Mapping Bikeability Based on OpenStreetMap

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Introduction

It has been widely accepted that bicycle use in transportation is beneficial for individuals and for our society as well. It is an effective way to promote health, reduce congestion, carbon emission, and pollutant emission. A bicycle friendly built environment has been shown to enhance uptake of bicycle use. However, little effort has been made to use spatial data and knowledge to define and map 'bikeability' as a way to provide evidence for intervention and for promoting travel by bicycle (Winter et al, 2013).

Similar to many countries, the Scottish government developed a 'Cycling Action Plan for Scotland' (Transport Scotland, 2017). It sets up a goal of increasing the proportion of cycle travel to 10% for all journeys by 2020. To realise this goal can be very challenging because the current level of cycling to work, for example, is merely 2.2% (Transport Scotland, 2017). One way to promote the level of bicycle use in travel is to provide cycling infrastructures and improve the cycling conditions. Bikeability can be defined as the suitability of an area for cycling (Winters et al, 2013). Thus, mapping the bikeability of an area is a powerful visual method to help assess areal suitability for cycling, identifying areas that need further improvements.

Previous research in this regard has been carried out in Vancouver, Montral, New York City, and Portland (Winters et al, 2013; Richards, 2010; Voros and Birk, 2010). But, no research has been carried out on bikeability in Scotland. This research fills this gap in mapping bikeability in Edinburgh, the capital city of Scotland.

Data and methods

Various data are needed to construct the bikeability index. For example Winter et al (2013) used five factors to define bikeability in Vancourer. We conducted an opinion survey (N=56) asking participants which factors they thought are important for cycling. Based on the opinion and data availability we selected 7 factors: Street Network, off-road cycle path, on-road cycle lane, bike storage, topography, traffic condition, and trip distance. The data of cycle infrastructure is from OpenStreetMap (OSM). OSM is a free online map database which is openly editable. Previously, users could only obtain spatial data from official providers, i.e., governmental agencies, cartographic centres and commercial agencies. However, high cost and license restrictions were the main barriers for wider access to spatial data. Since OSM launched in 2004, users had been able to make use of the data for various research. Four of 7 bikeability component factors were retrieved from OSM: Street Network, off-road path, on-road lane and bike storage. The other factors, trip distance, traffic volume and topography were separately collected from the 2011 population census, local authority and Ordinance Survey. Traffic volume represents traffic conditions and was extracted from the Annual Average Daily Flow (AADF) data at https://www.dft.gov.uk/traffic-counts. For topography we calculated slope based on the DEM data at a resolution of 90 meters. Other factors are in the vector form and were transformed into raster with the same resolution of DEM. Measures of lengths of off road cycle paths, on road cycle lanes, number of connected nodes, number of bike storage for each cell was derived. A buffer of 200 meters was applied to the cycle route before the calculation. Number of vehicles per year was derived for each cell for traffic conditions. These continuous measures were then re-classified into a scale of 10 with 10 indicating the most suitable for cycling and 1 the least.

The Weighted Liner Combination (WLC) is a common method used to combine decision criteria in multicriteria evaluation (Drobne, and Lisec, 2009). Each map layer is assigned a weight according to its importance based on the opinion survey. The equation is as follows:

*Bikeability = (B1 * Street Network (cycling way connectivity)) + (B2 *Type of Bicycle Facility(off road lane) + (B3 * Traffic Volume) + (B4 * Type of Bicycle Facility (on road lane)) + (B5 * TripDistance) + (B6 * Topography) + (B7 *Bike Storage)*

where B1–B5 are the weights applied to each layer. Weights are more or less equal. Apart from on road cycle lane (14%), trip distance and slope (both 13%), the rest of factors were assigned a weight of 15%.

Results

The bikeability map for Edinburgh is shown as Figure 1. The green colour shows high bikeability while the red colour low bikeability. It can be seen that the areas with high bikeability concentrate in the central part of Edinburgh city. In contrast, the peripheral areas shows low bikeability. Some southern areas such as Pentland Hills, Colinton, Morningside and northern areas such as Forth and Leith also have low bikeability score meaning improvements can be made. The overall bikeability map becomes most powerful when combined with specific component factor maps (Figure 2). Based on these maps, it is easier to understand the reason why areas received their corresponding score. For example, the middle part of the northern area of Forth has a low overall score, although it scores highly for topography (slope is low), has low traffic volume (safe for cycling), has short trip distance to work generally and has high density of off-road bicycle roads, it has low scores in terms of cycleway connectivity, almost has no on-road cycling roads and is short of bike parking.

Figure 1 Map of bikeability in Edinburgh

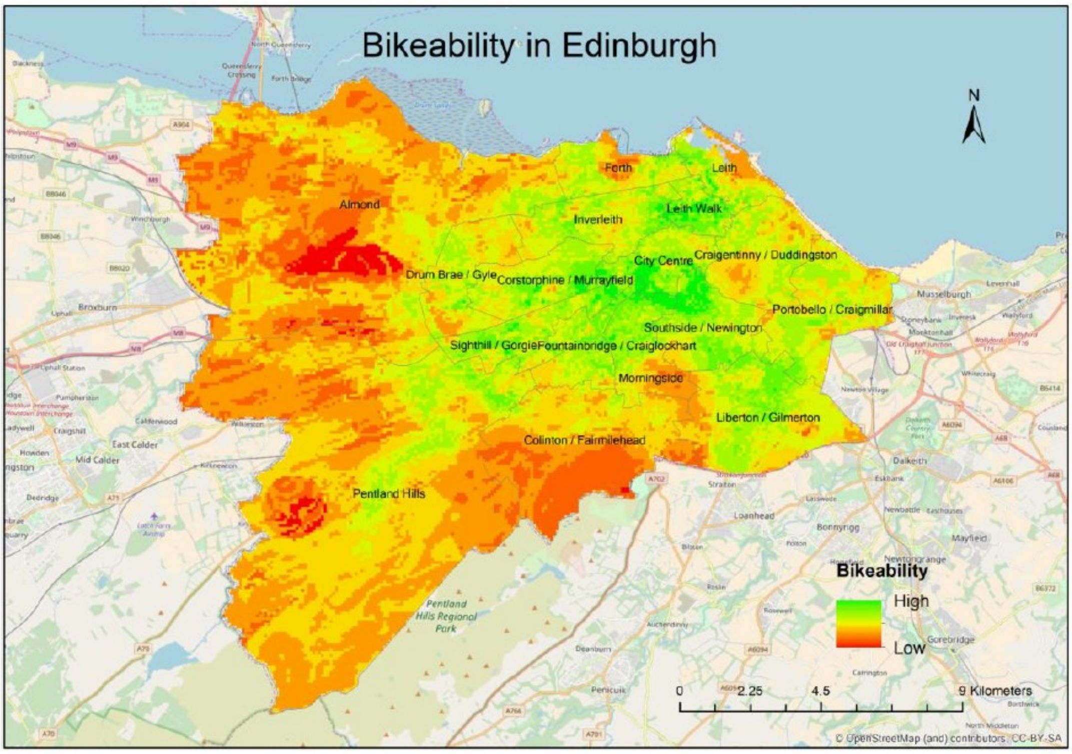

Figure 2 Map of component factors in Edinburgh (a: street network, b: on road lane, c: off road lane, d: traffic volume, e: trip distance, f: topography, g: parking storage)

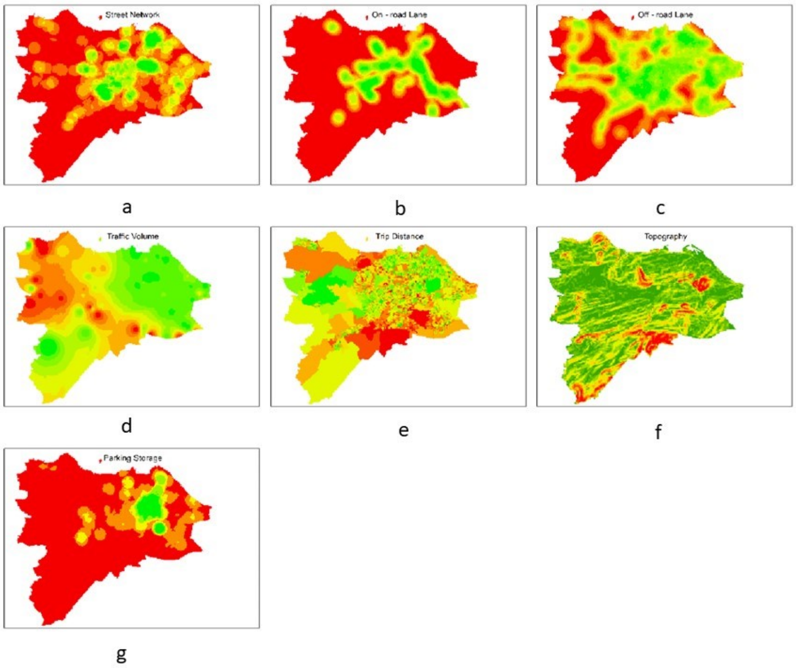

Table 1 shows modelling results from GLM logit regression models. The results provides evidence on whether areas with high level of bikeability are associated with a high level of cycling to work. It gives support on the validity of the bikeability index. Two models with the first a univariate model including only the datazone level index and the second a multiple regression model adjusting for other factors. The positive association between bikeability measures and the proportion of cycling to work gives evidence to support effectiveness of the index.

Table 1 Modelling results from logit regression of proportion of cycling to work in 2011

	Model 1			Model 2		
	Coeff.	Std error	P	Coeff.	Std error	P
Bikeability	0.209	0.25	0.000	0.122	0.029	0.000
Working age 25-34				-0.003	0.002	0.213
% car availability				-0.009	0.002	0.000
SIMD				0.136	0.011	0.000
_cons				-3.495	0.194	0.000

Conclusions

This research used open data and developed a method which can be applied to evaluate the bikeability of different locations. Seven component factors were combined and weighted, namely street network, off-road paths, on-road lane, traffic volume, trip distance, topography and density of bike storage. Mapping these factors provides a useful visual tool for analysing a region's friendliness for cycling (Winters et al., 2013). Additionally, analysing individual component factor enables us to better understand the contribution of each individual component which provides evidence on which specific dimension need improvements (Winters et al., 2013).

There are several strengths of this study. Firstly, the definition of component factors and weights was mainly based on the local people's opinions, which makes the bikeability index more suits for the local conditions. Compared with the previous research, the bikeability index is more comprehensive, for example, the bike storage factor was not included in previous studies but was contained in this study. Additionally, since the tool was developed using an open source data with a fairly common approach, it has huge potential to apply the methodology to other regions. The evaluation of bikeability index was carried out using a modelling approach which demonstrates the high association with propensity to use bicycle in trips to work.

There are some limitations in this study. Although the OSM data quality is generally high, its accuracy is often lower than official data provided by governmental departments (Girres and Touya, 2010). Secondly, for the bikeability index components selection, some factors which cyclists considered as important were not included, due to data availability, such as the quality of cycling surface. Finally, the data of different years was used which is an issue as some conditions may change.

References

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