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Mixed-use and Street Network Attributes of Vibrant Urban Settings

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Keywords

Land use mix, neighbourhood design, pedestrian activity, street network, urban vitality, walkability.

Abstract

This study examines two crucial interlinked physical planning and design aspects with potential impact on pedestrian flow in urban settings. Mixed land uses and gridded/interconnected streets are invariably characterised in the urban design literature as the essence of vibrant cities and lively street environments. The study develops a critical approach that investigates some of the most popular algorithms utilised in assessing mixed-use characteristics and their impact on pedestrian movement. "Entropy," "LUM," and "dissimilarity" indices are critically evaluated in terms of their reliability in predicting pedestrian travel patterns. The study also examines street network measurement indices and spatial analysis tools that enhance urban vitality and aid in the design and development of active street environments. It bridges the gap between disparate approaches aiming at understanding and prescribing the built environment attributes that enhance urban vitality. The theoretical quest of this study provides a robust foundation for future case study research on the built environment.

Introduction

This research engages planning and urban design literature to develop a nuanced understanding of the configurational and spatial dynamics that enhance pedestrian activity and street vitality. Design-based studies generally associate urban vitality with built environment attributes such as mixed uses, fine-grained urban blocks, connected streets, and enhanced building/street interface [1]–[5]. They invariably allude to traditional cities as providing models for walkable and pedestrian-friendly urban spaces [6]–[8]. Traditional cities tend to support communal living by mixing and integrating residential, commercial, and employment activities; their urban spaces are spatially defined and generally permeated with well-articulated relationships between buildings, sidewalks, squares, and streets [9]–[13]. On the other hand, environmental psychology and urban morphology studies emphasize that maximizing alternative routes between city spaces and linking them with easily identifiable networks of streets enhances the sense of orientation and ease of movement through space [14]–[17]. Furthermore, accentuating major urban nodes with contextually designed landmarks augments the image of the city and provides people with clear mental maps of their surroundings [18]. Rich visual dynamics play an important role in enhancing the image of the city. This is achieved by introducing a variety of enclosures, buildings, textures, scales, exposures, heights, colours, and so on. The image of the city is synonymous with urban legibility, i.e., the ease at which people can recognize spatial and urban form relations, which consequently affects their tendency to walk and occupy public spaces [19]–[21].

Against these well-established design assessments of the built environment, the study develops a critical approach that investigates some of the most popular algorithms utilized in the assessment of mixed-use characteristics and their impact on pedestrian movement. "Entropy," "LUM," and "dissimilarity" indices are critically evaluated in terms of their reliability in predicting pedestrian travel patterns [22]–[24]. The pros and cons of each tool and its potential application in various mixed-

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use urban settings are discussed. The study discusses street network measurement indices and spatial analysis tools that enhance urban vitality and aid in the design and development of active street environments. It juxtaposes several assessment methods related to land use and street networks to develop a nuanced perspective of the built environment attributes that enhance pedestrian activity.

I. Study Methods

This research adopts a rich and complex theoretical mosaic aimed at generating an interdisciplinary understanding of the influence of the built environment on pedestrian activity. It critically analyses a wide range of theoretical frameworks that aim to correlate land use mix and street network design to urban pedestrian flows. With a focus on pivotal works informing this debate, the study juxtaposes the design-based literature and algorithmic measurements that empirically associate built environment attributes with urban and street vitality. The objective is to highlight the most critical aspects of these two different, yet complementary approaches that inform the current debate centred on the intersection between the built environment and individual behaviour. Though accommodating a degree of overlap between some of these approaches, the paper discussions highlight the uniqueness of literature arguments that work in tandem to underscore the associations between the built environment and pedestrian movement. Theoretical arguments are inductively articulated as patterns of interconnected concepts and relationships that generate an understanding of the whole [25]–[26]. The intent is to avoid being constrained by one theory to the exclusion of others to build a nuanced understanding of built environment features that enhance street life. The paper deliberations are clustered into three major categories: land use mix, development grain, and critical discussions.

II. Land Use Mix

Mixed land use is broadly recognized in the literature as a conjoint quality of vibrant neighbourhoods and urban blocks. However, urban vitality is not simply achieved by mixing residential, commercial, and office buildings. Jacobs [1] emphasized the concept of diversity as a precondition for synergistic mixed land uses. Urban diversity denotes a rich mix of home tenures, work and production facilities, population density, old and new buildings, and a broad spectrum of social classes. She states that vibrant cities provide opportunities for functional diversity on two main levels, primary and secondary. Primary uses may incorporate dwellings, offices, and other compatible facilities for retail, manufacturing, education, and some forms of entertainment. She maintains that the coexistence of all or some of such primary uses does not necessarily ensure effective functional diversity. According to Jacobs [1], the key to effective functional diversity is the presence of a critical mass of people in the streets at different times of the day and for different purposes. Furthermore, the Urban Land Institute characterizes effective mixed-use areas as consisting of three or more significant revenue-producing and physically integrated functions such as residential, office, education, retail, or recreational [27]. Physical integration refers to geographic proximity and locational fit that allows pedestrians to occupy streets and public spaces as part of their daily work/live/play routine [28]–[29]. Accordingly, mixed land uses that generate street pedestrian flows are not simply an amalgamation of different functions in one area. Compatibility, density, and revenue generation potential beyond servicing immediate surroundings are essential ingredients of an effective primary use mix (Fig. 1).

Urban areas with such integrated land use configurations may generate synergy and bring people to the streets for different purposes at different times of the day. They have the potential to spawn another level of functional variety that Jacobs [1] calls “secondary

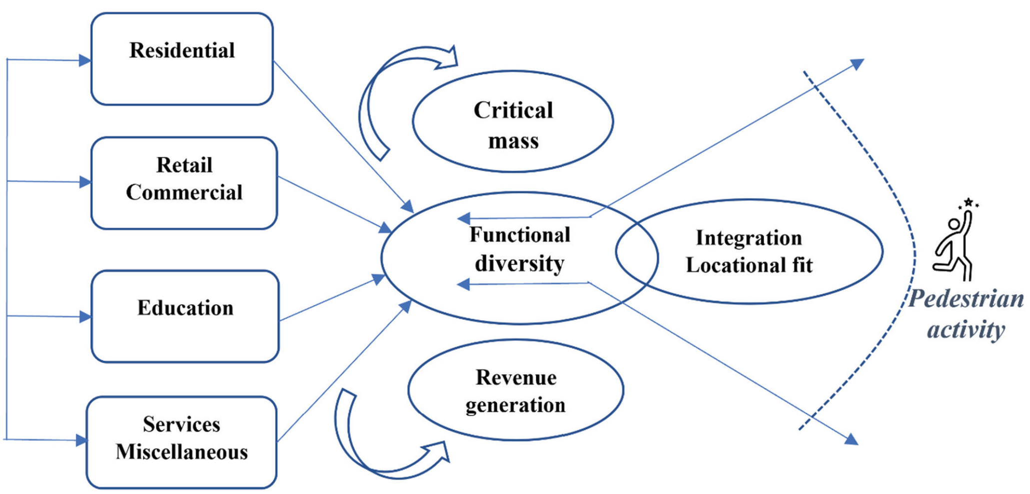

Fig. 1. Conditions of functional diversity leading to pedestrian activity [created by the author].

diversity". Secondary use functions emerge as a response to the effective primary uses to provide support services. Examples include restaurants, cafes, small-scale shops, kiosks, entertainment venues, etc. Exceptions regarding the need for multiple primary uses may be found in urban areas that house unique functions. Jacobs [1] cited the example of Carnegie Music Hall in New York, which was the primer that attracted many other smaller music, dance, performance, and recital facilities, along with needed housing, hoteling, and a host of small support services. In this case, Carnegie Hall generated a multitude of both primary and secondary use functions that ensure street vitality and pedestrian activity day and night. Reid Ewing argued that land use mix affects travel patterns; by operationalizing various aspects of the built environment, Ewing [30] emphasized that relatively higher densities and a balanced mix of residential, commercial, and employment activities would render active travel modes such as walking, biking, and transit more viable. Such assertions were supported by other studies that focused on disaggregated data measuring walking activity on the household and individual levels. Mixed-use developments with balanced retail, employment, and residential uses generated almost twice the walking of conventional suburbs [31]–[35].

The New Urbanism literature also supports mixed-use as an essential strategy in designing new developments aiming to enhance pedestrian activity and neighbourhood vitality [36]–[41]. Thus, there is a broad agreement in the design and planning literature on the merits of diverse mixed-use developments in enhancing urban vitality and pedestrian activity. However, widely accepted measures or indices that operationalize required levels of land use mix/diversity are yet to be perfected. Various studies refer to the notion of land-use interaction in mixed-use areas as a significant indicator of functional diversity. This indicator measures the percentage or relative size of unique land use types in an urban sector. Proximity and integration are key attributes of optimum functional diversity; the first measures the intensity and physical adjacency of land use types. The second determines the complementarity of heterogeneous land use in an area [42]–[45]. The land use intensity does not only refer to diverse land use categories but also different building configurations and property values. For example, the New Urbanism development proposals (Fig. 2) promote mixing single-family homes, multi-family units, and apartments together with complementary retail stores in what has been popularized as TND (traditional neighbourhood design [36]–[46].

A variation of the TND concept has been developed to accommodate a transit hub serving a high-density commercial centre and a heterogeneous mix of live/work/play configurations struck along a transit corridor, allowing a density gradient from high near transit stations to low on the development periphery. Dubbed TOD (transit oriented development (Fig. 3) is a concept that has been

Fig. 2. TND [46].

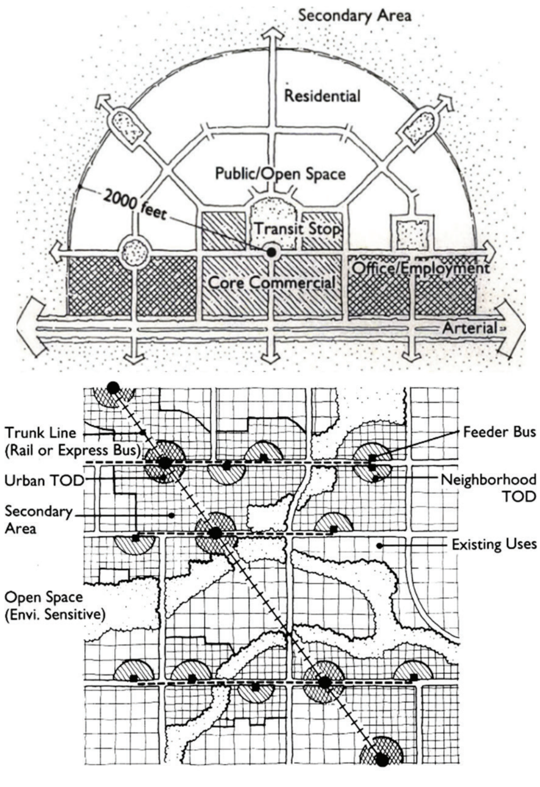

Fig. 3 TOD [47].

integrated into city official plans as a model for sustainable mixed-use development [47]–[49]. The following part of the study discusses the notion of land use interaction and highlights the different statistical models and methods that have been developed in the literature to measure the impact of land use mix on travel behaviour and a potential increase in pedestrian activity and street vitality.

A. Measuring Land Use Interaction

Frank and Pivo [23] employed an entropy index to assess the distribution (evenness) of seven land use categories in study areas. Based on the statistical analysis of built areas in the seven land use categories, the results were expressed as normalized values between zero and one. The higher value indicated more mix and diversity in land use types and was positively correlated with higher pedestrian activity. Manaugh and Kreider [24] expressed the entropy index as:

$$\frac{-\sum(A_{ij}\ln A_{ij})}{\ln N_j}, \tag{1}$$

where A_{ij} is percentage of land use i in census tract j; N_j is the number of represented lands uses in census tract j.

A variation of the entropy index, LUM, considers the gross floor area of uses rather than land areas [50]. The results of the index also range from zero to one. A perfect evenness or equal distribution between functional use categories in the area would score "one."

$$LUM = \sum_{i=1}^{n}\frac{(P_i \cdot \ln P_i)}{\ln(n)}, \tag{2}$$

where P_i being the proportion of the building's square footage of land use.

Kockelman [51] developed a mean entropy index, which is the average of all entropies calculated for developed lots or parts of contiguous neighbourhoods. The mean entropy (according to Kockelman) was more representative than the area-bounded entropy measure for estimating travel behaviour. Results also range from zero to one, with higher values indicating a balanced distribution of land uses.

$$Mean\ entropy = -\sum_{k}\frac{\sum_{j}\frac{[P_{jk}\cdot\ln(P_{jk})]}{\ln(J)}}{K}, \tag{3}$$

where K – number of actively developed hectares in the tract a; P_{jk} – proportion of use type j within a 0.8 km radius of the developed area surrounding the k^{th} hectare.

As elaborated next, the above entropy measures are fraught with imperfections and are often criticized for the way they seek an even balance in the mixed-use configuration of urban areas. Though providing a measure of use heterogeneity, even distribution does not consider the level of complementarity between the different land uses in an urban tract, which is a crucial factor in predicting travel behaviour and walking patterns [44]–[52].

B. Imperfections of Land Use Interaction Measurement

The entropy index variations assess the relative proportion of different land uses, rather than distinguishing between the types and spatial configurations of land use in built environments [53]. In this regard, developments can achieve higher scores irrelevant of how land uses are allocated through space. This runs contrary to the bulk of the urban design literature that places a premium on how mixed land uses are distributed in neighbourhoods. Land use functions that generally benefit from pedestrian movements, such as retail, cafés, parks, or other common facilities, ought to be planned along major movement corridors [54]. Cervero [55] developed the "dissimilarity index", to compute the dispersion of land use types in mixed-use centres. Dissimilarity index complements the entropy metric by predicting travel patterns between complementary uses such as housing, retail, office, and other support functions.

$$\text{Dissimilarity index} = \text{mix index} = \sum_{k}\frac{1}{K}\sum_{i}^{8}\frac{X_{ik}}{8}, \tag{4}$$

where K – number of actively developed hectares in the tract; X_{ik} – 1 if the central active hectares use type differs from that of a neighbouring hectare, and 0 otherwise.

While entropy reveals the balance or evenness of land use types in mixed-use areas, the dissimilarity index measures the land use variation amongst contiguous developments. For demonstration, this study compares two equal-area urban tracts with identical land use categories. The area of each tract is four hectares and consists of 36 gridded blocks. Both tracts boast six equally divided land use categories, as illustrated in Fig. 4. The main difference is the physical allocation of land uses throughout the 36 blocks forming each tract. With a measured exaggeration in the distribution, complementarity, and diversity of land uses amongst contiguous blocks, the computed entropy and dissimilarity indices underline the need for a more advanced algorithm.

Both tracts offer a perfect land use balance and entropy (1), yet diverging dissimilarity indices are 0.375 and 0.938 for tracts A and B, respectively. Though empirically verified in a variety of studies, adopting entropy and dissimilarity indices should be moderated with a comprehensive understanding of spatial and morphological aspects of built environments. Furthermore, urban development machinations in real-world cities can undermine the utility of entropy and dissimilarity results in predicting pedestrian activity. While mixed-use regulations in some cities differentiate land use types assigned to contiguous properties, others

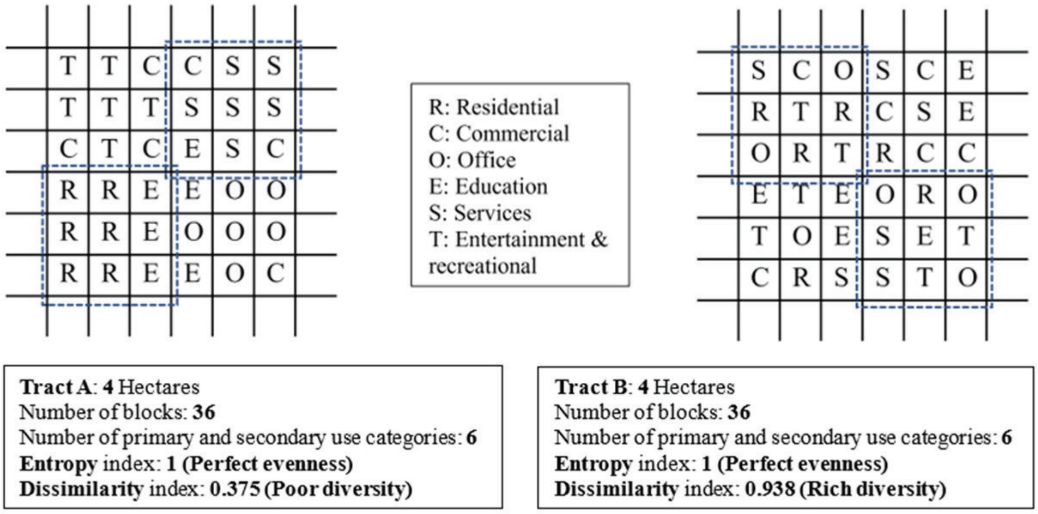

Fig. 4. Entropy and dissimilarity index calculations for two urban tracts [created by the author].

allow the mixing of different land use types in the same property.

Property developers in some cities can integrate retail, office, and residential uses in the same property (Fig. 5). Several properties may be consolidated to create large-scale developments. As well, various housing tenures and income groups may be integrated into a single development. Some mixed-use categories in such consolidated properties do not necessarily comply with existing codes but often get approved through variances that provide developers with opportunities to maximize their profits and respond to market needs. In some cases, the mix of commercial and office with residential uses in a block or several consolidated properties generates a richer diversity and synergy, but in other cases may reduce localized pedestrian activity across city blocks. Dissimilarity index calculations can be complicated further by factoring in vertical mixed-use configurations, as illustrated in Fig. 6 [56]. Developers may create a vertical mixed-use complex with commercial and office spaces occupying several podium floors, topped by numerous floors with different residential unit sizes and tenures. Empirical research results from Seoul have

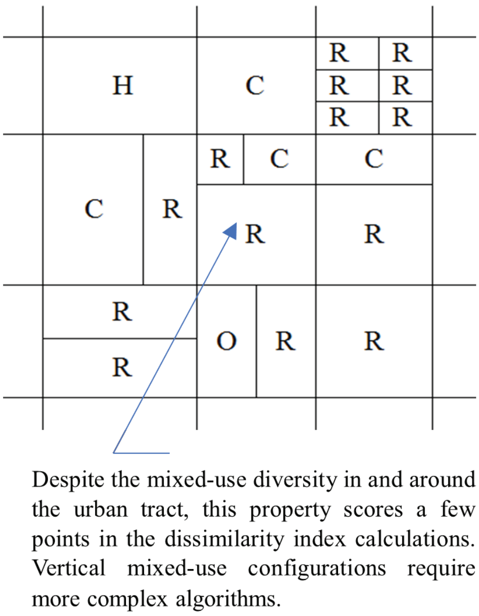

Fig. 5. Potential imperfect calculations of the dissimilarity index (adapted from [51]).

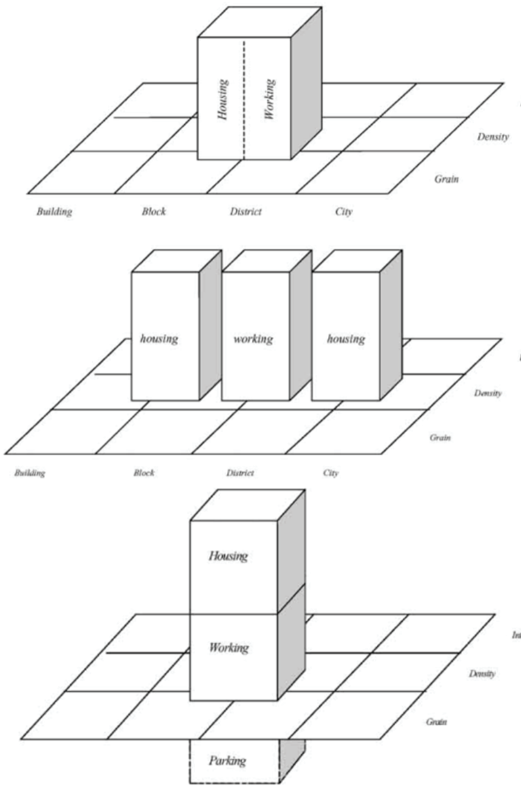

Fig. 6. Different mixed-use configurations [59].

revealed that the diversity of housing types and tenures at the neighbourhood level increases pedestrian activity more than the land use mix for five different categories [51]. Cervero et al. [22] have also pointed out that intensifying a land use type, such as commercial, or any other single land use for that matter, in adjacent developments creates the "island effect" with the consequence of internalizing pedestrian activity in and around such single-use concentrations. It also requires the provision of massive parking lots that exacerbate the separation between complementary uses, thus reducing pedestrian activity across urban tracts. Such results and arguments underline the need for a more complex logarithm; approximations and specific case study contexts are often used to develop more representative land use metrics.

III. Urban Development Grain and Street Network

Gridiron street networks have been employed in the spatial organization of cities for thousands of years. The grid provided a pragmatic approach to land division and property construction. It stood the test of time as an effective spatial organization approach that facilitates subdivision, annexation, amalgamation, and ownership transfer. Gridiron streets offered major advantages for movement flexibility and redundancy of travel paths throughout the network. More recently, the New Urbanism, smart growth, and urban resilience planning models expressed a renewed interest in traditional and modified gridiron networks and highlighted their adaptability to modern cities [8], [11], [36], [38], [40]. Some empirical studies differentiated street layouts as gridded, partially gridded (mix), or not (cul-de-sac), with values ranking network flexibility and connectivity from high or 1 for grid patterns to 0 for non-gridded streets [57]. The grain of urban settlements is invariably noted in the literature as a marker for pedestrian activity and street vitality. The key features of urban grain are block size, street geometry, connectivity, and concentration [1], [58]. As shown in Fig. 7, short blocks offer more flexibility in movement and enhance social encounters, which influence both pedestrian flows and neighbourhood economics. Network A, with shorter blocks, allows pedestrians to crisscross pathways and provides a common market pool for smaller retail outlets and service providers. In contrast, network B with longer blocks separates residents' and visitors' pathways, thereby reducing interactions and the potential of generating a complementary land use mix. Jacobs [1] presented the original 400-foot square block of Philadelphia as the most successful, especially when alleyways in between buildings split it. Some Philadelphia neighbourhoods started to break down as original alleyways were eliminated, and newer buildings blocked some streets, altering the block length to 700 feet. Contemporary superblocks more than 1000 feet long eliminate the multiplier socioeconomic effects of shorter blocks [1]. Based on the results of various empirical studies that corroborated Jacobs's assertions, some communities have adopted maximum block length standards ranging from 300 to 600 feet. Another variation of limiting block dimensions is the use of block size in acres without specifying maximum length or width to provide more flexibility with existing zoning regulations [59], [60].

Jacobs [1] also highlighted the need for concentration as a catalyst for pedestrian activity and urban vitality. Concentration is a holistic concept that does not simply refer to high population densities. It incorporates a complex array of urban features such as a variety of uses, a mix of home tenures, a mix of old and new buildings, a broad spectrum of social classes, and the presence of a critical mass of people in the streets at different times of the day and for different purposes. The relationship between concentrations of people and intensity of mixed land uses, according to Jacobs, is not a straight mathematical affair. Despite her emphasis on the need for dense concentrations of people as necessary conditions for urban vitality, Jacobs [1] distinguished between high population densities and

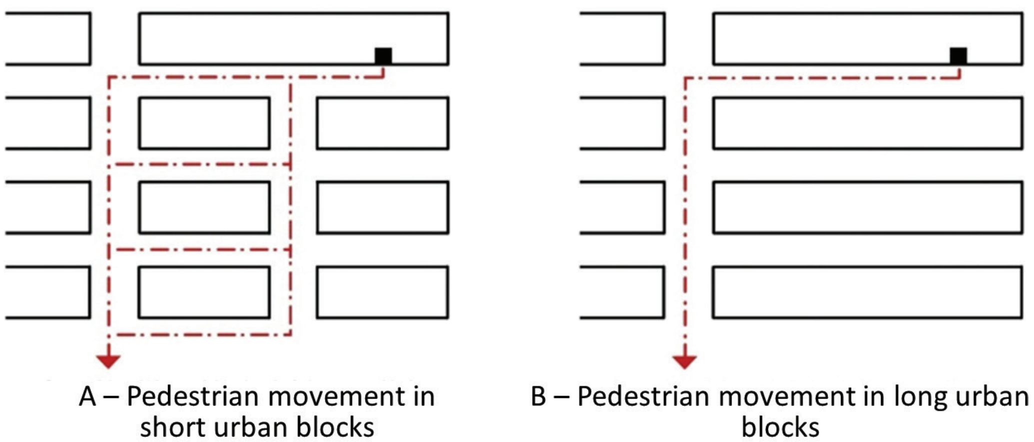

Fig. 7. Short versus long urban blocks (adapted from [1]).

overcrowded built environments, which oppress diversity and vitality rather than generate them. Based on her observational surveys of many thriving neighbourhoods across the United States, Jacobs estimated a density level of 100 dwellings per acre as necessary for creating vibrant city life. She underlined the need for six-story walk-up apartment complexes and twelve to fourteen-story buildings to achieve the above-mentioned density. For example, Greenwich Village in East Manhattan manages to house people at densities ranging from 100 to 115 dwelling units per acre without resorting to standardized buildings; it boasts a mixture of single and multi-family homes, apartment buildings, as well as mid-rise buildings (10–15 stories) in different sizes and shapes. In contrast, the Stuyvesant, an architect-designed housing project in Manhattan with a comparable density (115 dwelling units per acre) and highly standardized buildings, represents the superficial approach of zoning-regulated developments that fail to generate diversity and vitality.

Jacobs [1] challenged professionals to introduce a variety of uses and buildings with the level of concentration required for genuine diversity and vitality. Some studies have pointed to the lack of empirical verification for Jacobs's assertions regarding concentration and density [35], [61]. More recent studies, however, have confirmed the relationship between Jacobs's diversity conditions and pedestrian activity. When studying three neighbourhoods in Stockholm, Choi and Sardari [62] found positive correlations between higher population density in mixed-use spaces and pedestrian activity. Other experimental studies confirmed that the high population and employment density contributed to the increase in pedestrian activity. They assessed that 100–200 housing units per acre are critical for vibrant urban settings, which is close to the Jacobs's density formula [51], [63].

C. Street Network Connectivity Indices

Street network connectivity indices include various measures such as block density, intersection density, street density, connected node percentage, and the link-node ratio [22], [60]. The block density index denotes the number of blocks per urban sector or census tract. The higher number of blocks and smaller geometries for a given tract indicates a finer grain with improved accessibility and connectivity [64]. Intersection density refers to the number of four-way street intersections per unit area of measurement. The higher the number of four-way street intersections in a developed urban area, the higher the likelihood of accessibility, connectivity, and street vitality. Street density is positively correlated with intersection density and is represented by the cumulative length of street sections per unit area of the urban development tract. Connected node percentage refers to the proportion of street intersections to the total of intersections plus dead ends; values above 50 % indicate better network accessibility [60]. The link-node ratio often termed the connectivity index is derived by dividing the number of street links by the number of street intersections and nodes (cul-de-sacs or dead ends included). A higher connectivity index signifies a well-connected street system with the perfect grid scoring a ratio of around 2.5 [65]. Empirical studies from different cities confirmed the positive correlation between increased levels of pedestrian activity and higher connectivity indices [35], [66]. The example in Fig. 8 demonstrates the difference in connectivity between two urban tracts of the same size (one square kilometre). Though Tract I is not a perfectly open grid with three cul-de-sacs (dead ends), it manifests a moderately high level of connectivity (1.88). Tract II has a similar number of gridded blocks, but the addition of three dead ends dramatically changed the connectivity index, thereby resulting in a disconnected built environment and pedestrian pathways.

IV. Discussion

The analytical approach of this study juxtaposed the design approach with algorithmic instruments that assess the impact of land use mix and street network on pedestrian activity in urban settings. Most design characterizations emphasized precedence as the means of understanding and prescribing the built environment attributes that enhance urban vitality. They echoed much of the emotional and intellectual disposition of postmodernists by calling for more diversity, more emphasis on local context and mixed land uses, urban regeneration and building aesthetics [67]–[70]. This included a desire to revive the social and symbolic functions of city streets and public spaces and the way they affect the urban experience [1], [7], [11], [36], [71]. The new urbanists underlined the crucial role of mixed land uses and gridded street networks in supporting the economic and social functions of city streets. Physical elements such as vistas, urban axes, building facades, proportions, and decorative details figure prominently in design studies as cornerstones for organizing urban space, igniting a culture of community, and enhancing pedestrian flows in city streets. The design literature generally associated pedestrian movement patterns with the proper allocation of uses through space as well as fine-grain spatial structures and built forms [36], [39]. They contextualized mixed uses and street networks into a broad perspective that calls for reforming entire cities into self-sustaining neighbourhoods that provide residents with housing, employment, parks, schools, and daily retail services within easy walking distance. Mixed-use and fine-grain neighbourhoods are depicted as microcosms of the good city that provide their residents with spatially and visually attractive built forms that support their presence in the streets and public spaces.

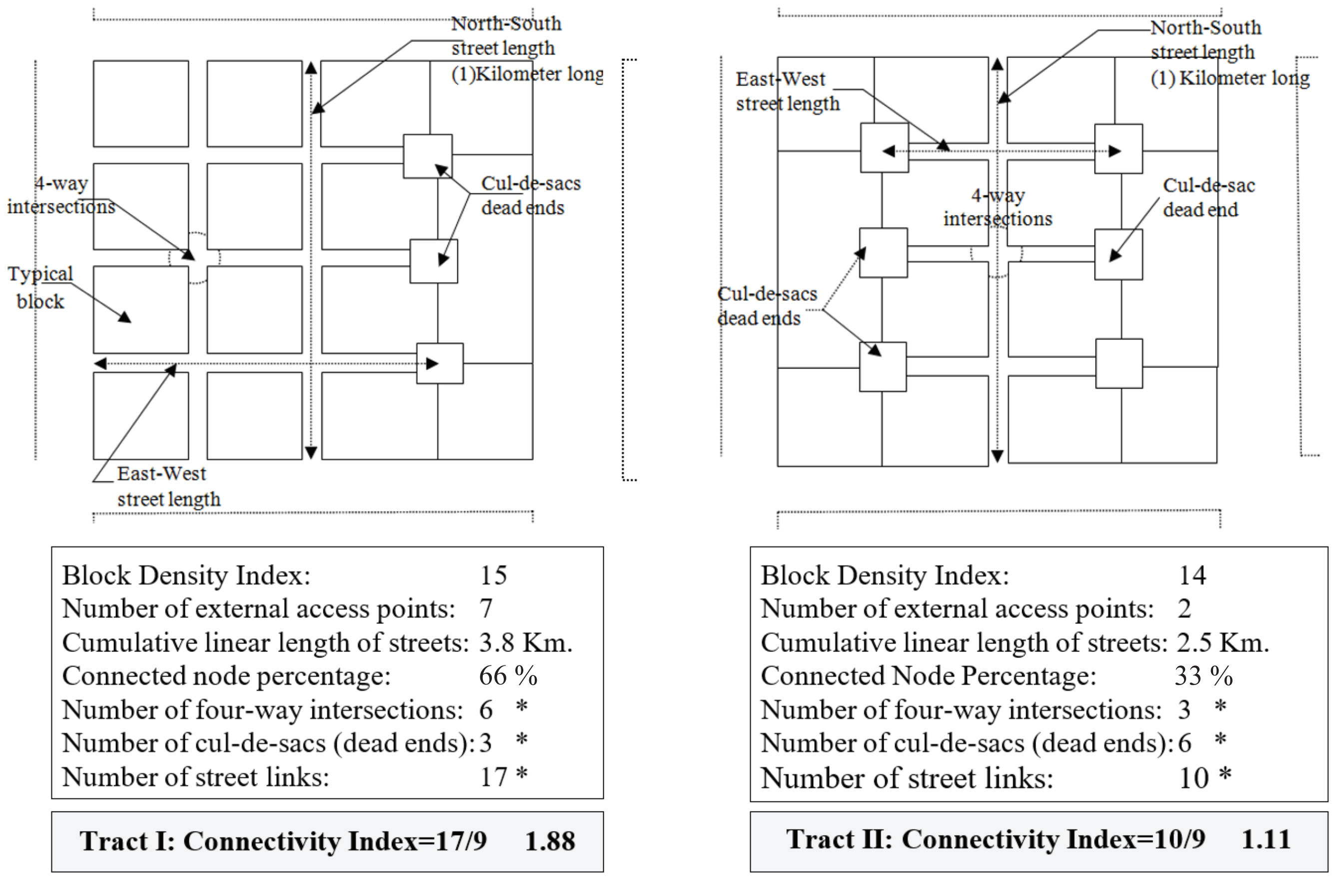

Fig. 8. Connectivity index calculations for one square kilometre urban tract [created by the author].

Algorithmic indices, on the other hand, have been tested and somewhat validated in various empirical studies. As a measure of the equal distribution or evenness of the land use mix, the entropy index has invariably offered an indication of pedestrian possibilities in urban neighbourhoods. Based on the statistical analysis of pre-defined seven land use categories in a variety of case studies, the higher values (closer to 1) indicated more mix and diversity in land use types and were positively correlated with higher pedestrian activity and vice versa for lower values [23], [50]. The entropy index, however, did not yield accurate results in less regulated built environments or in cities that permit multiple uses in the same property or building. Though providing a measure of use heterogeneity, the entropy index concept of even distribution did not consider the level of complementarity between the different land uses and their potential for predicting travel behaviour and walking patterns [44], [45]–[53]. Further improvements in measuring land use mix interactions and pedestrian flows were introduced by two critical entropy variations, LUM and dissimilarity. The application of LUM in cities with relaxed regulatory systems can produce a more accurate measure of the functional mix since it computes the built gross floor area of uses rather than land use classifications in building permit registries. Property owners, in such cases, modify building spaces and adapt them to different uses that respond to changing market dynamics without necessarily registering the changes. Yet, LUM still adopts the entropy logic of seeking land use mix evenness and fails to consider the dynamics of complementary land uses in built environments. The mean entropy index by Kockelman [52] raised a critical concern related to land use mix measurements. Pedestrian flows in each neighbourhood can be impacted not only by the land use mix in this neighbourhood but also by surrounding neighbourhoods. Hence, the average of all entropies of a group of contiguous neighbourhoods captures a better understanding of the built environment attributes that contribute to urban vitality. The dissimilarity index that was initially introduced by Cervero [58] computed the dispersion of land use types and provided a basis for predicting travel patterns between complementary uses such as housing, retail, office, and other support functions. It measured the land use variations amongst contiguous developments. However, the dissimilarity index did not factor in the different mixed-use configurations in some cities that allow mixing uses vertically as well as horizontally [59]. The algorithmic functions analysed in this study contribute to the current understanding of the associations between the built environment and pedestrian activity. None of them can be used in isolation from the other and need to be considered synergistically to measure pedestrian travel patterns as a dependent variable on the built environment.

The theoretical quest of this study has contrasted two different approaches to analysing the impact of mixed land uses and street networks on pedestrian movement patterns. Though manifesting various areas of agreement between the two approaches, this study has revealed the underlying variations between the design-based narratives, and the statistically grounded assessments. The design-based literature tackled a broad spectrum of issues that seem to impinge on human behaviour in urban environments. They often extended an all-encompassing approach that interlinks physical, spatial, and socioeconomic concerns in understanding and prescribing the land use mix and street network attributes that affect pedestrian movement. Design accounts introduced the traditional spatial and mixed-use typology as the solution to reviving city vitality. With a primary focus on precedence and case studies, some of the design arguments, however, have not been validated by scientific tools. It may all seem a little too rhetorical to say that both the spatial/architectonic approach and statistical functions are essential for an integrative understanding of the built environment features that support urban vitality and pedestrian activity. Mixed-use metrics should be supported by visual and spatial analyses that complement the application of the statistical tools and justify variations in index values or results from one case study to another. Design-based arguments should also be supported by algorithms to enhance their reliability and validity. These continue to prescribe traditional main street typology as an appropriate strategy to enhance vitality and pedestrian presence in streets and public spaces. However, traditional main streets have been transformed from retail and employment corridors serving their immediate residential surroundings to regional entities with highly specialized retail activities and a metropolitan-wide catchment area. Main streets within traditional downtowns no longer provide the daily needs of neighbouring residential districts, such as bakeries, vegetable stands, and various stores. They increasingly accommodate speciality and upscale retail items that attract elite urbanites and suburbanites with certain cultural aspirations [8]. In that sense, the design arguments should be moderated with an in-depth understanding of the machinations of the modern city, which has been transformed from the traditional monocentric structure to an open economic polycentric formation that dictated new urban geography with different functions throughout its neighbourhoods and streets. While some design-based arguments are still valid today as they were decades ago, they should be integrated with algorithmic tools that deal with modern development realities. This study has offered a nuanced perspective that juxtaposed several design assessments and planning tools that measure the impact of mixed uses and street network configurations on pedestrian activity.

Conclusions

The critical approach employed in this study revealed disparities within various urban design and planning theoretical frameworks concerning the configurational and spatial dynamics that augment pedestrian activity and street vitality. The study analysed design-based theoretical frameworks and algorithmic measurements that associate urban vitality with built-form scenarios related to mixed-use and gridded street networks. Entropy, LUM, and dissimilarity indices provide valuable insights regarding the impact of land use mix and street network attributes on pedestrian activity. Though each of these algorithmic functions assesses some critical spatial and design attributes, none of them can be employed in isolation from the other and need to be considered synergistically to measure pedestrian travel patterns as a dependent variable vis-a-vis the built environment. In contrast to these algorithmic models, the design literature emphasizes precedence as the means of understanding and prescribing the built environment attributes that enhance urban vitality. Design-based analyses generally associate pedestrian movement patterns with the proper allocation of uses through space as well as fine-grain spatial structures and built forms. They contextualize mixed uses and street network configurations into a broad perspective that calls for reforming entire cities into self-sustaining neighbourhoods that provide residents with housing, employment, parks, schools, and daily retail services within easy walking distance. Both design and algorithmic approaches demonstrate a level of reliability and validity in empirical studies. Despite the overlapping dimensions and agreements between both approaches, this study revealed critical variations between the design narratives and the statistically grounded assessments. It underlined the need to integrate the spatial/architectonic approach and algorithmic functions to describe and prescribe the built environment attributes that enhance urban vitality. The depth and breadth of this undertaking generated a robust foundation for future urban planning and design research aimed at enhancing urban vitality and accurately predicting pedestrian travel patterns in urban settings.

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