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ASSESSMENT OF WALKABILITY IN BUILT ENVIRONMENT AT DISTRICT LEVEL: A CASE OF AN-NAJAH NATIONAL UNIVERSITY DISTRICT

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Abstract

The mainstream research about sustainable development recommends walking as a top ranked active transportation and the most favorable healthy mode. This recommendation makes designing and implementing walkable communities a main goal for urban transportation planners and engineers as well as for public health specialists. This study takes a district consisting of three neighborhoods in Nablus City –namely An-Najah University District—to investigate the extent to which the built environment is pedestrian friendly. In order to answer this research question and to test the corresponding research hypotheses, the researcher conducted a field survey covering 23 Km of arterial, collector and local roads. The survey was designed to examine the space available for pedestrians along each side of the all road segments and the surrounding built environment from four aspects: (1) connectivity; (2) safety; (3) convenience; and (4) aesthetic aspects. A special Geographic Information Systems (GIS) tool was designed to conduct the analysis and to represent the results spatially. The results show low quality built environment in the four aspects of assessment and a significant spatial variation in the walkability scores across the study area and among the different classes of roads. The study is concluded with three types of recommendations to the decision and policy makers, the municipality engineers and urban planners, and the researchers to work together to improve the walkability at different spatial level.

Keywords: Walkability; Built Environment; GIS Modelling.

1. Introduction

The mainstream literature about sustainable development and livable communities recommends walking as a top ranked active transportation mode and the most favorable healthy one (Lachapelle et. al. 2011). Urban planners and transportation engineers promote walkability as an essential principle of transit oriented development (TOD) to limit the urban sprawl for the sake of reducing Vehicle Miles Traveled (VMT) and greenhouse gas emission (Adlakha et. al. 2018, Ewing and Handy 2009). Public health specialists perceive walkability as a solution for obesity and chronic diseases (Gebel et al. 2011; Frank et. al. 2007). Researchers in the aforementioned fields have recently worked in specialized teams and multidisciplinary groups on measuring and evaluating walkability as a first and essential step towards walkable built environment (Ewing et. al. 2006; Sallis et al. 2004; Chiang et. al. 2017).

Although walking as a mode of transportation depends on the people’s preferences and their socio-economic characteristics (Smith and Billig, 2012; Liao et. al. 2015; YinNg et. al. 2015), several studies have found the built environment as a factor of significant effect on walking (Agrawal et al. 2008; Sallis et al. 2004). This diversity in identifying the walkability driving forces is reflected on the approahces the researchers have followed in measuring walkabiliity of a specific area. Some researchers measured walkability depending on people’s preferences and their socio-economic characteristics (Lin et. al. 2016). Other researchers measured walkability using built environment characteristics (Dygryn et. al. 2010; Leyden 2003; Marinez and Lopez, 2017; Bahrainy et al 2015).

This study focuses on the built environment characteristics as a measure of the walkability. The main objectives of this study are to: (1) Measure and evaluate walkability following a new methodology that suits the Palestinian contexts – limited resources and data; (2) Design and implement a GIS tool that can be easily used by other researchers to measure the level of walkability; and (3) Present some examples on how the proposed methodology and GIS tool can be used to quantifying the walkability.

2. Methodology

Referring to the literature and constrained by the time, budget and data availability limitations, the researcher defined a set of 52 indicators that fall in one or more of the following categories:

(1) Connectivity: the features that provide more options (or limit the options) for pedestrians to reach more places, to move in different directions, and to cross from one side to another. The more options that exist, the higher the connectivity is.
(2) Safety: the features that participate in creating safer (or unsafe) environment for pedestrians to walk from one point to another, to cross streets, to refuge while crossing, to eliminate conflict points with traffic…etc.
(3) Convenience: the features that make the walking environment more (or less) comfortable and make the built environment more (or less) attractive for pedestrians.
(4) Aesthetic indicators: the features that make the physical environment more (or less) appealing.

Figure (1) below shows the four main categories and their corresponding indicators. It shows also overlap between each category and illustrates the indicators falling in more than one category.

The four components are given the same weight and each indicator is evaluated on a scale of 0 to 5 or in some special cases on 1 to 5. Another group of indicators is given zero if they did not exist and five if they were available including the following indicators: drinking fountain, public restroom, speed limit and speed calming. Finally, the availability of the aggressive dogs' indicator is given zero if available and five if not. Each road segment will be evaluated according to this scoring system. Table (1) shows a sample of the criteria used in the evaluation process and their corresponding scores. Following that, Table (2) shows the least score that a given segment can obtain if none of the indicators is satisfied and the maximum score if all indicators are fully satisfied. For example, the table shows the connectivity scores ranges from 5 to 32. When none of the connectivity requirements is satisfied, the connectivity indicators collect only 5 points. When all connectivity requirements are satisfied, the connectivity score sum up to 32 points as the best situation.

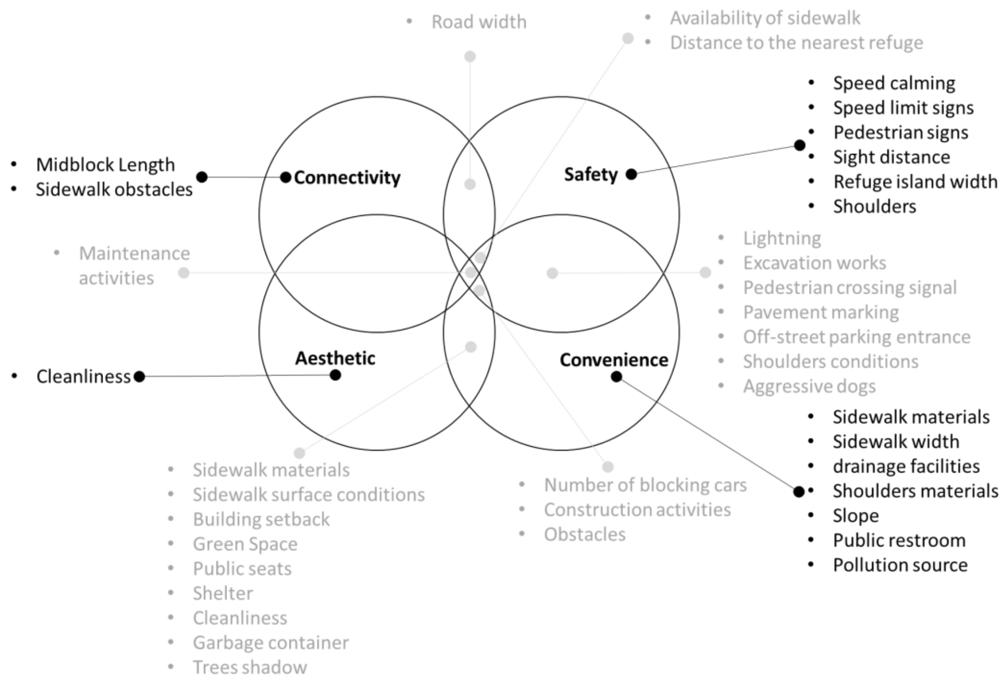

Figure (1): Classes of walkability indicators

Table 1. Sample of the Criteria and their Scoring System

Evaluation Criteria	Scoring System
Availability of sidewalk	0: does not exist/ 1: covers up to 25%/ 2: 25– 50/ 3: 50 – 75%/ 4: 75 – less 100%/ 5: 100%
Distance to the nearest refuge	0: does not exist/ 0: 12m and more/ 1: 10-12m/ 2: 8-10m/ 3: 6-8m/ 4: 4-6m/ 5: less than 4m
Refuge island width	0: does not exist/ 1: less than 1m/ 2: 1-2m/ 3: 2-3m/ 4: 3-4m/ 5: more than 5m
Pedestrian safety guard	0: does not exist/ 1: covers up to 25% or less / 2: 25– 50/ 3: 50 – 75%/ 4: 75 – less 100%/ 5: 100%
Shoulder availability	0: no shoulders available/ 1: available on up to 25% and less / 2: 25– 50%/ 3: 50 – 75%/ 4: 75 – less 100%/ 5: 100%
Shoulder's width	0: no shoulders available / 1: less than 1m/ 2: 1-2m/ 3: 2-3m/ 4: 3-4m/ 5: more than 5m
Green Space on/near/along the side walk	0: no green areas at all/ 1: up to 25% and less / 2: 25– 50%/ 3: 50 – 75%/ 4: 75 – less 100%/ 5: 100%

Table 2. Maximum and minimum scores that could be achieved by each walkability component

Connectivity		Safety		Convenience		Aesthetic		Overall walkability	
Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
5	32	8	141	4	210	0	95	17	478

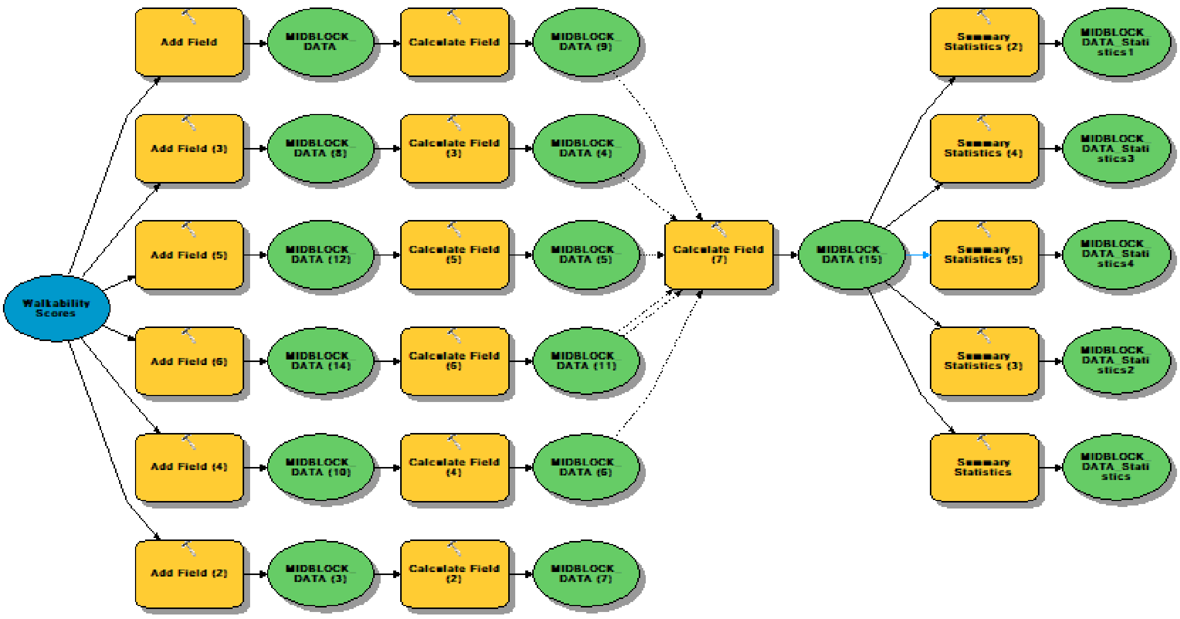

Figure 2. GIS walkability analysis model

A GIS tool was specifically designed for the purpose of walkability analysis and mapping. The tool is a simple GIS model implemented in ESRI ArcGIS 10.1 environment as shown in Figure (2). The inputs are the four sets of indicators illustrated in Figure (1) above and the output is the walkability scoring.

Each component of the four walkability components is added as a new attribute to the road network and the researcher can go farther in the spatial analysis at street, neighborhood, district and city level if data is available. This study analyzes and discusses the walkability variation at the street and district level.

The study area selected for this research is An-Najah National University (ANU) District that consists of three neighborhoods in Nablus City with 2.2 Km^2 area. Each road segment for each side of the road between two consecutive intersections was given a unique ID and surveyed by a separate data collection sheet. The total number of road segments shown in Figure (3) and Table (2) is 280 segment out of which is 24 classified as arterial, 71 collectors and 186 local with overall length of 46.8 Km.

3. Results and Discussion

As mentioned above, the overall walkability score is split into four components. Using the GIS model each component was calculated and presented in a separate map (figures from 4 to 7). The score of the four components is summed to give the overall walkability score which is in turn represented in a fifth map as shown in Figure (8).

3.1 Connectivity Analysis

The spatial distribution of the connectivity scores—shown in Figure (4)—shows that the surroundings of the two ANU campuses have higher levels of connectivity while the roads segments between the two campuses are less connected. As to the results of the road classes analysis listed in Table (3), arterial roads have higher average scores of connectivity (19 points) while the collectors have moderate average scores (17 points) and the local streets have the least scores with only 15 points. As the connectivity map shows, it is obvious that a limited number of segments fall in upper interval (30 – 32 points), which indicates that the connectivity status in the study area is very weak.

3.2 Safety Analysis

Although the built environment provides more safety procedures around the two campuses than other parts of the study area, the best segments do not achieve more than 60% of the ideal conditions listed in Table (1) above. As the map in Figure (5) shows, scores of the best segments fall between 74 and 86, and most of these segments are concentrated around the ANU new campus and to less extent around the old campus.

The road network, in general, shows very low levels of safety as the results in Table (4) tell us. The best road class is the collectors with average of 65 while the arterials and the local roads achieved only 61 and 59 points, respectively. These results, in fact, show a serious problem in the safety procedures in the study area, which affects the overall walkability score.

Table 2. Number and length of roads on two-directional basis

Road type	Count of road segments	Total length of each type
Arterial	24	4,987
Collector	70	13,257
Local	186	28,578
Total	280	46,822

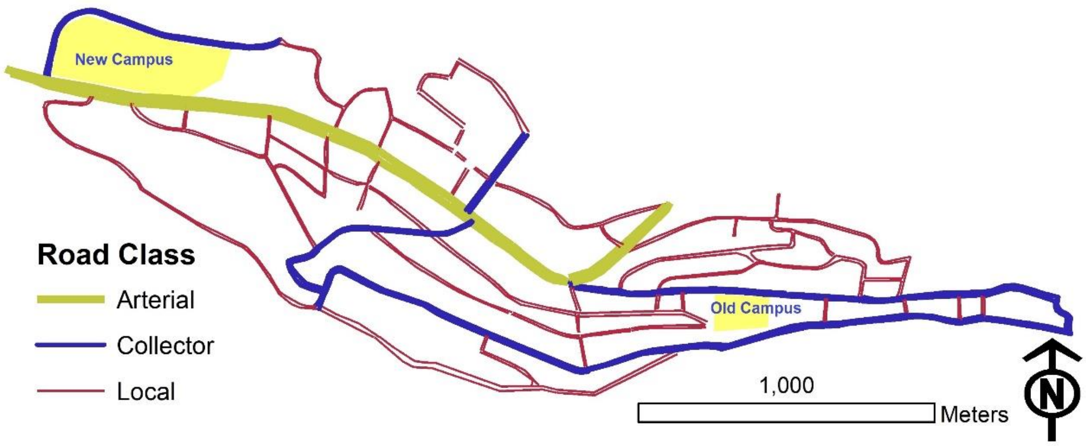

Figure 3. Functional road classification in the study area

3.3 Convenience Analysis

The spatial patterns of the convenience scores are more dispersed than the pattern of other walkability components. Figure (6) shows better convenience status at the main gates of the two campuses but still the scores achieve between 103 and 119 points, which is no more than 57% of the best score (210) listed in Table (1) above. The results in Table (5) show that the collectors, in general, achieve better scores (92 points) than the arterials (89 points) and the local roads (81 points).

3.4 Aesthetic Analysis

No significant differences between the patterns of the aesthetic scores shown in Figure (7) and the patterns of the other components. The road segments adjacent to the main gates of the two campuses achieve the highest scores besides other isolated segments dispersed over the study area. The area between the two campuses achieve the least levels of aesthetic aspects with 26 points. As to the road classes' results listed in Table (6), it is obvious that collectors achieve relatively better levels of aesthetic scores (with average of 53 points) than the arterials and the local roads with (46 points for both classes).

Table 3. Average connectivity scores for different classes of roads

Road type	Minimum connectivity score	Maximum connectivity score	Average connectivity score	Standard deviation
Arterial	12	30	19.1	4.9
Collector	10	24	17.5	3.4
Local	5	32	15.7	4.1

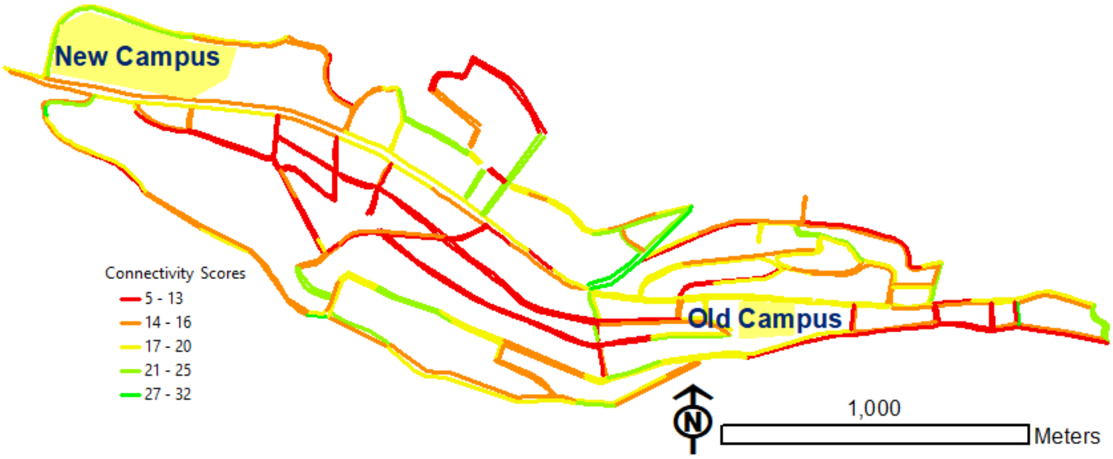

Figure 4. Connectivity scores

Table 4. Average safety scores for different classes of roads

Road type	Minimum safety score	Maximum safety score	Average safety score	Standard deviation
Arterial	39	85	61.5	12.7
Collector	42	86	65.1	8.6
Local	32	83	59	9

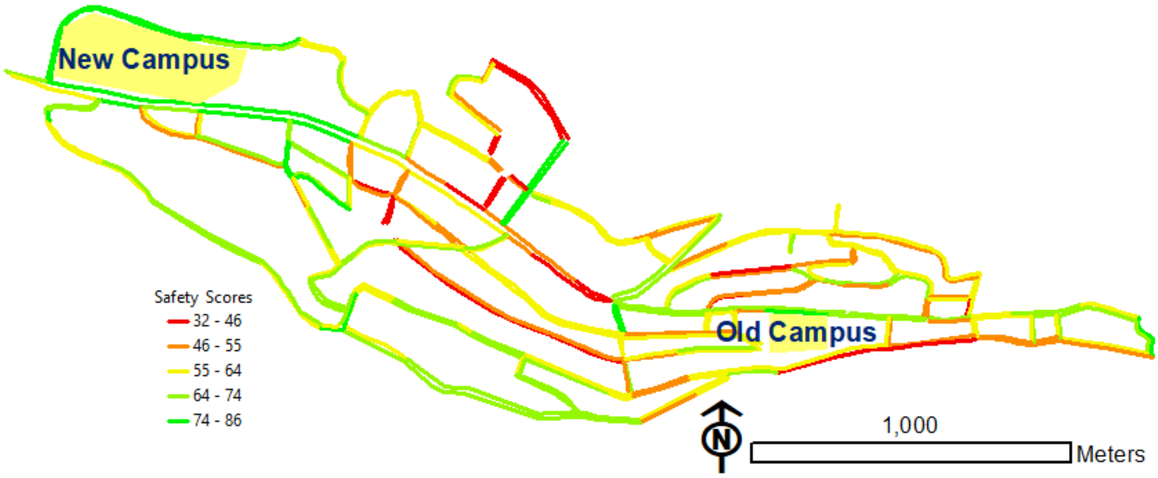

Figure 5. Safety scores

Table 5. Average convenience scores for different classes of roads

Road type	Minimum convenience score	Maximum convenience score	Average convenience score	Standard deviation
Arterial	53	114	89	15.1
Collector	64	119	92.7	11.6
Local	51	112	81.5	12.4

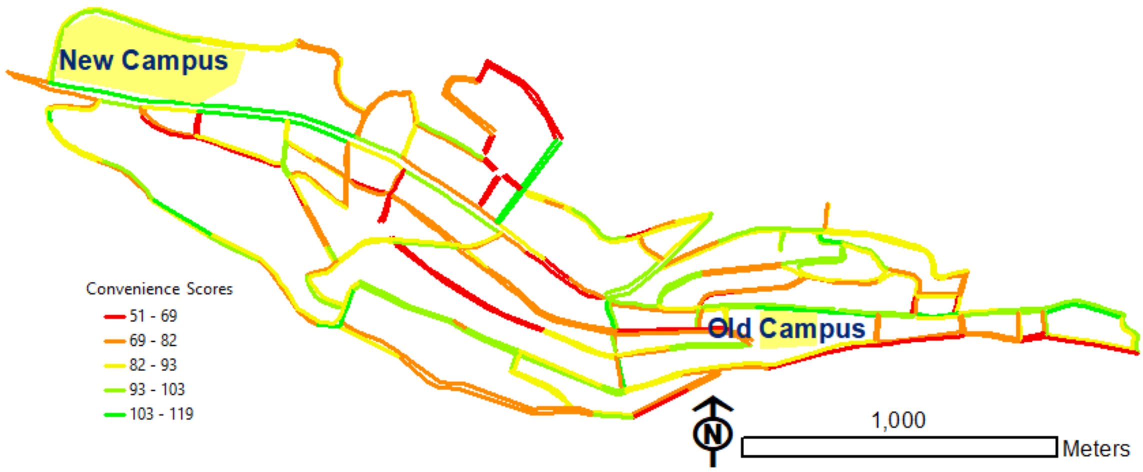

Figure 6. Convenience scores

Table 6. Average aesthetic scores for different classes of roads

Road type	Minimum aesthetic score	Maximum aesthetic score	Average aesthetic score	Standard deviation
Arterial	26	65	46.9	9.3
Collector	33	72	53.1	7.8
Local	28	67	46.6	7.6

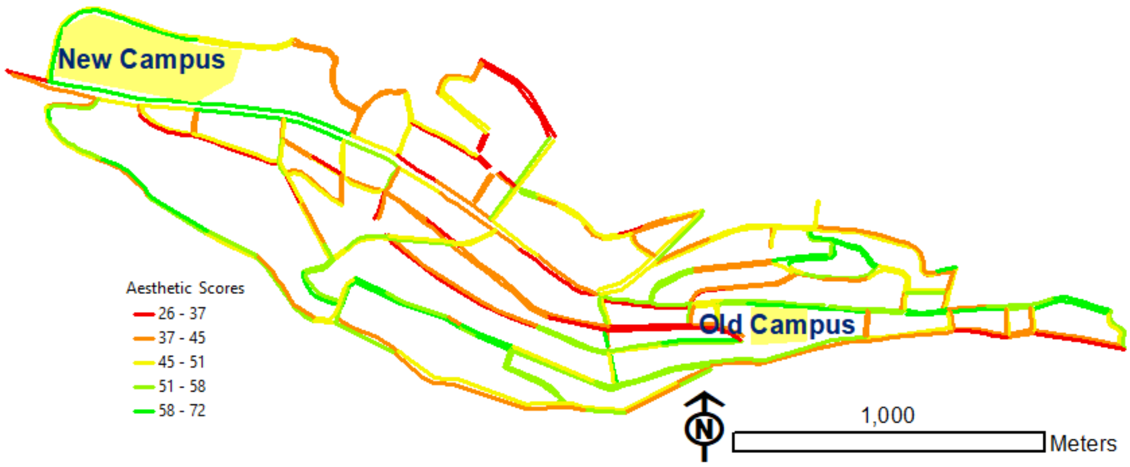

Figure 7. Aesthetic scores

3.5 Overall Walkability Analysis

As the final walkability score is the direct summation of the four scores, the spatial distribution of the four components is, by default, reflected on the spatial patterns of the overall walkability scores. The surrounding of the two campuses are better than the other parts of the study area with higher walkability scores for road segments adjacent to the campuses as shown in Figure (8) below. The highest walkability score is 282 out of 478 points (listed in Table (1)) that is only 59% of the walkability score in the ideal conditions. The lowest walkability score, on the other hand, is no more than 25% of the walkability under the best conditions. The least walkable road segments are mainly between the two campuses.

Figure (9) and Figure (10) illustrate the relationship between the overall walkability scores and the distance from the new ANU campus and the old one, respectively. The quality of walkability declines as we move away from the new campus according to a negative linear relationship:

Walkability score = - 0.0172 Distance + 220.93 --- (R^2 = 0.904) -------------------- Eq. No. 1

The distance explains 90% of the variation in walkability scores as the R^2 = 0.9 shown in the diagram below. Same is applicable on the distance from old campus and the walkability scores. The equation of the old campus is slightly different from the equation of the new campus and less R^2 indicating a weaker relationship:

Walkability score (y) = - 0.0075 Distance (x) + 214.93 --- (R^2 = 0.869) -------- Eq. No. 2

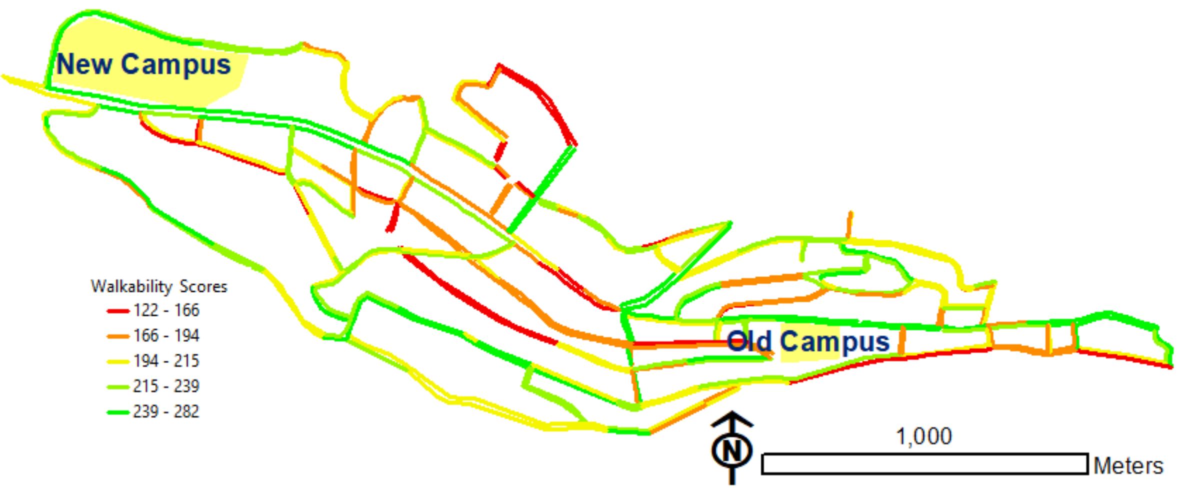

Figure 8. Walkability score patterns and the average walkability scores for each road class

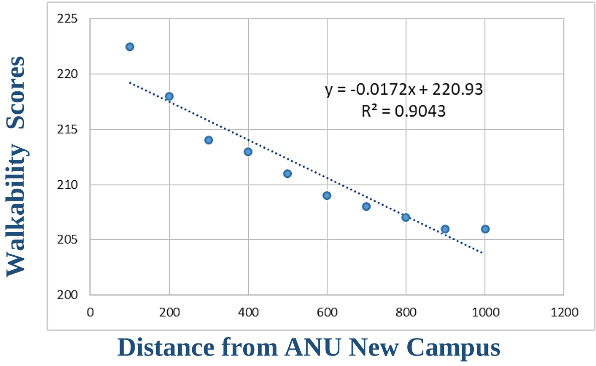

Figure 9. Walkability scores vs. distance from the ANU new campus

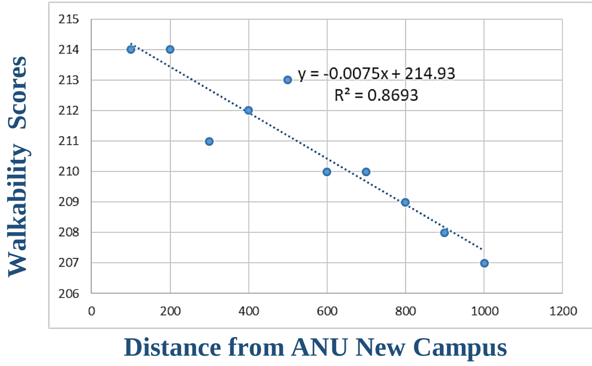

Figure 10. Walkability scores vs. distance from the ANU old campus

The walkability quality variation among the road classes is also similar to the four components. The collectors achieve the highest walkability score (227 points) as shown in the chart below. The arterials are less wlkable than the collectors with 214 points score, and the local roads have the leasts walkability score with only 202 points. The chart in Figure (11) below show the significant difference between the average walkability score and the highest score that could be achieved under the ideal conditions. The substantial difficiency in the walkability scores can be attributed to the high number of unsatisfied requirements for the enhanced walkability components, especially the safety and the convenience.

4. Conclusion and Recommendations

The proposed GIS tool was effective in quantifying the walkability in built environment and in presenting the spatial patterns of the walkability variation over the study area. The tool enabled the researcher form analyzing the four walkability components separately and together and to represent their results spatially. Overall evaluation, the results show better walking quality around the two ANU campuses as the most active walking sites in the study area. The walking quality declines constantly as we move away from the two campuses, which indicate that more attention has already been given to the ANU campuses neighborhoods. However, the scores are still low and do not achieve more than 50 – 60 % of the ideal conditions.
As to the road classes, the arterials achieve better connectivity scores and the collectors are the best in the safety, convenience and aesthetic aspects. These results are reflected on the overall walkability scores. The best walkability scores are achieved by the collectors and the least by the local streets. As mentioned above, although the collectors and the roads adjacent to the two campuses are better than the other roads, the highest walkability scores are still low and need more actions to be improved.

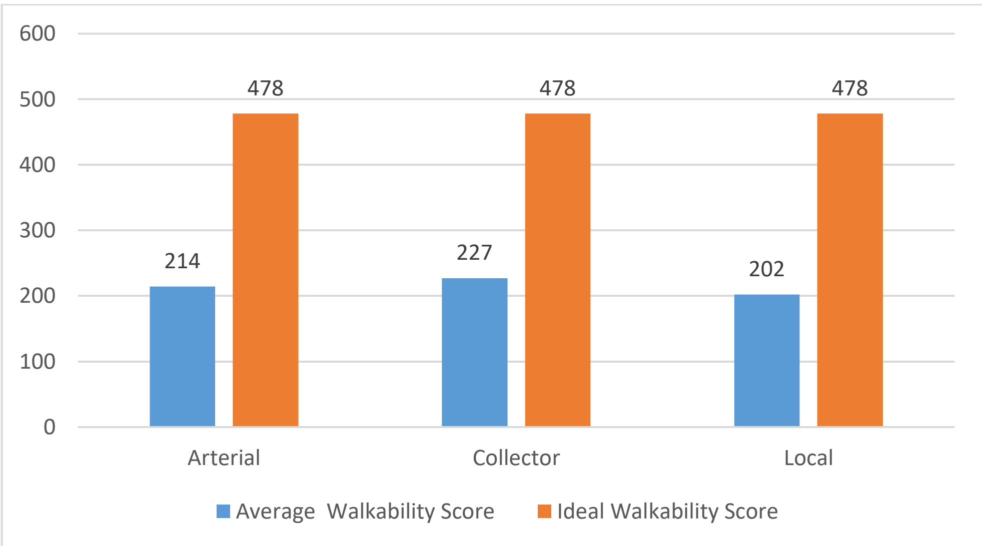

Figure 11. The average walkability scores for each road's class compared to the ideal overall walkability scores that could be achieved in the idea conditions

It is recommended that:

1. The decision makers at the municipality of Nablus city take the results of this study into their account and spare more budget to improve the walking environment in the study area.
2. The engineers pay more attention to develop more GIS tools – like the one proposed in this study—to monitor the walkability status in Nablus city, in general, and in the study area, in specific.
3. The researchers out-scale the results of this study by improving the proposed GIS tool, collecting more data about the Palestinian cities, and propose more practical solutions for the problem of weak walkability in Nablus city.

Finally, the study can be considered as a serious attempt to provide the Palestinian engineers with a simple methodology and tool that enables them from making wise decisions about where and how to start improving the walking environment in the Palestinian communities.

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