-making (Cariolet et al., 2019).

Connectivity

Connectivity is the ability to easily communicate within and across the systems (Feliciotti et al., 2016). Connectivity shows the interaction strength between urban elements (Salat et al., 2010; Boeing, 2018; Samuelsson et al., 2019). This characteristic helps urban form to facilitate reorganization (Nyström and

TABLE 3 | Quantitative measurements of resilient characteristics.

Resilient characteristics	Measurements	Computation tools	References
Connectivity	• Theoretical grid: • Ideally, the theoretical grid is the most connected and coherent grid in any empirical context. • The difference of additive and removal between theoretical and existing grids will define the connectivity of street networks of specific area of study. This refers quantifying the two phenomena of amalgamation and fragmentation of urban units besides the concept of incisions. • Ideal grid also applied in public transit network to determine its connectivity. • Ratio of metric reach between the implemented grid and existing grid define the connectivity. • Measures of Metric Reach for GIS data, as well as CityZoom. • Metric reach also measures the distance to amenities and accessibility and connectivity. • Intersection density $Intersection\ density = \frac{Number\ of\ intersections}{Area}$ (4) • Connected Node Ratio (CNR) $CNR = \frac{Number\ of\ intersections}{Number\ of\ intersections + Cal-De-Sac}$ (5) • Link Node Ratio $Link\ Node\ Ratio = \frac{Number\ of\ links}{Number\ of\ nodes}$ (6) • Pedestrian Route Directness (PRD) $PRD = \frac{Route\ distance}{Stright-line\ distance}$ (7) • Effective Walking Area (EWA) $EWA = Number\ of\ parcels\ within\ 400\ meter$ (8) walking node	GIS Space Syntax CityZoom	Dill, 2004; Peponis et al., 2008; Turkienicz et al., 2008; Vialard, 2012
Diversity	• Shannon Entropy: Quantifying mixed (diversity) land use. $H = \sum_{i=1}^{n} \left(p_i \log_2 (p_i)\right)$ (9) *P is proportion of land use category (Residential, commercial…)* • Simpson diversity index: equilibrium of distribution. The value toward one is more diverse of more different categories. $D_1 = \frac{C}{C-1}[1 - \sum_{i=1}^{n} p_i^2]$ (10) *C: number of categories* *P is proportion of category* • Salingaros power law formula: diversity among different scales. $S = \frac{1}{Cat} \sum_{i=1}^{Cat} [\frac{n_i - p_i}{p_i}]^2$ (11) *Cat: number of categories (all scales)* *n: number of objects in same scale* *P is proportion of category* • Rules of changes: numbers of amalgamated or fragmented urban units. This shows a diversity in size and shape. • Diversity of experience using PPGIS. • Pielou's diversity (evenness): evenness of categories (value 0-1) $E = \frac{H'}{Hmax}$ (12) *H': shannon wiener index* *H max: ln (S) the most equitable condition. S: is number of categories.* • Categories are defined in the specific urban form attributes that need to measure diversity in urban setting.	PPGIS (Participatory GIS)	Salat et al., 2010; Vialard, 2012; Bordoloi et al., 2013; Samuelsson et al., 2019
Redundancy	• Spatialized version of Simpson's diversity index: distribution of open spaces in district $D_{spatial\ distrubtion} = \frac{Q}{Q-1}[1 - \sum_{district=1}^{Q} (\frac{A_i}{S_i})^2]$ (13) *Q: number of districts* *A: area of open space* *S: area of district* • Balance Index and open space diversity: exploring the diversity of OSSs with respect to urban density $DI = \frac{\sum m2\ unbuilt-up\ area}{\sum m2\ built-up\ area}$ (14)	GIS	Salat et al., 2010; Villagra et al., 2014; Samuelsson et al., 2019
Modularity	• A rule of 400 m radius of a pedestrian shed (4 min walk) of different activity.	GIS	Mehaffy et al., 2010; Sharifi, 2019a
Efficiency	• Blocks with higher fragmentations and medium building coverage in the correlation between building coverage (built area/ block area) and building fragmentation (number of built-up units) • Ideal depth to building footprint is 6–7 m (20′-23′). • square compactness (SqCpct): efficiency of block or plot by the different of SqCpct of block and SqCpct of footprint (Value 0–1) $SqCpct = \frac{4\pi A}{P^2}$ (15) *A: number of districts* *P: Perimeter of shape*	GIS Space Syntax	Steadman et al., 2009; Vialard, 2012; Berghauser Pont et al., 2019

TABLE 4 | A link between main urban-form attributes of a neighborhood and resilient characteristics at different hierarchal scales.

Geographical scales	Morphological scales	Main attributes	Sub-attributes	Main resilient characteristic	Number of indicators	References
Meso scale	District	Neighborhood Geometry, function, and Pattern distribution	Size and shape	Diversity	4	Salat et al., 2010; Cumming, 2011; Feliciotti et al., 2016; Jacobs, 2016; Boeing, 2018; Samuelsson et al., 2019
			Number of blocks in district, Blocks distribution pattern	Modularity		Feliciotti et al., 2016; Sharifi, 2019a
			Figure and ground ratio	Efficiency		Vialard, 2012; Lowry and Lowry, 2014; Jacobs, 2016; Boeing, 2018;
			Land use	Diversity		Cervero and Kockelman, 1997; Bordoloi et al., 2013; Lowry and Lowry, 2014; Jacobs, 2016; Boeing, 2018
	Sanctuary Space	Geometry and Pattern distribution	Size and shape	Redundancy	3	Feliciotti et al., 2016
			Type (green, vacant, open space)	Redundancy		Feliciotti et al., 2016
			Ratio of green, vacant, open space. Distribution pattern in district	Redundancy		Feliciotti et al., 2016
	Street	Typology and geometry	Type of transports routes (orthogonal and non-orthogonal grid, curvilinear, cul-de-sac, radial, organic, and hybrid)	Connectivity	6	Cumming, 2011; Vialard, 2012; Feliciotti et al., 2016; Boeing, 2018; Sharifi and Yamagata, 2018; Samuelsson et al., 2019; Sharifi, 2019a
			Cycling and pedestrian network pattern	Connectivity		Feliciotti et al., 2016; Boeing, 2018; Sharifi and Yamagata, 2018; Samuelsson et al., 2019; Sharifi, 2019a
			Design and layout, (length, width, orientation, network segments)	Connectivity		Mehaffy et al., 2010; Cumming, 2011; Feliciotti et al., 2016; Boeing, 2018; Sharifi and Yamagata, 2018; Samuelsson et al., 2019; Sharifi, 2019a
			Types and numbers of intersections	Connectivity		Anderies, 2014; Feliciotti et al., 2016; Samuelsson et al., 2019; Sharifi, 2019a
			Access to amenities	Connectivity		Lowry and Lowry, 2014; Sharifi and Yamagata, 2018
			Public transit routes	Connectivity		Lowry and Lowry, 2014; Sharifi and Yamagata, 2018

(Continued)

TABLE 4 | Continued

Geographical scales	Morphological scales	Main attributes	Sub-attributes	Main resilient characteristic	Number of indicators	References
Micro scale	Block	Typology and geometry	Size, height and perimeter	Efficienc	4	Salat et al., 2010; Vialard, 2012; Jacobs, 2016; Boeing, 2018
			Block type	Diversity		Cumming, 2011; Jacobs, 2016
			Block density, floor plan density	Efficiency		Moudon, 1986; Lowry and Lowry, 2014; Samuelsson et al., 2019
			Number of plots in block, Plots distribution pattern	Modularity		Montgomery, 1998; Anderies, 2014
	Street edge	Geometry and function	Size and shape	Diversity	8	Vialard, 2012; Jacobs, 2016; Boeing, 2018
			Front usage	Redundancy		Vialard, 2012
			Urban sphere (Block-Street relationship	Modularity		Sharifi, 2019a
	Plot	Typology and geometry	Geometry layout, size, height of dwelling	Diversity		Salat et al., 2010; Jacobs, 2016; Boeing, 2018
			Density (floor plan)	Efficiency		Moudon, 1986; Lowry and Lowry, 2014; Samuelsson et al., 2019
			Building or housing type	Efficiency		Lowry and Lowry, 2014; Sharifi and Yamagata, 2018
			Setback's measurements	Redundancy		Lowry and Lowry, 2014; Sharifi and Yamagata, 2018
			Roof type	Diversity		Sharifi and Yamagata, 2018

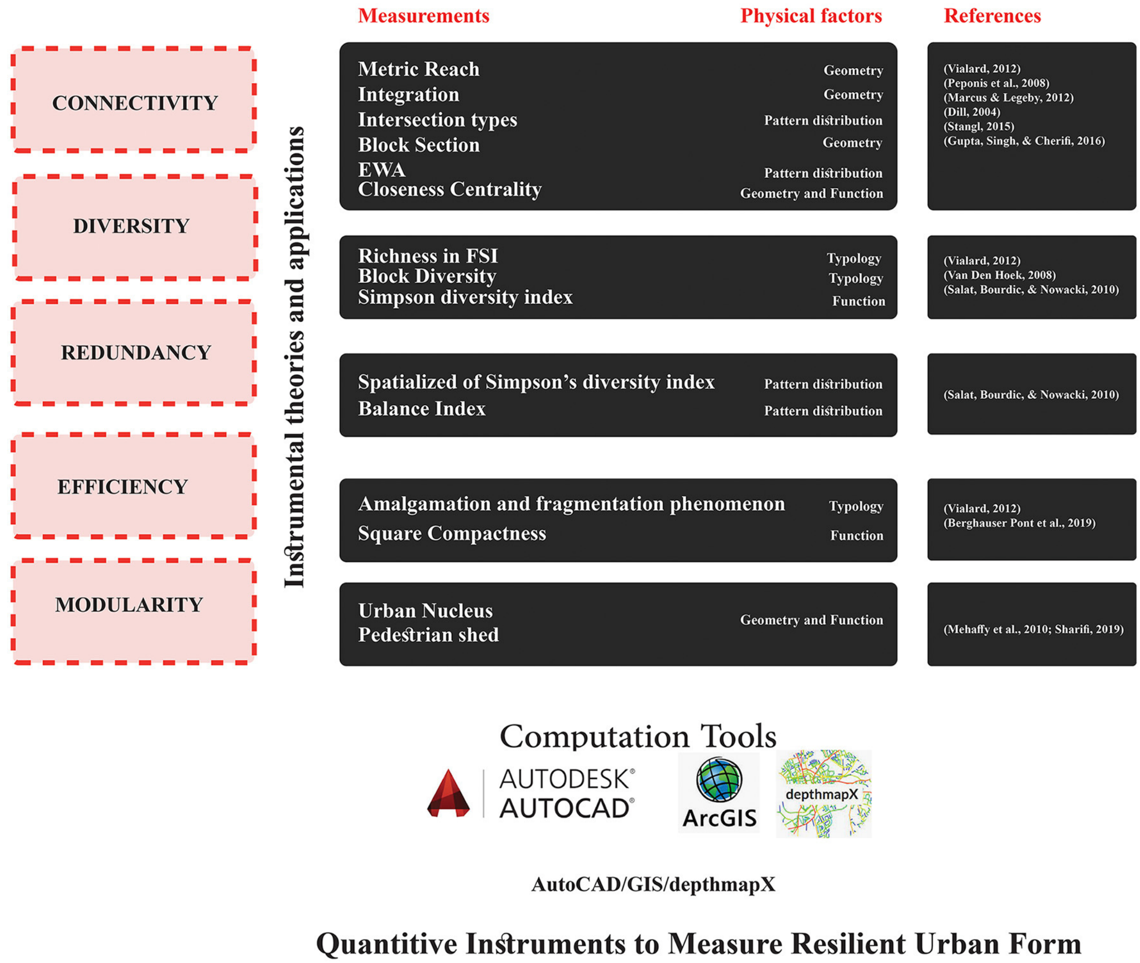

FIGURE 3 | The assessment tool of resilient urban form of refugee neighborhoods.

Folke, 2001), besides improving communication, human travel patterns, and accessibility. The idea of connectivity as the strength of systems components has a complicated relationship with resiliency (Samuelsson et al., 2019). Connectivity at the urban scale includes street networks and their properties such as intersection types and density (Boeing, 2018). Connectivity in resilience has two sides: higher connectivity helps to absorb and recover, and lower connectivity reduces the diffusion of disturbance and preserve memory by limiting fragmentation (Marcus and Colding, 2014; Feliciotti et al., 2016).

Urban form literature has several methods to quantify connectivity for street networks and their properties. The method of a theoretical grid applies a series of intersected straight or curved lines that have ideal connections traced from the existing network. This method emphasizes the hierarchy of streets. In this regard, the connectivity of existing street networks decreases by with higher degree of deviation from the quality of gridedness (Boeing, 2021). The street segment changes have some removals (amalgamation phenomenon) that decrease the connectivity and other additives (fragmentation phenomenon) that enhance the connectivity (Vialard, 2012). Meanwhile, incisions are alterations of block boundaries that enhance connectivity. For example, Alice Vialard applied the theoretical grid and analyzed the street changes in her study of the two cities of Savannah and Atlanta. Atlanta has four additives of street segments, and 35% of the blocks have incisions. While Savannah has only two additives, and 42 removed streets, including 32% of blocks are affected by the amalgamation phenomenon. The percentages of street changes show Atlanta has better connectivity. Hence, connectivity measurement depends on the type and location of amalgamated or fragmented blocks besides any incisions. The method quantifies the properties of each area (the number and location of amalgamated or fragmented units) rather than the street network itself.

Metric reach measurement is a helpful tool to describe a connected street network. For instance, applying a metric reach ratio between implemented grid and the existing network the difference in connectivity can be calculated (Peponis et al., 2008). A ratio value close to 0.00 means more changes, in contrast, the a ratio value of 1.00 means the street segments are stable with better connectivity. The example of Savannah and Atlanta shows that the Savannah network decreased by the ratio of metric reach, and the Atlanta network increased specifically by the block's incisions (Vialard, 2012). Yet, the method uses more layers to measure connectivity to amenities and public transit. It indicates how the network follows a geometric order and expresses the degree of street homogeneity, hierarchy, centrality, orientation (Vialard, 2012). The main objective of this method is to determine the performance, accessibility, and functionality of the street network.

Integration also measures the connectivity by determining the accessibility of streets within a street network. The measurement identifies social interaction potential and human travel pattern which shows copresence of social capital within the any neighborhoods (Marcus and Legeby, 2012). Integration is good indicators to measure connectivity in the case of refugee communities, and can be used to characterize street network and pedestrian routes.

Other methods to measure connectivity are the number and types of street intersections. **Table 3** includes the formulas of different methods. These formulas measure the intersection properties such as Intersections Density of the ratio between the number of network intersections and the square area (Equation 4) (Dill, 2004). The number of intersections indicates how the blocks are connected and how subtle and coarse the network is (Boeing, 2018). Another measurement is Connected Node Ratio (CNR). It is a ratio between the number of intersections and the number of both intersections and *cul-de-sac* (Equation 5) (Dill, 2004). CNR value toward 1.00 with fewer *cul-de-sac* has better connectivity. Moreover, the Link Node Ratio measures the number of links to the number of nodes (Equation 6) and a higher value means a more connected network. Nevertheless, intersection types have other spatial characteristics than connectivity. For instance, a four-way intersection is more connected but less safe while *cul-de-sac* is considered a friendly type. In a resilient urban, there is a need for balance between connectivity, safety, and friendly types (Samuelsson et al., 2019).

Lastly, pedestrian and cycling routes are important urban form attributes that enhance connectivity. They are essential for better neighborhoods with more social traveling patterns. Eventually, better connectivity of such traveling networks increases neighborhood resiliency. In this regard, there are two measurements to quantify the connectivity of pedestrian and cycling routes. Pedestrian Route Directness (PRD) is a ratio between existing route distance and straight-line distance (Equation 7) (Dill, 2004). This measurement has values of 0.00 to 1.00 while 1.00 has a more direct route and is better connected. On the other hand, Effective Walking Area (EWA) is a measurement that indicates the number of parcels within 0.40 km pedestrian shed (Equation 8) (Dill, 2004). EWA shows the accessible areas within 5 min walking distance.

Diversity

Diversity allows urban forms to have coping capacity and multiple stability in use and geometry (Feliciotti et al., 2016), and to support wellbeing and spatial justice among the neighborhood's residents (Samuelsson et al., 2019). Diversity also shapes travel behaviors in urban contexts (Cervero and Kockelman, 1997; Bordoloi et al., 2013). All urban forms need diversity (Salat et al., 2010), and there is a need to identify and evaluate the quality of urban form in terms of resilient diversity (Samuelsson et al., 2019) based on geometry, pattern distribution, and function (Feliciotti et al., 2016; Jacobs, 2016; Boeing, 2018). However, diversity of developments, density, and activities determine compactness of urban form (Jabareen, 2006). In refugee contexts, diversity will focus on the compactness theme to promote quality of life in spaces of social interaction and access to services and facilities (Jabareen, 2006).

Diversity in quantitative terms is the equity between different elements, meaning, functions, and distributions. Spatial diversity is concerned with the complexity of urban fabric which is a difficult parameter to define and measure. However, many theories provide a measurement of diversity among similar objects, different scales, or spatial distributions (Salat et al., 2010). The most popular is Shannon entropy (Equation 9) to measure land-use diversity. The entropy defines the complexity of the distribution of specific categories among others and ideally quantifies diversity in relation to even distribution. In addition, mixed land use provides better commute and human travel that affect the social and economic aspects (Torrens and Alberti, 2000; Van and Senior, 2000). It is essential for risk management, sustainable urban form, and future resilience.

There are several ways to define the diversity of networks, resources, and sizes, some of which are specified in **Table 3**. For instance, Simpson Diversity Index (Equation 10) indicates the richness of urban fabric (Salat et al., 2010). This index was developed to include different categories of urban forms. The measurement has a value between 0 and 1, where 1 has better diversity.

Salingaros's index (Equation 11) defines the diversity of distribution among different scales, such as the distribution of different scales of routes (Salat et al., 2010). Therefore, Salingaros's distribution works for the right proportion of objects of different sizes and scales.

The method of the theoretical grid also shows the changes of blocks diversity in shape and size. Therefore, more amalgamated or fragmented blocks indicate better diversity in the numbers and sizes of blocks. The method of theoretical grid measures both connectivity of street network by its closeness to gridedness, while changes of segments from theoretical grid give more diverse blocks in their sizes and shapes. Thus, there is a need to balance connectivity and diversity characteristics to meet the desirable resiliency.

A study of Stockholm city in Sweden investigates human experiences of connectivity and diversity for quantifying resilience (Samuelsson et al., 2019). This empirical investigation of Stockholm measured the spatial diversity by different indicators such as the proportion of working spaces, residential areas, roads, and natural elements. The study used public participatory GIS (PPGIS) to show spatial diversity of users' experiences. The results were compared with Pielou's diversity (evenness) (Equation 12) for the same indicators. The results showed that higher diversity occurs in intermediate connectivity based on the correlation between connectivity and diversity (Samuelsson et al., 2019).

Redundancy

The existence of spare capacity in urban form against threats is redundancy (Tyler and Moench, 2012; Anderies, 2014). Multiple components of same, similar, or backup functions often contribute to redundancy (Feliciotti et al., 2016). Put differently, redundant urban form contains alternative urban elements that reinforce each other so that urban form is able to reorganize or self-organize the space and people if and when needed (Feliciotti et al., 2016). In general, redundancy improves overall resilience. For example, a redundant network improves connectivity and accessibility (Sharifi, 2019a). A resilient urban form contains redundancy at all morphological scales (Vialard, 2012). A careful subdivision of urban blocks and districts with a degree of mixture in different ranges will lead to a more redundant urban form (Feliciotti et al., 2016).

A quantitative measurement of redundancy calculates the spatial distributions of spaces that allow an opportunity to reorganize, such as sanctuary spaces (Feliciotti et al., 2016). A spatialized version of Simpson's diversity index (Equation 13) is to know the distribution of these spaces at the district scale. A value close to 1.00 will have more equal spatial distribution of sanctuary spaces and will have an equal redundancy capacity in their specific areas. Open spaces or greenery spaces have many positive outcomes added to image of neighborhoods, quality of life of communities, sustainable lifestyle, and enhancements of the ecological life (Jabareen, 2006).

Balance index (Equation 14) is another equation that determines the balance between built area and unbuilt area (open spaces) to urban density (Villagra et al., 2014). In this regard, the resilient urban form will be enhanced in any neighborhood with equally distributed sanctuary spaces because of the improvement in both characteristics of diversity and redundancy. In urban block and plot scales, the redundant capacity is not limited to sanctuary spaces, it exists in street edges within urban block and plot scales. Street edges is redundant based on frontage spaces. Redundancy increases in fragmented and smaller size blocks (Vialard, 2012). This is measured by the frontage index for plot or block which is a ratio between frontage street length and plot or block perimeter length (Bobkova et al., 2021).

Modularity

The modules are self-standing systems or subsystems of a larger system. They consist of proper elements with independency in functionality and geometry (Feliciotti et al., 2016). Modules are not fixed urban patterns; instead, they are a homogeneous distribution of urban form that gives wholeness ensuring identity (Salingaros, 2000). They work like a nested structure within a hierarchical urban form. Modules in neighborhoods provide community capacity of absorption and recovery from disturbances (Allan et al., 2013). Modules can be emergent patterns of uses and peoples (Sharifi, 2019a). Therefore, the emergent neighborhood model has overlapped layers of varied spaces for better self-organization in any time of disturbances (Mehaffy et al., 2010; Sharifi, 2019a). The modules are important nodes with concentrated urban activity spaces with pedestrian shed of 400 meters and pedestrian flow of minimum 4 min walking (Mehaffy et al., 2010).

Modularity concerns the equal pattern distributions, such as having layers of an equal distribution of blocks in a district or plots in a block. Modularity characteristic has similar quantitative measurements of redundancy of spatial distribution. Therefore, modularity is measured by different layers in urban nuclei such as different dense activities, mixed-use corridors, green spaces, green corridors, and natural areas (Mehaffy et al., 2010). Urban nucleus places emphasis on hierarchy of community, movements, and natural elements. Moreover, the distribution of layers of activities determines the quality of sustainable transport including walking, cycling, and transportation through travel time (Jabareen, 2006).

In regard to street connectivity, the nucleus has different types:

- Centered nucleus is located at the center of neighborhood
- Edge nucleus is located at the edge of neighborhood
- Exposed nucleus is located along urban movement network
- Shielded nucleus has layers of complex uses that are shielded by main network.

However, the mixture of edge/shielded or centered/exposed nuclei represents an outcome of many layers that can support self-organization as well as self-standing subsystems that have independency in functionality and geometry (Mehaffy et al., 2010). The main objective of any study on modularity is to measure the mixture of these types to obtain emergent neighborhood model with dynamic complexity.

Efficiency

The general definition of efficiency is the ability of any system to avoid wasting resources and time while achieving the desired result. In urban form, it means maintaining the function of static urban form relative to dynamic processes (Godschalk, 2003; Kim and Lim, 2016). Nevertheless, efficiency in resilience is debatable, since it can be described as the expenses of other resilient characteristics of diversity, connectivity, redundancy, and modularity. Efficiency decreases urban resilience in simple urban forms (Feliciotti et al., 2016). However, more complex urban forms are more efficient structures with different elements at different scales (Feliciotti et al., 2016). Efficient urban forms often have a large number of small and flexible elements mixed with a few large ones that support each other (Wood and Dovey, 2015).

In this section, efficiency measurement focuses on block scale. Block scale works as an intermediate scale between streets and plots. The efficiency of the block has specifications of the size and shape of buildings or their circulation pattern (Siksna, 1997). This scale, therefore, has the space of urban community and identity at its edge (Vialard, 2012). Also, the performance of the social capital of any neighborhood occurs at this scale. Blocks in urban form determine the capacity of urban resilience and community resilience. The performance of urban blocks generally is related to their geometrical parameters and metric properties (Vialard, 2012).

Efficiency related to the resilience of a block depends on a balance between circulation patterns (fragmentation) and the footprints of buildings (amalgamation). The geometrical compatibility or incomparability of fragmentation and amalgamation depends on:

1) The size of footprint, which is related to the block threshold,
2) The shape of building/s, which defines the shape of a block,
3) The size of the building in relation to the size of block, and
4) The degree of building complexity related to block size.

Block threshold is an average distance between the perimeter to the centroid of a block. It is also called depth (Parent, 2009). The relationship between footprint and depth measures the block density. For an efficient block, the desirable depth to building footprint is 6–7 m ($20^{'}-23^{'}$) for natural light, ventilation, and accessibility (Steadman et al., 2009).

Vacant spaces enhance block efficiency, and increase its redundancy capacity (Moudon, 1986). Thus, a correlation between building coverage (built area vs. block area) and building fragmentation (number of built-up units) identifies the most efficient block in an urban context (Vialard, 2012). For instance, this correlation will have blocks with three types of configurations (1) vacant of 0 built area and 0 fragmentation; (2) fully built with building coverage of 1; and (3) fragmented and variable coverage. In this regard, blocks with higher fragmentations and medium building coverage are more efficient (Vialard, 2012). The measure shows important relationship between block density and urban character of building fragmentations (Jabareen, 2006), and the quality of compactness (Jenks et al., 2000).

However, block configuration is not the only way to measure block efficiency. Determining compactness in urban blocks shows the degree of intensification that is the density of developments and activities (Jabareen, 2006). Compactness determines the shape of the footprint and its compatibility with the block shape. The calculation of square compactness (SqCpct) is the area to perimeter ratio (Equation 15). Further compatibility between SqCpct of block and SqCpct of footprint identifies the efficient block. In the same study of Savannah and Atlanta, the efficient block is the block of a large and complex footprint and higher SqCpct (Vialard, 2012). In general, amalgamated urban blocks can accommodate large and complex footprints. The efficient shape and size of blocks have the flexibility to accommodate different building types (Vialard, 2012).

Table 4 provides a summary of the literature describing various resilient characteristics or attributes of urban form. They are divided into the categories of geometry, pattern distribution, typology, and function. They are further divided into more measurable sub-attributes of a neighborhood's urban form. The main attributes and sub-attributes in **Table 4** may have positive and negative values for the resilience of neighborhood when calculated using the following equations (Sajjad et al., 2021). However, all attributes summarized in the table have a positive value for spatial resilience:

$$Z'=\frac{\mathbf{x}-\mathbf{x}_{\min}}{\mathbf{x}_{\max}-\mathbf{x}_{\min}} \quad \text{positive contributed attribute} \quad (1)$$

$$Z'=\frac{\mathbf{x}_{\max}-x}{\mathbf{x}_{\max}-\mathbf{x}_{\min}} \quad \text{negative contributed attribute} \quad (2)$$

x: is the value of specific attribute in the neighborhood
x max: is the maximum value
x min: is the minimum value

Where z' is a value standardized between 0 and 1, while 0 is less resilient and 1 is more resilient. In this regard, spatial resilience index is calculated by Cronbach's alpha as follows (Cronbach, 1951) in which an indicator is given combining all attributes of a neighborhood at a specific scale:

$$\alpha=\frac{\mathbf{Nc}}{v+(\mathbf{N}-\mathbf{1})\mathbf{c}} \quad (3)$$

N is the total number of attributes in specific scale
c is the average covariance between attributes-pairs in specific scale
v is the average variance of attributes in specific scale

Cronbach's alpha is applied to calculate the internal consistency of all attributes in all scales of the neighborhood. **Table 4** has 25 attributes for the overall spatial resilience of the neighborhood. For example, street scale in a neighborhood has 6 attributes, therefore street resilience can have one overall value for all its attributes using Cronbach's alpha.

In conclusion, resilient characteristics work individually to assess the resiliency of urban forms in a neighborhood, while Cronbach's alpha value indicates the final resiliency value for urban forms at all scales. The same process can be used to operationalize the resilience sub-components of economic, social, and institutional factors of neighborhoods (Sajjad et al., 2021).

DISCUSSION: RESILIENT URBAN FORM ASSESSMENT IN REFUGEE NEIGHBORHOODS

The five resilient characteristics of urban form resilience are connectivity, diversity, redundancy, modularity, and efficiency. In general, quantitative measurements can be used in any empirical study. They depend on the availability and accessibility of geometric and spatial data, straightforward application, the use of computation tools, and direct relationship to the specific resilient characteristics. The measurements also include the following elements of morphological scales and indicators of human behaviors and activities:

- Street layout and network elements, properties, and functions determine the connectivity of neighborhood
- District, block, and plot pattern distribution, typology, and functions determine the diversity of neighborhood
- Sanctuary spaces' distribution and typology determine the redundant capacity of neighborhood
- Block geometry and typology determining the efficiency of neighborhood
- Block–street functions, relationships, and geometry determine the modularity of neighborhood

TABLE 5 | Contextualizing the measurements of resilient urban form in refugee neighborhoods.

Resilient Characteristics	Measurements	Quality of life indicators
Connectivity	Metric reach, Integration, EWA, Block section, intersection types, closeness	Personal connectivity with settlements worker Physical and communities infrastructure
Diversity	Diversity in blocks, housing, and land use.	Quality of different activities, choices, and uses
Efficiency	Block type Compactness	Quality of urban fabric in blocks, a resident walking experiences and perception, the image of neighborhoods
Redundancy	Spatial distribution open spaces Setback redundancy	Quality of life of less mental distress and higher life satisfaction Quality of hierarchy of spaces (Public, semi-public, semi-private, private)
Modularity	Urban nucleus	Resources availability and Human behaviors

Identifying resilient measurements is essential to contextualize the parameters for resilient urban forms of refugee neighborhoods. The parameters help define the stable physical structures that can fulfill the short and long-term needs of refugees. However, there is limited literature examining refugee contexts; few pieces of literature show their neighborhoods with complex spatial patterns of interactions, activities, and structures. The spatial structure of refugee neighborhoods varies depending on the formality and informality, demographic, and spatial experience. Concerning spatial challenges and vulnerability, urban pressures exist due to the demands and needs of sudden refugee influxes in urban services, housing, labor market, accessible transportation, sanitation, education, and health care. The disturbance of demographic changes affects residents and their quality of life (Ribeiro and Gonçalves, 2019).

Accordingly, **Figure 3** and **Table 5** summarize the measurements for resilient urban forms of refugee neighborhoods. The selected measurements are related to network accessibilities and mixed land uses. The set of parameters utilizes geospatial technologies of ArcGIS and space syntax to help reduce the communication gap in the interactive platform between decision-makers in refugee settings.

Connectivity is the main factor in planning cities and their neighborhoods. There are two indicators for the connectivity of refugee settlements. The first one is personal connectivity of settlement's workers that can be measured through quantifying metric reach, and access to amenities and workplaces. On the other hand, physical and communities' infrastructure uses integration as an indicator of social capital, and effective walking area; intersection types as indicators of safety, friendly and connectivity neighborhood. Diversity has the quality of different refugee activities, choices, and uses blocks, housing, and land use. Efficiency defines the quality of urban fabric in blocks; and refugee walking experiences with their perception and image of neighborhoods; therefore, an urban block is a scale for efficiency characteristics as it focuses on neighborhood design. Redundancy helps maintain less mental distress and higher life satisfaction through recreational, open spaces, and green areas that enhances the quality of life for refugees. Moreover, the hierarchy of spaces (public, semi-public, semi-private, private) also plays a role in the redundant capacity of setbacks. Finally, modularity defines the overall quality of the spatial structure of different layers of streets, pedestrian routes, pedestrian shed, urban nucleus (centers).

TABLE 6 | Adapted the matrix of the sustainability of urban forms by Jabareen (2006).

Resilient characteristics	Rank
Connectivity	1. Low 2. Moderate 3. High
Diversity	1. Low 2. Moderate 3. High
Efficiency	1. Low 2. Moderate 3. High
Redundancy	1. Low 2. Moderate 3. High
Modularity	1. Low 2. Moderate 3. High
Total	5–15

The article does not have an illustrative example; therefore, it adapts the sustainability of urban forms matrix by Jabareen (2006) to conclude the assessment of resilient urban forms of different refugee neighborhoods as shown in the **Table 6**.

CONCLUSION

This study reviews urban resilience by focusing on assessing the resilient urban form of refugee neighborhoods. It integrates different conceptions of resilience and various knowledge domains. However, any urban resilience assessment framework must be contextual and must differ in terms of urban forms of refugees and their morphologies. Specifically, the study suggests an approach to proactively make resilient spatial structures that can adapt to and recover from the shock of displacement to ensure the security, stability, inclusion, functionality, and livability of refugee spaces.

The review summarizes important knowledge regarding resilient urban form. It gathers quantifying characteristics to enhance the resiliency concept. In addition, resilience assessment specifies different tools to utilize for improving practical resilience by official organizations working in refugee contexts.

However, the literature has been limited to measuring resiliency in cities of developed countries. Therefore, future research should consider measuring the resiliency of refugee contexts in developing countries to build theories based on the differences, changes, and transformations. Also, further studies need to examine refugee neighborhood conditions and gather refugee opinions on their urban forms. This will help to develop a model-based resilience assessment.

AUTHOR CONTRIBUTIONS

Both authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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