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ANALYSES OF WALKABILITY IN CITY CENTERS: A FRAMEWORK TO ASSESS WALKABIITY BASED ON STREET CONDITIONS, PROXIMITY OF SERVICES & URBAN MORPHOLOGICAL CONDITIONS

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Abstract: Many studies utilized the 'Walkability Index' to measure the level of the walkability of cities predominately based on street conditions and road infrastructure availability while giving limited attention to factors such as urban morphological conditions and proximity to activities and services. This study argues that the actual walkability should be calculated by using not only considering the effects of walking conditions on streets but also, considering the urban morphological conditions and the proximity of services. The main objective of the study is to develop a framework to measure walkability in the city centers' by accessing the multidimensional aspects including walking conditions on streets, density, functional mix, accessibility, and proximity to services. As the main outcomes, the study was able to i. develop a quantitative framework to measure walkability in the city centers' by considering and combining the multidimensional aspects ii. quantify the level of the walkability of ten small and medium-sized towns in Sri Lanka and rank them. Accordingly, the study concludes that the findings could be beneficial for urban planners as they can effectively quantify the level of walkability in town centers by using the developed framework when developing Site Plans/ Development Guide Plans/ Local Plans. Further planners can utilize this framework to identify the parameters that they need to enhance to improve the walkability of towns.

Keywords: *Walkability, Walking conditions, Urban Morphological Conditions, Proximity of Services, Small and Medium-Sized Towns*

1. Introduction

The walkable city concept has become a popular academic and professional discourse about the future of cities. Walkability has always been correlated with human health and well-being, and urban design and planning greatly consider the walking behavior of people in cities (Saadawy & Hady, 2022). Further high walkable cities consider eco-friendly and human-powered cities which appear to support community health, safety, and livelihoods and reduce carbon emissions by reducing car dependency (Ahmad & Naharudin, 2022). Additionally, the COVID-19 pandemic has increased the demand for walkable neighborhood construction, particularly in urban areas (Zaleckis, Chmielewski, Kamičaitytė, Grazuleviciute-Vileniske, & Lipińska, 2022). Furthermore, walkability has been interrelated to many physical characteristics of the urban environment including permeability, density, safety, footpath quality, built environment, land use mix, and climate (Pafka & Dovey, 2017). Therefore, to promote sustainability, walkability is very beneficial in urban planning.

Accordingly, numerous academics have conducted extensive research on how the built environment influences walking and how to measure the level of walkability in cities (Gaglione, Gargiulo, Zucaro, & Cottrill, 2022). Based on the literature review, the study revealed there are mainly three groups of criteria utilized for measuring walkability in recent studies. Those are walking conditions on streets based on the 'Walkability Index', urban morphological conditions, and spatial proximity for activities and services. Generally, the measurement used to assess a city's walkability is called the 'Walkability Index' (Ahmad & Naharudin, 2022). Global Walkability Index qualitatively examines the walking conditions considering the safety & and security, convenience & and attractiveness, and policy support of the pedestrian environment (Krambeck, 2006).

This analysis helps to better understand how walkable cities are currently and shows where improvements can be made to pedestrian facilities (Krambeck, 2006). In India, the Walkability Index was based on the number of walkways and the quality of the facilities for pedestrians (Leather, Fabian, Gota, & Mejia, 2011). Walking Conditions significantly concern whether there are safe spaces for pedestrians to walk (Knapskog, Hagen, Tennøy, & Rynning, 2019).

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The second group measure walkability based on urban morphological conditions. Limited studies were developed to measure walkability based on urban morphological factors. Kim Dovey and Elek Pafka have introduced, density, functional mix, and access which are called Urban DMA as key urban morphological factors that influence walkability (Dovey & Pafka, 2020). In the opinion of Dovey and Pafka, the urban DMA is an intellectual framework for comprehending and building a more walkable city. Urban DMA has its roots in the writings of the late Jane Jacobs, whose book "The dead and Life of Great American Cities" was published in the middle of the 20th century, a time when many great cities were being abandoned to automobiles and subpar urban planning (Dovey & Pafka, 2020).

The third group assesses walkability utilizing the geographical proximity of services which focused on pedestrian accessibility and pedestrian walkable distance for neighborhood facilities (Caselli, Carra, Rossetti, & Zazzi, 2022). This criterion is mainly evolved with the 15-minute city concept (Noworól, Kopyciński, Hałat, Salamon, & Hołuj, 2022). A 15-minute city's citizens should be able to get the majority of their daily needs met within easy walking or biking distance of their houses (Marquet & Miralles-Guasch, 2015).

In the literature review, it has been identified that walkability studies are mainly focused on only a single dimension thus there is a limited number of studies that are focused on multidimensional aspects. This study argues that the actual walkability should be calculated by using not only considering the effects of walking conditions on streets but also, considering the urban morphological conditions and the proximity of services. However, the study noted that no or very limited studies have been done yet, to assess the walkability of cities by considering the cumulative effect of walking conditions on streets, urban morphological conditions, and the proximity of services. Therefore, this research aims to develop a framework to assess walkability in city centers based on a multidimensional analysis taking into account not only street conditions but also considering urban morphological conditions such as density, functional mix, accessibility, and proximity to services.

In light of this, this study aims to significantly address the following two important research gaps found in recently published research. First, many contemporary research has utilized walking conditions or urban morphological conditions, or proximity of services to measure walkability independently but has not compared and contrasted the level of walkability considering different criteria. Further, there is still no standard framework to measure walkability considering multidimensional aspects including street conditions, density, functional mix, accessibility, and proximity to services. Second, no or very limited research has been done to assess the level of walkability in city centers in Sri Lanka's middle and small towns by considering the urban morphological conditions. Therefore, it is worthwhile to measure and rank the level of walkability in city centers in small and medium towns in Sri Lanka accessing the multidimensional aspects including street conditions, density, functional mix, accessibility, and proximity to services.

Considering the above, the main objective of the study is to develop a framework to measure walkability in the city center by accessing the multidimensional aspects including street conditions, density, functional mix, accessibility, and proximity to services. Accordingly, this study is seeking an answer to the main research question of how the walkability of the city center can be analyzed with a multidimensional aspect including street conditions, density, functional mix, accessibility, and proximity to services.

2. Methodology

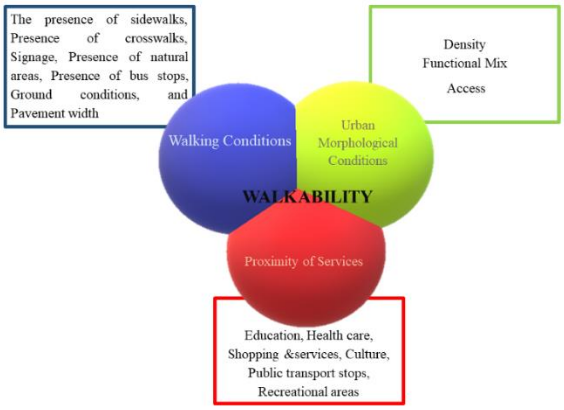

Figure 1 -Relationship between 3 criteria (Source: : Compiled by Author)

This study was conducted in four stages. In the first stage, a review of the literature was conducted to identify the methods used to measure walkability and the variables that affect it. The second stage involved the development of a quantitative framework for measuring walkability in the city center. This framework encompasses multidimensional aspects, including walking conditions on streets, density, functional mix, accessibility, and proximity to services. In the third stage of this study, the walking conditions on streets, urban morphological conditions, and proximity of services were mapped and calculated for ten case study towns. Subsequently, the walkability of each town was analyzed by comparing the various criteria. A walkability index was developed based on the z-score cumulative value of each criterion, and the actual walkability level of each case study town was measured and ranked accordingly. In the final stage, the study compared and contrasted its findings with those of the current literature.

2.1. PROPOSED FRAMEWORK

Initially, this study established the 15-minute town boundaries for 10 case study towns. To accomplish this, a "Network Service Area" analysis was conducted, which determined the 15- minute walkable area originating from the main bus terminal of each case study town. The second step involved the calculation of multidimensional factors, which were based on several attributes related to walking conditions on streets, urban morphological conditions such as density, functional mix, and accessibility, as well as proximity to services. Ultimately, the z-score walkability index was determined for selected towns, taking into account the z-scores of proximity to services, walking conditions on streets, and DMA. The towns were subsequently ranked based on this index. The proposed conceptual framework can be visualized in Figure 2, encompassing four main steps:

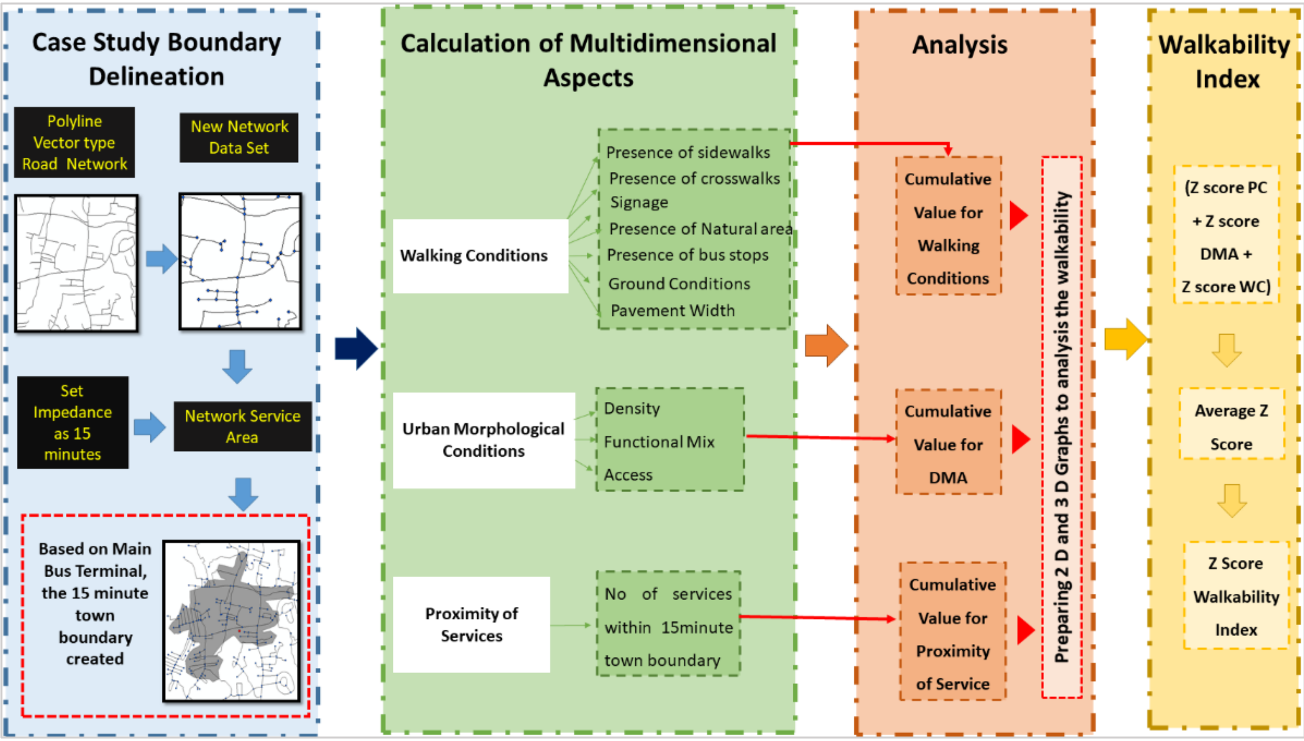

Figure 2 -The proposed Framework (Source: : Compiled by Author)

The Conceptual Framework includes 4 steps.

(1) **Boundary Delineation-** The "Network Service Area" analysis was done to determine the 15-minute walkable area based on the main bus terminal of the case study town.

(2) **Calculation of Multidimensional Aspects-** Walking conditions on streets, urban morphological conditions (DMA- density, functional mix, accessibility), and proximity to services are calculated to determine the actual level of the walkability of town centers.

(3) **Analysis-** Preparing 2D and 3D Graphs, to assess the walkability of cities by considering the cumulative effect of walking conditions, urban morphological conditions, and the proximity of services.

(4) **Calculation of Walkability Index-** Based on z scores of the proximity of services, walking conditions on streets, and DMA, the level of walkability was measured and ranked in small and medium towns in Sri Lanka

2.2. CASE STUDY AREA

The Western Province of Sri Lanka's middle- and small-sized cities were chosen for this study since they currently house more than 60% of the country's urban population, which is growing quickly. Accordingly, based on four criteria, case study areas were chosen for this study. (1) Variety of Spatial Forms (2) The population level of towns - As per (Munasinghe, 2005), small-sized cities in Sri Lanka are those with a total population of less than 100,000, while medium-sized cities have populations between 1,000,000 and 200,000 (Manesha, Jayasinghe, & Kalpana, 2021). (3) Urbanized level of. (4) Availability of Data.

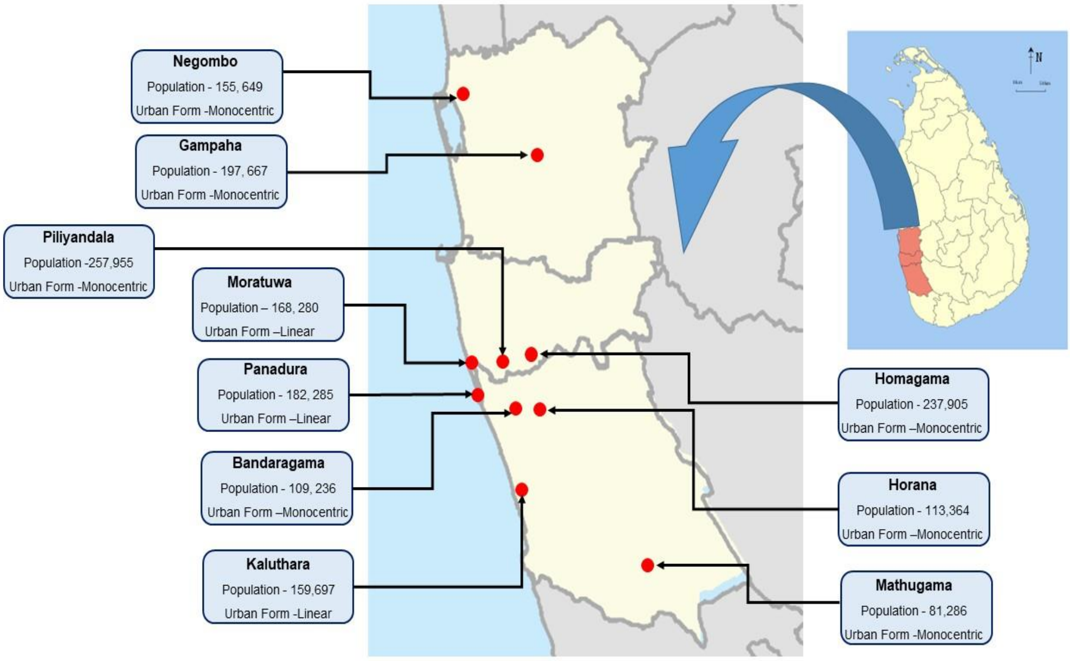

Figure 3 - Case Study Areas (Source: : Compiled by Author)

2.3. WALKABILITY INDEX

The Walkability Index is a composite measure that combines three distinct indices: the Walking Conditions Index, the Urban DMA Index, and the Proximity of Services Index.

Cumulative Z score for Walking Conditions= [(z - SW) + (z -GC) + (z – PW)]

z= the z score for each sub-criteria SW= Cumulative value of % of Standard sidewalks
GC= Cumulative value of Ground Conditions PW= Cumulative value of Pavement Width

Cumulative Z score for DMA= [(z - D) + (z -M) + (z – A)]

z= the z score for each sub-criteria D= Cumulative value of Density
M= Cumulative value of Mix A= Cumulative value of Access

Cumulative Z score for Proximity of Services= [(z - NS) + (z -OS) + (z – SS)]

z= the z score for each sub-criterion NS= Cumulative value of Necessary Services
OS= Cumulative value of Optional Services SS= Cumulative value of Social Services

Finally, the calculation of Walkability Index is measured as follows (3),

Walkability Index = [(z – WC) + (z - DMA) + (z – PC)]-----------------(3)

z= the z score for each criterion WC= Cumulative Z score for Walking Conditions
DMA= Cumulative Z score for DMA PC= Cumulative Z score for Proximity of Services
Accordingly, the Walkability Index for any town can be calculated and ranked by using the above method.

3. Results

Based on the results, all of the towns have a good level of urban morphological value compared to the walking conditions on the streets. But the walking conditions of all towns are significantly less than DMA. Therefore, even though urban morphological values are high in selected towns, walking conditions on streets are an issue in these towns. Accordingly, urban planners should be more concerned with the walking conditions on streets when improving the walkability of towns. Furthermore, except Negombo, other towns have services within the walkable distance of a 15-minute town boundary. The urban morphological level differs variously. But overall, all case study towns have significantly low value for the walking conditions.

According to the results of case study towns, there is no relationship between urban morphological conditions and proximity to services with the walking conditions on streets, based on the findings of the studies Urban DMA Vs Walking Conditions and Proximity Services Vs Walking Conditions. Therefore, this framework can be used to quantify how the walkability of the city center varies with density, functional mix, accessibility, and proximity to services, regardless of how favorable the walking conditions on the streets are. Then planners can get a decision as to what factors should change or improve in order to increase the walkability in the town center. Thus, this framework considers walking conditions on streets, urban morphological conditions, and the proximity of services to describe the actual level of the walkability of the city center.

- As per street conditions, all case study towns have a significantly low value compared to urban morphological conditions and proximity of services.
- Comparatively, except Matugama and Bandaragama, other case study towns have a high DMA(Density, Mix, and Access) value.
- As per proximity of services Bandaragama has the highest value for services within a 15-minute town boundary while Negombo has the lowest value.
- The presence of sidewalks is a significant factor in walking conditions. But all of the case study towns have less than 20% of roads with sidewalks.

Town	Density	Mix	Access	DMA	Walking Conditions	Proximity of Services
Negombo	0.72	0.78	0.71	0.74	0.17	0.60
Kaluthara	0.69	0.79	0.19	0.56	0.22	0.79
Mathugama	0.48	0.40	0.05	0.32	0.15	0.85
Piliyandala	0.67	0.55	0.25	0.5	0.17	0.81
Horana	0.59	0.64	0.19	0.48	0.21	0.76
Bandaragama	0.45	0.28	0.08	0.27	0.19	0.88
Panadura	0.74	0.83	0.30	0.63	0.20	0.85
Moratuwa	0.70	0.71	0.38	0.6	0.18	0.77
Homagama	0.55	0.59	0.16	0.44	0.16	0.81
Gampaha	0.70	0.78	0.24	0.58	0.19	0.81

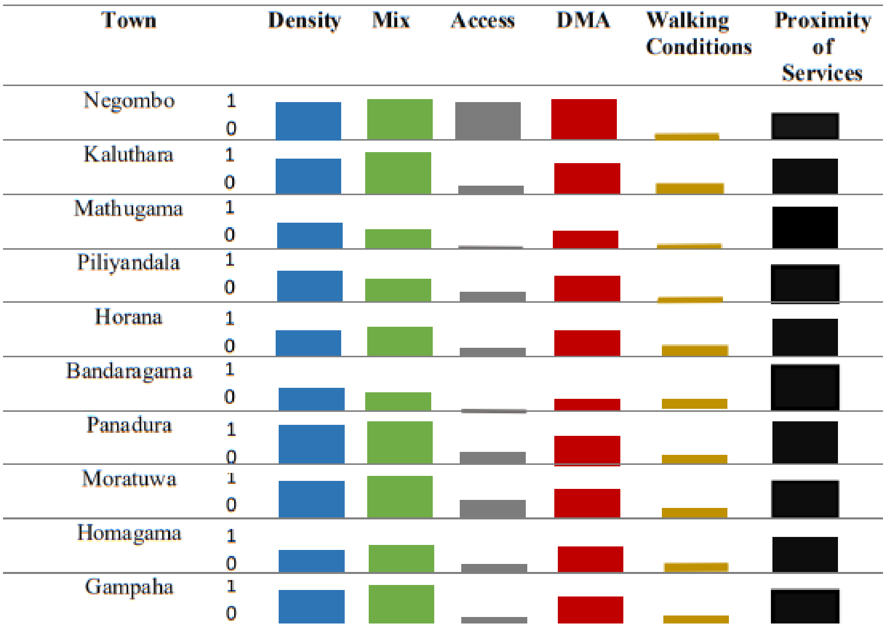

Figure 4 -Summary (0 = Low 1=High) (Source: : Compiled by Author)

The towns are ranked based on walking conditions on streets, urban morphological conditions, and proximity of services.

- According to the ranking based on the walking conditions on the streets, Kaluthara was given the top spot, followed by Horana, Panadura, Gampaha, Bandaragama, Moratuwa, Negombo, Piliyandala, Homagama, and Mathugama, who were ranked second, third, fourth, fifth, sixth, seventh, eighth, and tenth, respectively.
- According to a ranking based on the morphology of urban areas, Negombo is at the top, followed by Panadura, Moratuwa, Gampaha, Kaluthara, Piliyandala, Horana, Homagama, Mathugama, and Bandaragama, who are ranked second through tenth, respectively.
- According to rankings based on proximity of services, Bandaragama is ranked first, followed by Mathugama, Panadura, Gampaha, Piliyandala, Homagama, Kaluthara, Moratuwa, Horana, and Negombo, who are ranked second, third, fourth, fifth, sixth, seventh, eighth, ninth, and tenth, respectively.

According to the below graph, the z-score walkability index of Kaluthara, Negombo, Moratuwa, and Gampaha have most equal to their z-score of walking conditions on streets. Gampaha and Panadura have the most equal values for the z-score walkability index with the z-score DMA, the z-score proximity, and the z-score walking conditions on streets. According to the z score walkability index, Panadura has obtained the highest value which implies the highest walkable town among the other case study towns. And Mathugama has obtained the lowest value which implies the lowest walkable town among other case study towns. The z score Walkability Index for each town helps in understanding which among the towns has the highest and lowest Walkability Index by accessing the multidimensional aspects including street conditions, density, functional mix, accessibility, and proximity to services.

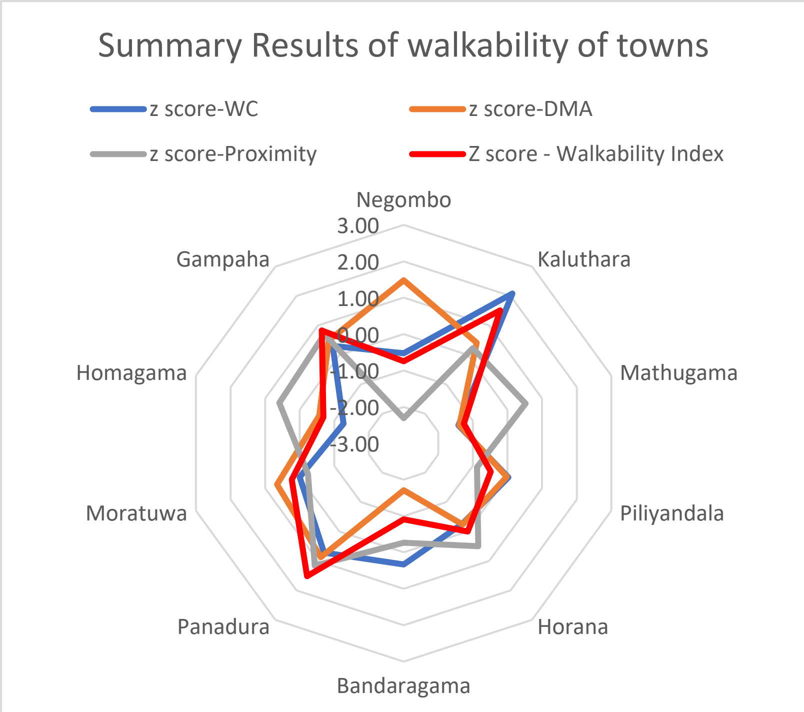

Figure 5 -Summary Result (Source: : Compiled by Author)

4. Conclusion

The key findings are summarized below,

(1) This study has developed a framework to assess the walkability in city centers with a multidimensional aspect including walking conditions on streets, density, functional mix, accessibility, and proximity to services. Accordingly, a Walkability Index was developed based on the z scores of walking conditions, DMA, and proximity of services.

(2) Normally countries like Sri Lanka, walking conditions on streets are low. But in this research, walkability is measured based on a multidimensional perspective including walking conditions on streets, urban morphological conditions, and proximity of services. And this study implies, most small and middle-scale towns in Sri Lanka have high urban morphological conditions and high proximity of services while walking conditions on streets are relatively low in terms of walkability.

(3) And finally, this research has measured and ranked the actual level of walkability in city centers in small and medium towns in Sri Lanka.

The literature review revealed that most walkability studies are mainly focused on only a single dimension. But this study argues that the actual walkability should be calculated multidimensional aspect by using not only considering the walking conditions on streets but also, considering the urban morphological conditions and the proximity of services. According to the results of Urban DMA Vs Walking Conditions and Proximity Services Vs Walking Conditions, there is no corresponding relation between urban morphological conditions and proximity of services with the walking conditions. Based on the variation of these factors, the proposed framework can be said to be effective. Therefore, whether walking conditions are good or bad, how the walkability of the city center differs with density, functional mix, accessibility, and proximity to services can be captured from this framework. Therefore, this framework describes the level of the walkability of the city center considering walking conditions, urban morphological conditions, and the proximity of services.

Furthermore, the developed Walkability Index gives a single value for the actual level of walkability in towns by accessing the multidimensional aspects including street conditions, density, functional mix, accessibility, and proximity to services. And this z score Walkability Index for each town helps to understand the level of the walkability of each town.

Based on this framework, Planners can effectively capture the walkability level in town centers and can get decisions on the walkability based on walking conditions on streets, urban morphological conditions, and proximity services when developing Site Plans/ Development Guide Plans/ Local Plans. And planners/policymakers can identify the parameters that need to develop (walking conditions/ urban morphological conditions/ proximity of services) to enhance the walkability in towns.

Can be done more case studies in the future as this study has only used 10 case studies. And not only Sri Lankan towns, this study can be expanded to compare walkability with towns in developed countries.

Furthermore, not only the city center but also this study can be expanded to the entire urban area. For the improvement of this study in the future, it is recommended that additional criteria can be used for the z-score walkability index; in example for the walking conditions criteria.

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