IDENTIFYING HIGH AND LOW WALKABLE NEIGHBOURHOODS USING MULTI-DISCIPLINARY WALKABILITY CRITERIA

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Abstract

Neighbourhood features contributing to the walkability (pedestrian friendliness) of a neighbourhood are diverse and depend on both its physical and social attributes. Earlier work in the Cleaner, Greener, Leaner (CGL) Study identified differences in opinion between professional stakeholder groups (planners, designers, engineers, public representatives, and public health and advocacy professionals) on what constitutes a walkable environment [1]. This diversity has implications for neighbourhood design and planning policy. The findings of a multi-disciplinary focus group study were used to generate a list of walkability criteria to select areas for a population study. In this study twenty areas were shortlisted and grouped under four categories: high walkable deprived, high walkable not deprived, low walkable deprived and low walkable not deprived. This paper presents the process undertaken to identify the study sites. International walkability research has favoured macro-scale objective geographic information systems (GIS) information to identify study areas [2]. While these macro scale attributes are important for walkability, alone they were considered insufficient for site selection by the CGL team as street characteristics were not considered and the attributes had a bias towards transportation walking. Also, indications from the focus group participants were that walkability is perceptual and therefore some resulting criteria were subjective, for example 'a pleasant atmosphere contextual to area characteristics' and therefore difficult to measure objectively. The CGL site selection process presented a number of challenges including limitations with available GIS information, unrepresentative neighbourhood boundaries on GIS datasets, and only one deprived neighbourhood identified as high walkable by the focus group participants. An investigation of the role of high and low walkable environments on resident's behaviours and health can be used to inform future planning, transport, public health and neighbourhood design policies.

Introduction

The most commonly used method for selecting sites in city-wide walkability studies is using GIS datasets and census data to stratify areas using composite walkability and socio-economic status (SES) measures [2]. These measures predominately comprise of GIS measurements of residential density, connectivity and land use mix which contain little or no street level context. Walkability is a complex concept [1] therefore to create an accurate as

possible representation of high and low walkable areas a site selection method should include as many identified characteristics of walkable communities as is feasibly possible using available data. The purpose of this paper is to outline the methods employed to select sites for the CGL population study. The aim of the CGL study is to investigate the relationship between the built and social environment, and walking and mobility behaviours in the Greater Dublin Area (GDA). The methods used for this study consider both the neighbourhood structure and the street level characteristics, and encompasses urban design principles including imageability and scale. The 5-step process used a novel method which encompasses local professional knowledge, objective GIS measurements and criteria for walkability developed in a previous study. A key research challenge was the limited availability of GIS datasets of relevant environmental and social measures at representative neighbourhood scales for the GDA. Some walkability studies supplement the GIS data with street level audit information to investiage relationships between neighbourhood features and behaviours [2]. However, as these attributes were not considered in the assignment of the walkability status the results can therefore contain a bias. A walkability score which reflects the true street level characteristics along with the functional structure of an area would make the assigned walkability score more relevant by acknowledging the multidimensionality of the term.

In this study the density, connectivity and land use mix of the selected sites are objectively measured using GIS measures for comparability to international studies such as the IPEN project (http://www.ipenproject.org/). Site visits for verification of criteria scores and ground truthing were also carried out to include street characteristics in the assignment of a neighbourhood walkability rating. Twenty neighbourhoods in the GDA were identified and categorised under four headings: high walkable not deprived, high walkable deprived, low walkable deprived and low walkable not deprived. Objective measures and criteria scores were compared between area categories.

Procedure

The procedure used involved five stages. By applying each successive method the number of areas on the shortlist of potential study sites was reduced.

A focus group study (5 groups, N=26) which was undertaken to explore the understanding of walkability among identified stakeholders presented an opportunity to enlist the expertise of these individuals for the site selection process. These stakeholders included spatial and transport planners, engineers, urban designers, landscape architects, architects, public representatives, public health professionals and advocates. Participants in each focus group were asked to select six high walkable and six low walkable areas in the GDA. Two high and low walkable areas in each of the inner city, outer city and the suburbs were required to ensure a geographic dispersion of areas. Maps were given to participants to assist in their area selections. The reasons for area selection were discussed. Individuals who expressed an interest in participating in the focus group study but could not attend were sent a web-link to a survey asking them to select areas in each of the same categories with their reasons for selection. This data was considered alongside the data collected in the focus groups. There were a number of inclusion criteria for the purpose of this study: (i) participants were required to have personal experience of walking or spending time in the area, (ii) recreational destinations or areas predominately referred to because of a recreational destination in the neighbourhood were excluded and (iii) areas must have a sufficient residential population to undertake a survey within the area which reflects the characteristics that make the area high or low walkable. A frequency count of identified areas was carried out on the qualitative data.

Evidence suggests that the SES of a neighbourhood can impact on how walkable it is perceived by its residents. Walkability studies have identified that individuals with low incomes/SES show a less favourable neighbourhood satisfaction score, higher perceived danger from crime and lower aesthetic/attractiveness scores [3]. SES is also a strong and consistent correlate of physical activity and is a major source of health inequalities [4]. To investigate these relationships, sites of varying SES as well as varying walkability needed to be identified. Method two applied a deprivation score to the areas shortlisted in method one. International walkability studies which have investigated the walkability/ SES link, have used

single (income) or composite (including education level, job status and home ownership) measures derived from census data [5]. The publication of the Haase Deprivation Index on census small areas on a web-based GIS interface hosted by Pobal (www.maps.pobal.ie) facilitated the application of deprivation scores to the identified areas [6]. Areas were labelled deprived or not deprived.

A research challenge arose at this point in the shortlisting process when the high walkable deprived category only had one area remaining following deprivation categorisation and was therefore incomplete. This low number of deprived areas categorised as high walkable was interesting and reflected previous findings of negative perceptions of the environment in deprived neighbourhoods [3]. Four additional deprived areas were identified that met the high walkable criteria established by the focus group study. The added areas are similar in layout, age and character to the most frequently selected high walkable areas and the identified high walkable deprived area. It was also noted at this point in the study, before proceeding to the next method that some suburban regions needed to be sub-divided into smaller areas. The small area mapping used in the deprivation study facilitated with the identification of smaller geographies within these regions.

The third method undertaken was to objectively measure the macro-scale environment features which are frequently used for walkability site selections. This was done on 27 shortlisted areas. The National Transportation Authority (NTA) made GIS datasets available to the researcher. Proxy measurements of residential density, connectivity and land use mix were calculated using the Dublin street network and the Dublin Transportation Model (DTM). The DTM incorporated data from the Central Statistics Office census of population 2006 POWCAR dataset onto a 250metre grid to anatomise results in a suitably small scale. This included geocoded origin and destination address points for regular work trips. GIS is a cheap and efficient method for citywide analyses; however effective GIS analysis relies on the assumption that the information provided is constant over the sample area and is therefore limited by the quality of the data available. Measurement could not be carried out on all of the areas as the road and path networks needed to be checked and updated by the researcher. This task was unfeasible for a large number of areas or at a city-wide level. GIS analysis was carried out using Arc GIS software version 10.1. The population density and land use mix measures were calculated from merging the 250 metre DTM grid layer with a 1 km radial buffer from an identified point. The connectivity measurement, PedSheds [7] was also taken from this point. A WI walkability index was calculated which is frequently used to identify study sites by stratification of areas into high and low walkability based on an assigned walkability score derived from GIS data [8]. The WI (walkability index) is calculated from the equation: ***WI = (z-score of land use mix) + (z-score of net residential density) + (z-score retail floor area ratio) + (2 * z-score of intersection density)*** [9]. When faced with data limitations some projects selected their areas based on the composite GIS measure using the data available to them [2]. For this study an adaptation of the WI walkability index was constructed substituting the Pedshed connectivity ratio for the intersection density. The retail floor area element of the equation was omitted similar to the BEPAS study [5]. The land use mix measure was substituted with a standardised measure of employment points per hectare, 'land use'. This resulted in the following equation ***WI = (z-population points per hectare) + (2*z-Pedshed ratio) + (z-employment points per hectare).*** At this stage of the shortlisting process the objective results were only used to inform the next method. The GIS analysis was repeated on the final shortlisted areas. In shortlisted areas with no identifiable core, or dispersed over a large suburban area, a number of potential study locations were identified by considering if an area comprising of adjacent census small areas: (i) had a sufficient residential population, (ii) adjacent small areas had similar deprivation status, and (iii) area characteristics were consistent with the reasons why the areas were selected in the focus group study, and were subsequently assessed using GIS.

The forth short-listing method was a desktop study and site visits. A 14-item walkability criteria was derived from qualitative research findings (unpublished), Table 1. However, not all of the developed walkability criteria could be objectively measured with available spatial data and undertaking neighbourhood street audits in all of the shortlisted areas was unfeasible. The desktop study involved applying walkability criteria to the shortlisted areas

by considering objective measurements of the environment from method three of this study and miscellaneous street and neighbourhood information from a variety of sources alongside qualitative data from the focus groups. This process addresses the limitations of either method by adopting a mixed methods approach. The CGL study research team (N=6) met and discussed the area selections and their suitability for the study. Each member of the team was given a pack which included: (i) Ordinance Survey street mapping (Scale 1:15 000 and 1:7 500 for inner city areas), (ii) Slides with images (photographs and aerial photographs) and alternative maps, such as OpenStreetmap for areas where OS mapping or Google Maps™ were out of date, (iii) where available, additional street level imagery was consulted using with Google Street View™, (iv) a summary of the qualitative data associated with the shortlisted areas, (v) the walkability criteria list developed in study two, Table 1, (vi) GIS results from method three and (vii) Pobal interactive mapping showing the small area boundaries and the deprivation scores for shortlisted areas from method two. These resources were used to inform discussion on the selected areas by being able to review the area structure, land uses and streetscape remotely. Ordinance survey mapping at this scale identifies hierarchal street network, public transport information and local amenities (post office, library, churches, parks, schools etc).

Table 1: Walkability Criteria

A walkable area…	
Scale	1. is built to human scale
Village	2. is an identifiable place
	3. has accessible facilities in a village centre or frequent nodes
	4. has a recreational walk facility nearby
Permeability	5. has a connected street network within the area with various routes available
	6. is not severed by a large, fast through road
	7. has sufficiently wide, good quality footpaths
	8. has good public transport access
	9. has seamless connections to adjacent areas
	10. has no major barriers to access the greater city area
Streetscape	11. has visual interest along routes
	12. has a pleasant atmosphere contextual to area characteristics
	13. has no visual disorder
	14. has routes overlooked with doors onto the street

Following the desktop study, three of the CGL research team visited the 27 areas shortlisted at the end of method three. Each of the areas was visited and researchers walked around areas individually to undertake a physical observation audit and experience the area's atmosphere and activity. Photographs and notes were taken and information was sought from local shop owners relating to the practical area boundaries and the safety of the area. Following the site visits each member of the site visit team (N=3) used information from the research team discussion, desktop study resources and observations from site visits to generate a 'walkable area criteria score'. A positive score was applied for each criterion met and a negative score given for each criterion negatively associated with the area. It was noted that not all criteria were relevant to all areas. In scenarios where a criterion was not clearly met no score was given. For example where an area does not have a village core or node it is difficult to assess if the area is severed by a large fast through route, also an area may have an adjacent village but the village may be difficult to access on foot (e.g. Stepaside). If there was a disagreement on an area, the area was discussed with respect to the criteria. Following discussion if two or more researchers disagreed with an area's inclusion then the area was removed from the shortlist. At the end of the site visits the areas within each category were listed preferentially based on criteria score and suitability for surveying. Five areas were listed in each category with four to be surveyed and a reserve area. Care was taken to ensure a spatial distribution of areas which represent the whole city area for comparison.

In method five the GIS analysis outlined in method three was repeated using centre-points of the final 20 shortlisted areas. The resulting data and criteria scores were tested for normality of distribution. When divided into the four area categories (HWD, HWND, LWD &LWND) the data was not normally distributed and non parametric tests were used to investigate differences between the categories. Kruskal-Wallis tests were carried out to investigate if differences exist between all categories and were followed by Mann Whitney U tests to test for differences between two independent categories. A Bonferroni adjustment of six was applied in the investigation of walkability/ deprivation categories and an adjustment of three was applied to the investigation of city zones. Effect sizes were also calculated for all investigated relationships.

Results

A total of 316 area selections were made during the focus group study with an additional 100 site selections made by web-link. Following analysis, 39% (n=61) of the high walkable focus group area selections remained valid across 14 geographic areas. There were 110 (71%) valid low walkable focus group area selections across 15 geographic areas. An additional two areas were included from the online selections. A percentage agreement of 97% was observed between high walkable and not deprived areas. Low walkable areas selected by focus group participants showed greater SES diversity than high walkable selections and included deprived and non-deprived areas. This method was applied to streamline the site selections into four categories, one of which was incomplete (high walkable deprived) following this method. High walkable areas tended to be closer to the city centre or the coast whereas low walkable areas were predominantly in the outer city or western suburbs. Inner city areas listed as low walkable were areas along major traffic thoroughfares with high concentrations of social housing (Figure 1). The final selected areas are illustrated on Figure 1 and the walkability criteria scores for the shortlisted areas are presented graphically on Figure 2. The boxes indicate the overall criteria score and the lines indicate the range of relevant criteria. Therefore an area where the box is close to the top of the line indicates a greater number of positive walkability scores.

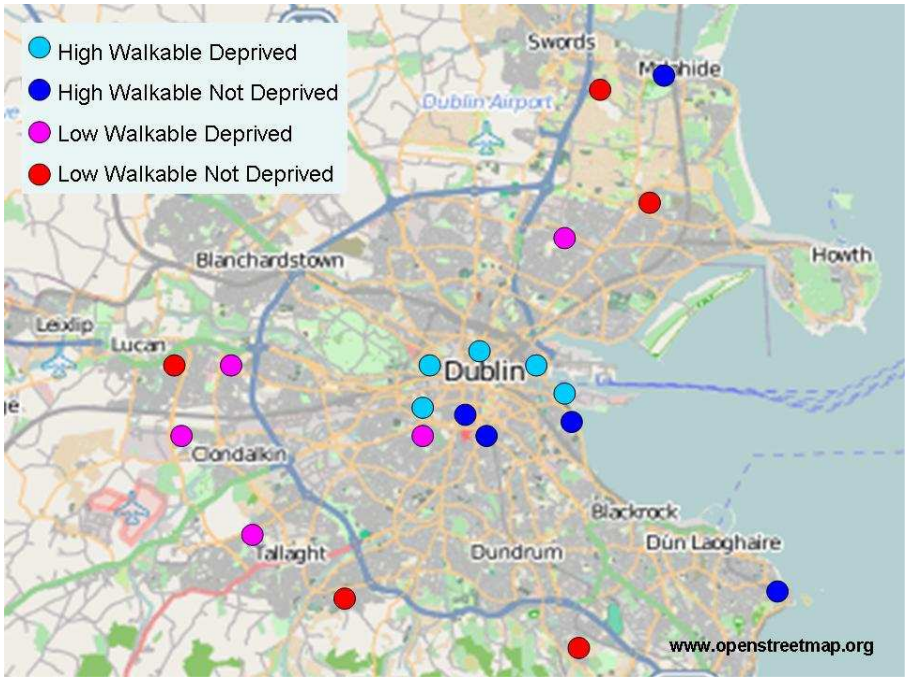

Figure 1: Final Shortlisted Areas

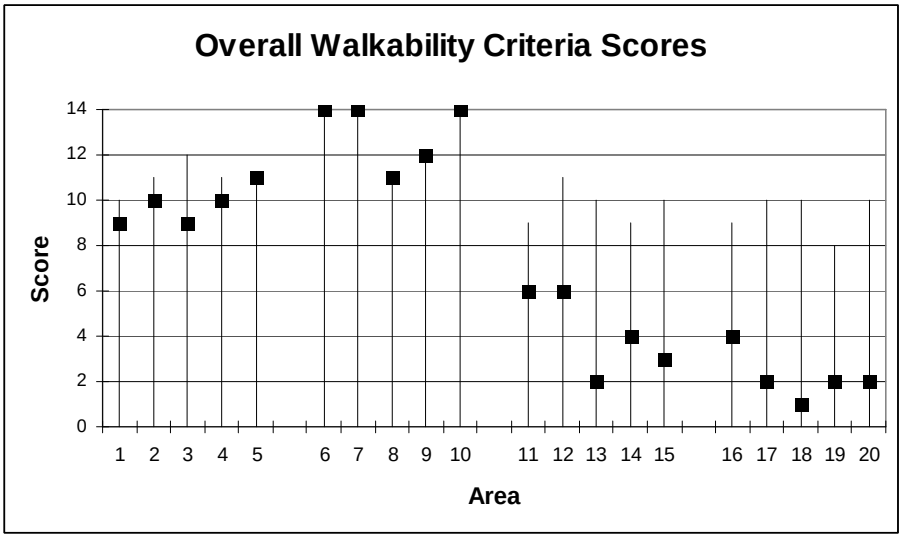

Figure 2: Walkability Criteria Scores (Areas 1 to 5: High Walkable Deprived, Areas 6 to 10: high Walkable Not Deprived, Areas 11 to 15: Low Walkable Deprived, Areas 16 to 20: Low Walkable Not Deprived)

Results for all 20 areas are presented on Table 2 as standardised z- scores with raw data reported in brackets (parenthesis) in each column except for the WI and criteria score. Table 3 shows a significant difference in population density between the four area categories however this difference was not substantiated in post hoc tests. Low walkable deprived areas have a significantly lower 1km connectivity score to all of the other area groups with a large effect size (r=0.8). High walkable areas, deprived and not deprived, were also significantly more connected than low walkable deprived areas over 5km (Table 3). The WI measure showed a significant difference where high walkable areas scored higher than the low walkable not deprived areas. No significant difference was observed between high walkable areas and the low walkable deprived areas. A significant difference was observed between low walkable deprived and low walkable not deprived areas. High walkable not deprived areas score significantly higher *criteria scores* than all other area categories (Table 3). High walkable deprived area's *criteria scores* were also significantly higher than low walkable areas, both deprived and not deprived. The differences between *criteria scores* had a very large effect size (r= 0.9).

Discussion

As the field of study investigating the relationship between the built environment and physical activity, health and well-being develops, the role of neighbourhood characteristics and their contextual design need to be considered alongside objective (quantitative) measures of the neighbourhood to gain a better insight into resident's perceptions. The benefits of the mixed methods site selection methodology used for this study included the utilisation of professional knowledge to encapsulate environmental perceptions of their familiar geographies. This afforded a unique forum to discuss areas for selection. In method one, the low percentage of valid high walkable area selections was because a high number of selections did not meet the study's inclusion criteria, for example, recreational destinations such as seafront promenades and urban parks which have little or no residential populations. The walkability criteria for area selection, applied in method four, takes account of the importance of the proximity to recreational walking facilities. A prioritisation for the areas which received the most nominations strengthens the validity of this method. An unavailability of consistent SES data for the GDA at a sufficiently small spatial scale which could reflect operational neighbourhoods presented a challenge to this research. The timely publication of the Haase Deprivation Index [6] and census small areas provided the solution, permitting the identification of deprived and not deprived areas at local small scale. The low number of high walkable deprived areas selected by the focus groups was consistent with previous findings that individuals with low incomes/SES show a less favourable neighbourhood satisfaction score, higher perceived danger from crime and lower aesthetic/attractiveness scores [3]. While interesting, this outcome resulted in a research

challenge. By applying the rationale for area selection outlined by participants in the qualitative study to deprived areas in the GDA additional areas were identified and subsequently verified using during the desktop study and site visits.

Table 2: Objective GIS results for final areas

Area No.	*1km PedShed Connectivity*[1]	*5km PedShed Connectivity*[2]	*Density* [3]	*Land Use*[4]	*WI*[5]	***Criteria Score***
	Z (ratio)	Z (ratio)	Z (Pop/ha)	Z (Emp/ha)		
1	0.28 (0.40)	0.49 (0.59)	0.40 (53.9)	0.25 (30.9)	1.22	9
2	1.25 (0.55)	1.15 (0.69)	1.26 (74.7)	0.81 (46.0)	4.57	10
3	-0.04 (0.35)	0.56 (0.60)	-0.21 (39.1)	0.98 (50.7)	0.69	9
4	1.47 (0.59)	0.95 (0.66)	2.13 (95.7)	1.99 (77.8)	7.06	10
5	-0.22 (0.32)	0.36 (0.56)	-0.09 (42.0)	0.12 (27.4)	-0.41	11
Average	*0.55 (0.44)*	*0.70 (0.62)*	*0.70 (61.1)*	*0.83 (46.6)*	*2.63*	*9.8*
6	0.69 (0.46)	0.09 (0.53)	-0.31 (36.6)	-0.03 (23.3)	1.04	14
7	1.39 (0.58)	0.69 (0.62)	-0.77 (25.6)	-0.69 (5.4)	1.33	14
8	0.90 (0.50)	1.22 (0.70)	1.87 (89.4)	2.94 (103.6)	6.61	11
9	1.04 (0.52)	1.02 (0.67)	1.06 (69.9)	0.06 (25.8)	3.20	12
10	-0.60 (0.26)	0.56 (0.60)	-0.15 (40.6)	-0.54 (9.4)	-1.89	14
Average	*0.68 (0.46)*	*0.72 (0.62)*	*0.34 (52.4)*	*0.35 (33.5)*	*2.06*	*13*
11	0.47 (0.43)	0.36 (0.57)	0.59 (58.5)	-0.34 (14.9)	1.20	6
12	-0.10 (0.34)	-0.83 (0.39)	-0.07 (42.4)	-0.74 (3.9)	-1.02	6
13	0.05 (0.36)	-1.03 (0.36)	-0.66 (28.2)	-0.61 (7.5)	-1.18	2
14	0.27 (0.40)	0.09 (0.53)	0.16 (48.0)	-0.22 (18.3)	0.49	4
15	0.02 (0.36)	-0.90 (0.38)	-0.66 (28.1)	-0.26 (17.1)	-0.89	3
Average	*0.14 (0.38)*	*-0.46 (0.45)*	*-0.13 (41.0)*	*-0.43 (12.3)*	*-0.28*	*4.2*
16	-1.78 (0.07)	-1.96 (0.22)	-1.43 (9.4)	-0.84 (1.3)	-5.85	4
17	-1.41 (0.13)	-1.43 (0.30)	-0.72 (26.7)	-0.81 (2.2)	-4.34	2
18	-1.06 (0.19)	-1.10 (0.35)	-1.29 (12.9)	-0.74 (3.9)	-4.15	1
19	-1.78 (0.07)	1.08 (0.68)	-1.35 (11.5)	-0.75 (3.8)	-5.65	2
20	-0.84 (0.22)	-1.36 (0.31)	0.22 (49.6)	-0.57 (8.8)	-2.02	2
Average	*-1.37 (0.14)*	*-0.95 (0.37)*	*-0.91 (22.0)*	*-0.74 (4.0)*	*-4.40*	*2.2*

(Areas 1 to 5: High Walkable Deprived, Areas 6 to 10: high Walkable Not Deprived, Areas 11 to 15: Low Walkable Deprived, Areas 16 to 20: Low Walkable Not Deprived), [1]Ped-Sheds ratio 1km walking catchment area to 1 km crow-flies area, [2]Ped-Sheds ratio 5km walking catchment area to 5 km crow-flies area, [3]Density calculated as population per hectare 1km radius, [4]Land Use calculated using a proxy measure of employment destinations per hectare within a 1km radius, [5]WI = (z score population density) + (2*z score connectivity ratio) + (z score land use mix)

Table 3: Objective GIS differences between high/ low walkable deprived/ not deprived areas

Measure	*HWD*	*HWND*	*LWD*	*LWND*				
	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)	F(3)	ω	ρ	
z Population Density	.70 (1.0)	.34 (1.1)	-.13 (.5)	-.91 (.7)	3.3	0.5	.047*	Not in post hoc
z 1km Connectivity	.55 (.8)	.68 (.8)	.14 (.2)	-1.38 (.4)	12.7	0.8	.000**	LWND < HWD*, LWND< LWD & HWND**
z Land Use Mix	.83 (.7)	.35 (1.5)	-.43 (.2)	-.74 (.1)	3.7	0.5	.035*	HWD > LWND *
z 5km Connectivity	.70 (.3)	.71 (.4)	-.46 (.6)	-.95 (1.2)	6.7	0.7	.004**	HWD & HWND > LWND*
WI	2.60 (3.1)	2.10 (3.1)	-.30 (1.1)	-4.40 (1.5)	8.9	0.7	.001**	HWD & HWND > LWND*, LWD > LWND**
Criteria Score	9.8 (0.8)	13.0 (1.4)	4.2 (1.8)	2.2 (1.1)	69.8	0.9	.000**	HWND > LWD &LWND**, HWND > HWD*, HWD> LWD**, HWD > LWND**

HW: High Walkable, LW: Low Walkable, D: Deprived & ND: Not Deprived, *ρ<0.05, **ρ<0.01

The GIS results suggest that high and low connectivity has the greatest relationship with the walkable areas identified by focus group participants of the three macro scale factors measured (density, land use and connectivity). A limitation of the land use mix measurement used in this study was lack of an indicator of the diversity of the employment destinations within the neighbourhoods selected unlike the land use diversity measure generally used in the WI index [8]. Our measure indicates employment points or uses other than residential. However, the livability and diversity of services in each neighbourhood were considered in method four. The significant differences in criteria scores between all of the area categories, except low walkable deprived/not deprived areas, illustrate greater differences between area categories than the WI index. As the criteria are based on multidisciplinary opinion and were applied to site selection using a mixed method process they encompass a greater acknowledgement of the features which contribute to an area's walkability. The walkability criteria scores, deprivation scores and objective measure of the environment allow for a holistic exploration of what makes these areas walkable or not.

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